

COVID-19 Return To Life A Systems Perspective

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This research is not associated with any institution.

It is ongoing and part of a broader set of COVID-19 systems oriented research areas.

www.cassbeth.com/covid-19

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Abstract

The COVID-19 pandemic is a massive disaster. Returning to normal life will not be a trivial exercise. This research will be done real time by the people. There will be different policies and procedures that will be developed around the world that reflect different systems. Each of these systems will have different performance characteristics with the ultimate test being how many people will get sick and die. Once again, a systems perspective will be used to understand the various Return to Life systems that will be developed.

Preface

My name is Walt and I am performing COVID-19 rapid response research from a systems perspective. I interact with various colleagues and other researchers to try and help address this disaster. This captures the body of work as it continues to expand.

Walt Bio

Professor Walt Sobkiw is performing research on the COVID-19 pandemic from a Systems Engineering Perspective. He published a detailed report on returning to normal life and the research findings are at: <http://www.cassbeth.com/covid-19/return-to-life/index.html>. He is a member of the COVID-19 Healthcare Coalition <https://www.c19hcc.org> and shares his research with the coalition and others fighting this pandemic.

Walt is an electrical engineer who became involved in systems engineering early in his career. He has over 43 years of systems experience working on large complex computer and communications systems for air traffic control, air defense, and communications. He has published at technical conferences and is author of multiple books on systems engineering.

Walt was requested to provide his systems experience to university students and advised University of Pennsylvania undergraduate students on their senior year systems engineering projects. Sustainability was the focus and the projects included alternative power, automobile fuels, health care, and sustainable villages. He stopped the activity to support a Drexel request to help develop systems engineering curriculum and course content. He is one of the founding members of the Drexel Systems Engineering Program and is developer and subject matter expert for multiple Systems Engineering courses at Drexel University.

Authored Books:

- Privatization A Systems Perspective, 2019
- Systems Engineering Design Renaissance, 2014.
- Systems Practices as Common Sense, 2011.
- Sustainable Development Possible with Creative System Engineering, 2008.

Acknowledgements

RCA Dining Philosophers Club

This is a group of engineers that formed at RCA in Camden NJ. All the club members through the decades are acknowledged. The members have varied through the years. Today the following folks are providing key information on this crisis: Bill, Bob M, Bob P, Paul, Pete, Pete R, Ca S.

Special mention is Dr Peter. Pete came to the US to study systems engineering at University of Pennsylvania in 1962. After my serious corporate burnout circa 1995, he has been an inspiration for all my systems work. His impact on the local Delaware Valley systems community is immeasurable.

Other Researchers

These are other professionals that I share information with, and we discuss various aspects of the COVID-19 pandemic. They are: Engineering colleagues Steve, Carl, Don B. and many others. Pharmacists Dan (sterilization disinfection expert) and Allen, teachers Carol, and others. Healthcare workers and teachers in my inner circle. Drexel COVID-19 research group and systems engineering faculty and the COVID-19 Healthcare Coalition.

Introduction

The COVID-19 pandemic is a massive disaster. Returning to normal life will not be a trivial exercise. This research will be done real time by the people. There will be different policies and procedures that will be developed around the world that reflect different systems. Each of these systems will have different performance characteristics with the ultimate test being how many people will get sick and die. Once again, a systems perspective will be used to understand the various Return to Life systems that will be developed.

Since the start of the COVID-19 disaster many are just focused on return to work. However, that system boundary is incorrect, it is too small. The system boundary is clearly - Return to Life.

A quick note about the systems perspective and this analysis.

In a systems engineering effort for a problem of this magnitude all technologies and products are examined that may be able to address the need and provide a viable solution. This requires massive resources and in the past the US government and a handful of systems engineering companies performed this type of systems engineering. This is called large complex systems engineering. Examples of large complex systems engineering from the previous century are the US Space Program, Air Defense, Air Traffic Control, etc. The following was offered as a definition of Systems Engineering from [Systems Engineering Design](#):

*Discipline that concentrates on the design and application of the whole (system) as distinct from the parts. It involves **looking at a problem in its entirety**, taking into account **all the facets and all the variables** and **relating the social to the technical aspect**. -- Simon Ramo.*

For the specialists that are working their respective areas, in a systems effort they are represented and sit at the systems engineering table. As they present their analysis findings their work informs other specialists in completely different analysis areas. It is this cross fertilization that allows all specialists to broaden their perspectives and enables them to detect new patterns in their own body of work, especially if they are stuck. Systems engineering is the mechanism that allows specialists to quickly and effectively communicate their analysis to completely different areas and significantly shift the overall results in a positive direction. This systems engineering analysis is offered in that spirit of an effective systems engineering activity.

One of the key challenges in systems engineering is to determine the key needs, key analysis, key requirements, and key system architecture approaches that will solve the problem. This is very difficult because there is the important consideration to filter out the noise (irrelevant) while not losing what may be the answer. There is an old saying that practitioners use to communicate this challenge: We don't care about how many angels can dance on the head of a pin and we can't throw out the baby with the bathwater.

One of the important elements that the systems perspective provides is that it includes the human condition in the system. The system solution must include the reality that people are part of the system and that they do not behave rationally. So the system must account for irrational human behavior otherwise it will fail or have very poor performance characteristics. Without the systems perspective this is always lost. The purpose of all the analysis is to enable the

development of potential architecture and design solutions. Eventually the architecture(s) and design(s) must be selected.

This is a long hard read. Use the table of contents to navigate. It is constantly being updated and follows the natural flow of all systems engineering efforts; some analysis is a dead end and is abandoned, some analysis converges, some analysis diverges, and some analysis stays at a steady state level until new information surfaces, typically from a specialist on the team.

More information on the systems perspective for this problem is available as part of this systems engineering analysis at: [Systems Perspective](#).

1918 Flu Pandemic Informing 2020 COVID-19 Disaster

The 1918 Flu Pandemic (Spanish flu - wrongly named it did not originate in Spain) started in 1918 and lasted until 1920. It ran through four waves of outbreak. The second wave was more deadly than the first. A third wave of the flu started in late January 1919. In the Spring of 1920 a fourth wave occurred in: New York City the United Kingdom, Austria, Scandinavia, South American islands. It infected 500 million people, about a third of the world's population at the time. The death toll is estimated to have been anywhere from 17 million to 50 million, and possibly as high as 100 million, making it one of the deadliest pandemics in human history [1]. [\[spreadsheet 2020-1\]](#)

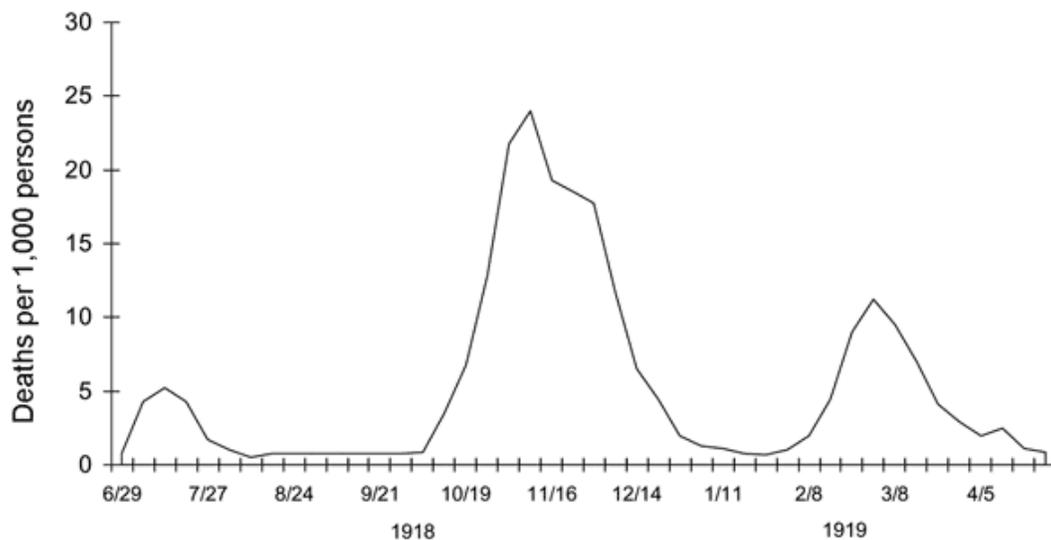


Figure 1 - 1918 Flu Pandemic

Schools opened and windows closed for the winter !!!

Most suggest that a large factor in the worldwide occurrence of the 1918 Flu Pandemic was increased travel. Modern transportation systems made it easier for World War I soldiers, sailors, and civilian travelers to spread the disease. Another was lies and denial by governments, leaving the population ill-prepared to handle the outbreaks. Eventually the tools used to contain the 1918 Flu Pandemic were masks, shutdown of businesses and other public gathering, and quarantine.

The US was very different at the time. Most of the people were still living on farms and were more self-sufficient than city dwellers. The people were also more spread out and not concentrated in large urban centers. This meant that the 1918 Flu Pandemic spread was naturally slower than what may happen today. There was also the ability for sections of the country to isolate themselves from the pandemic. This is not possible today. So, without conscious effort the spread of COVID-19 will not be 2 years but can happen in the span of months overwhelming the civilization and causing massive collapse.

If the COVID-19 disaster follows the 1918 Flu Pandemic trend it is possible to make some predictions.

The analysis approach is to map the 2020 COVID-19 disaster dates to the 1918 Flu Pandemic graph. The mapping is not exact because there was a trend departure after the first wave. In the 1918 pandemic the number of deaths dropped significantly after the first wave. In the 2020 disaster the number of deaths did not drop. A reasonable explanation is that in 1918 there was no air conditioning and the people were living outside and so the infection rate dropped significantly in 1918 as opposed to 2020. There is a huge point of infection that occurred in the early Fall of 1918. A reasonable explanation is that children went back to school and the windows were closed in schools as the cold months started. A reasonable assumption is that the same thing will happen with the COVID-19 disaster when children return back to school.

Multiple assumptions were made to predict what may happen going forward. The first is that the number in early fall is a new plateau and that plateau will be the departure point for the second wave. The second assumption is that the second wave just follows the trend from that departure point. The third assumption is that there is no peak in the second wave and that there is a constant moving forward from early fall.

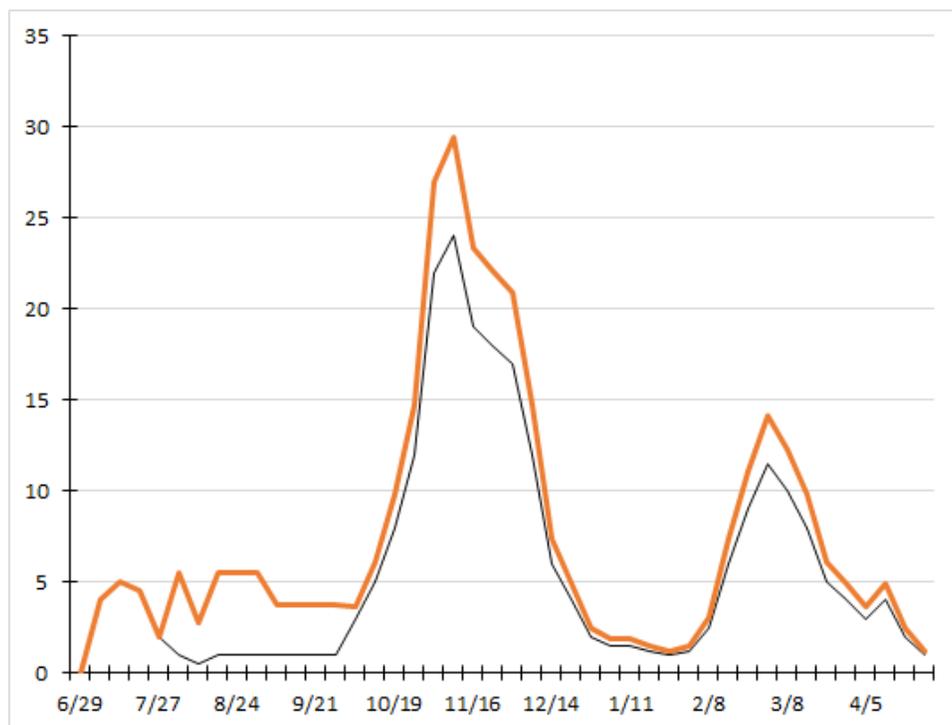


Figure 2 - 2020 COVID-19 Disaster Prediction Assumption 1

The high plateau is the new infection starting point. [[spreadsheet 2020-1](#)]
This could be attributed to higher population and the massive shift to non-rural living.
Based on Data up to November 01, 2020

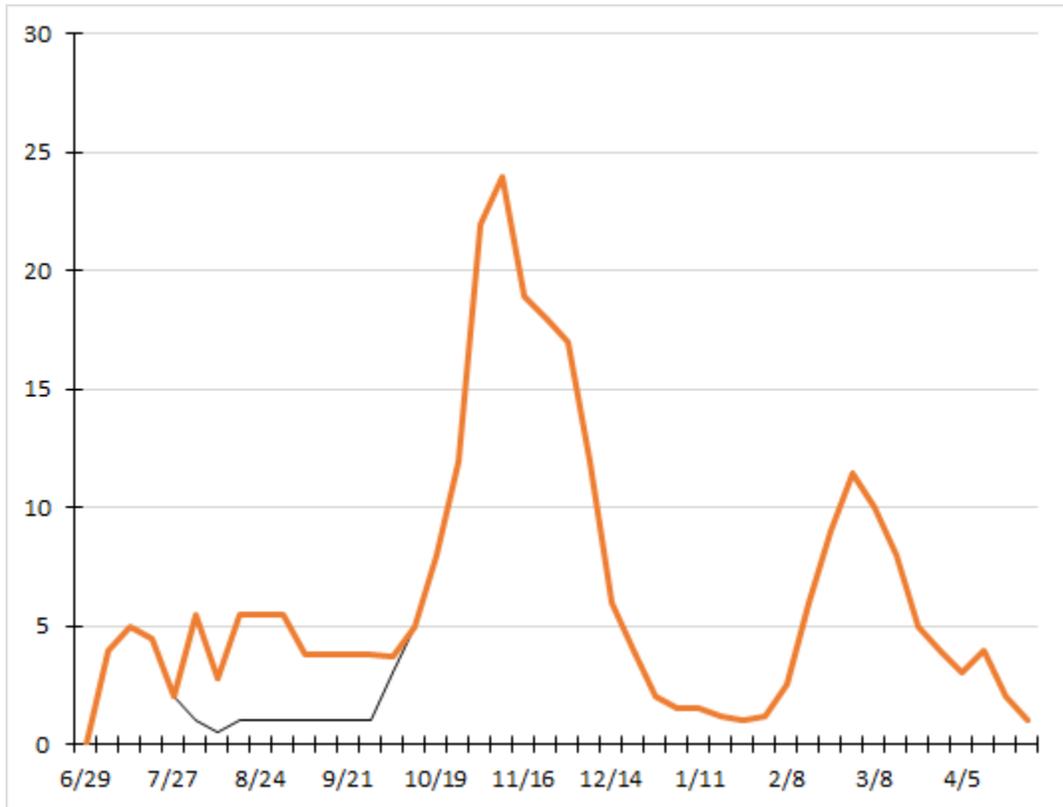


Figure 3 - 2020 COVID-19 Disaster Prediction Assumption 2

The high plateau is ignored and the trend is just followed. [[spreadsheet 2020-2](#)]
This could be attributed to air conditioned indoor settings in the summer.
Based on Data up to November 01, 2020

In both cases the death rates are horrific and unacceptable given that this is the 21st century and we know much more than people knew in 1918.

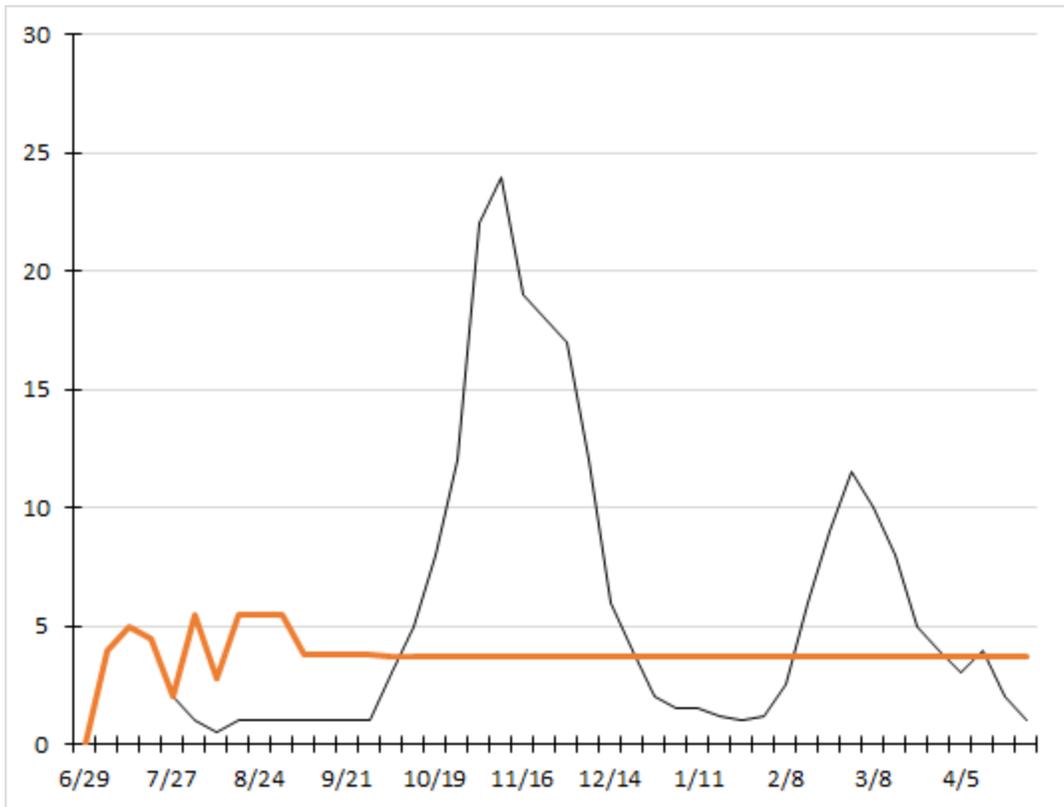


Figure 4 - 2020 COVID-19 Disaster Prediction Assumption 3

The 1918 trend is ignored, stability has been reached. [[spreadsheet 2020-3](#)]
 Schools opened windows closed for the winter in 1918 !!!
 But in 2020 there are modern forced air heating systems that may be better than 1918.
 Based on Data up to November 01, 2020

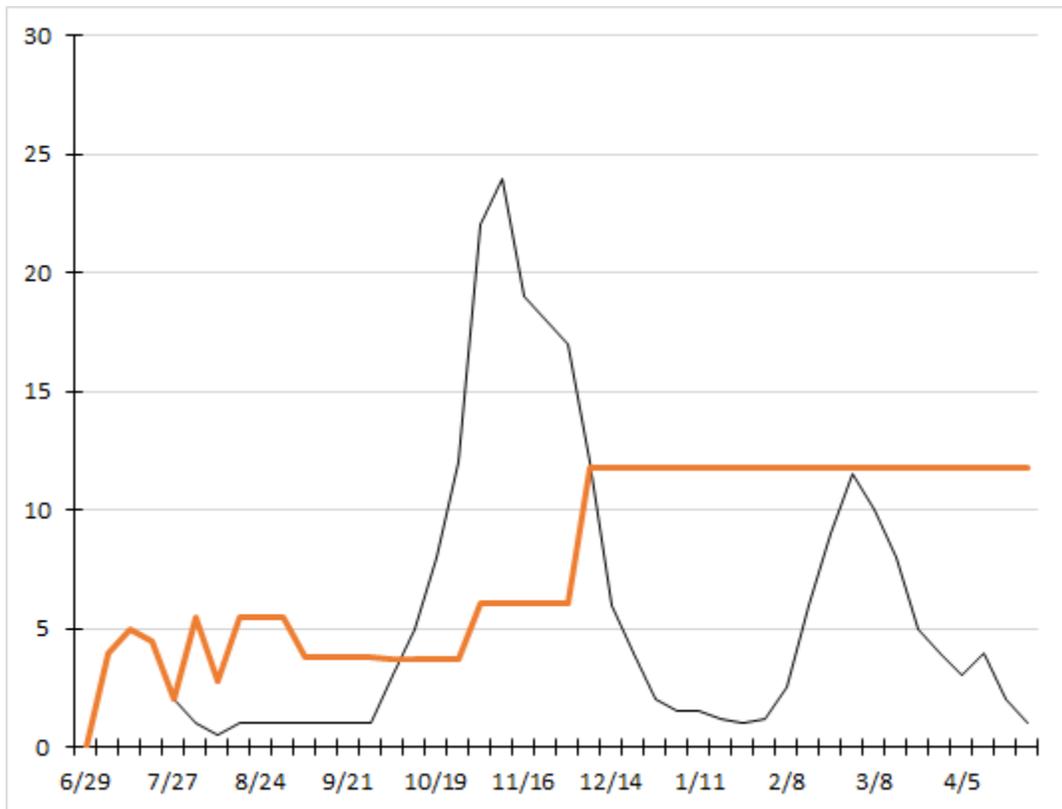
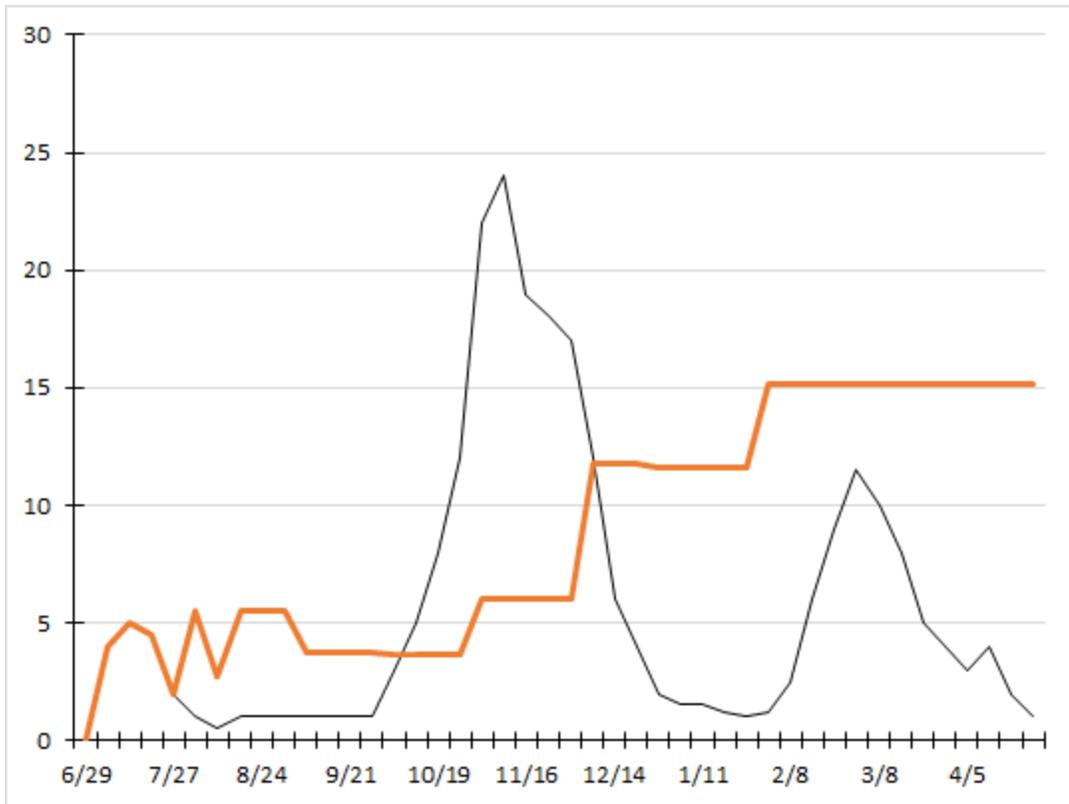


Figure 5 - 2020 COVID-19 Disaster

Stability ignored, massive political pressure to open in October 2020.
 Some schools opened physical classes that started later than normal in 2020 !!!
 Thanksgiving Holiday travel via airplanes and airports 2020 !!!
 Based on Data up to December 10, 2020

COVID-19 Not Following 1918 Trend

The COVID-19 disaster is not following the 1918 trend. This is a bad turn of events. Either we failed to have a return to life system that was as good or better than the 1918 system or something is very different. The difference might be associated with the nature of the virus or the change in our life styles. In 1918 a large portion of the US population was still agrarian not living and working in cities.



The COVID-19 disaster is not following the 1918 trend.
Based on Data up to February 01, 2021

Figure 6 2021 COVID-19 Disaster Departs 1918 Trend

The results are as follows [[spreadsheet](#) 2020-1 to 3]:

Table 1 - 2020 COVID-19 Disaster Prediction Assumptions 1 to 3 Results

| Scenario | Total Deaths (Jan 2021) | Total Deaths (May 2021) | Total Deaths (August 2021) | Based on Data up to | Comment |
|-------------------------------------|-------------------------|-------------------------|----------------------------|---------------------|--|
| Assumption 1: New starting point | 475,678 | 603,928 | - | Nov 01, 2020 | Hospitals will be overwhelmed |
| Assumption 1: New starting point | 289,102 | 344,107 | - | Dec 01, 2020 | Infections are significantly up in November Deaths lag infections |
| Assumption 1: New starting point | 305,252 | 407,794 | - | Dec 10, 2020 | Hospitals will be overwhelmed Starting to see the effects of air travel during Thanksgiving |

| Scenario | Total Deaths (Jan 2021) | Total Deaths (May 2021) | Total Deaths (August 2021) | Based on Data up to | Comment |
|------------------------------------|-------------------------|-------------------------|----------------------------|---------------------|--|
| | | | | | Holiday |
| Assumption 2: Follow 1918 trend | 426,359 | 530,644 | - | Nov 01, 2020 | Hospitals will be overwhelmed |
| Assumption 3: Constant rate | 275,555 | 365,905 | | Nov 01, 2020 | Still tragic and the disaster continues until herd immunity is reached |
| Assumption 3: Constant rate | 306,218 | 454,487 | - | Dec 01, 2020 | Hospitals will be overwhelmed |
| Assumption 3: Constant rate | 339,302 | 628,178 | 866,052 | Dec 10, 2020 | Hospitals will be overwhelmed Starting to see the effects of air travel during Thanksgiving Holiday |
| Assumption 3: Constant rate | - | 690,023 | 996,147 | Feb 01, 2021 | New virus strains appear in US |
| Assumption 3: Constant rate | - | 660,098 | 919,672 | Mar 01, 2021 | Holiday travel done, vaccinations started |

As far as differences in the behavior of the people, it is probably the same, however the root cause of the behavior is probably different. In 1918 people were ignorant of the science that would eventually become standard health care in the coming century. They just did not know through no fault of their own. In 2020 the people had access to all the knowledge and technologies from the previous century and many decided to reject that knowledge and the technologies. They consciously decided to remain ignorant. I call these people stupid because you can't fix stupid.

In 1918 it is possible that the people were not stupid, just ignorant, and once they learned about the science they respected the findings and did what was needed. In other words there were fewer stupid people in 1918. When I refer to the people I am not just talking about the masses, I am primarily referring to the leaders in the society especially government, higher education institutions especially engineering schools, local school boards, some companies, ministries, most small business owners, home owner associations with club houses, etc. because they significantly influenced the stupid masses to follow their toxic internal agendas. It was not enough for engineering schools to have their faculty publish their research on UV and HVAC systems. They should have implemented those findings in their classrooms, dorms, and other

campus facilities. For example there are small business owners and home owner associations installing UV systems and upgrading their HVAC systems.

Some are contacting industry and finding that elite facilities and hospitals are using proven UV and HVAC technology to maintain their facilities clean and safe. This includes intelligent people associated with small businesses like restaurants [8] [9] [10] [11], home owners associations with club houses [12] [13], homeless shelters [14], and school systems [15] [16]. The problem is they are in the minority and because of that simple fact the COVID-19 disaster will be significantly prolonged. Only government action can change this sad simple fact.

COVID-19 Predictions

Unfortunately there is additional analysis suggesting that the COVID-19 disaster will not end like the 1918 flu because the population is significantly larger. This means it will take longer for herd immunity to be reached than in 1918 and many people will be infected by the virus with long term health impacts or loss of life [2]. That is why a vaccine is critical. The vaccine will quickly increase the herd immunity without leading to significant loss of life or health to those that are vaccinated. If there is a vaccine these are the possible results [[spreadsheet](#) Vaccine].

Table 2 - Vaccination Results

| Population | Naturally Immune % | Vaccine Effectiveness % | Vaccinated % | Exposed Population | Deaths @ 2% | Deaths @ 3% | Deaths @ 3.5% | Comment |
|-------------|--------------------|-------------------------|--------------|--------------------|----------------|-------------|-------------------|--|
| 328,000,000 | 10% | 70% | 70% | 134,480,000 | 2,689,600 | 4,034,400 | 4,706,800 | Likely vaccine result with some natural immunity |
| 328,000,000 | 10% | 90% | 90% | 29,520,000 | 590,400 | 885,600 | 1,033,200 | Unlikely vaccine result with some natural immunity |
| 328,000,000 | 0% | 70% | 70% | 167,280,000 | 3,345,600 | 5,018,400 | 5,854,800 | Likely vaccine result with no natural immunity |
| 328,000,000 | 0% | 90% | 90% | 62,320,000 | 1,246,400 | 1,869,600 | 2,181,200 | Unlikely vaccine result with no natural immunity |
| | | | | | | | | |
| 328,000,000 | 0% | 0% | 0% | 328,000,000 | 6,560,000 | 9,840,000 | 11,480,000 | No vaccine, natural herd immunity |
| 328,000,000 | 10% | 0% | 0% | 295,200,000 | 5,904,000 | 8,856,000 | 10,332,000 | No vaccine, natural herd immunity |

Notes:

1. The herd immunity death rate without a vaccine is extremely high. See section [Vaccine Systems Perspective](#).
2. Further in the analysis there are tables showing the impacts associated with UV systems and upgrading HVAC systems.

Directly Related External Research - [COVID19 Trend Analysis Case Study](#)

Everyone is referring to COVID-19 as a pandemic [3]. From a systems perspective it is a disaster because it did not need to happen and it did not need to get out of control. We had the expertise and the tools but we failed as a people [4] [5] [6]. This may be one of the greatest failures in human history and once the world eventually overcomes this disaster almost every institution will be changed especially in the US.

The mass media provided some insight into the process at the White House. The experts provided the science and data in terms that were very easy to understand. President Trump understood the information. Why the President provided a different message than the findings presented at the briefings is a mystery. Instead the President provided the wrong message to the people basically undermining all the findings. What is also a mystery is why the White House staff responsible for implementing policy implemented policy that was counter to the briefings presented by the experts. The briefings included: where we were, where we are, and the possible scenarios moving forward. Simple examples like wearing a mask, social distance of 6 feet or more, and telework especially if you are in the vulnerable category were all undermined. As a result people died needlessly [4] [5] [6] [7]. The disclosures also included:

- Political pressure and dynamics on the doctors and the task force from various senior political figures in the west wing that implement policy
 - Doctors struggled with a hard challenging dynamic to develop critical guidelines and documents, such as from the CDC
 - Doctors were bullied, when they stood their ground they were not at the press briefing the next day because it was not in line with the message
- Doctors and top scientists were undermined
 - By senior level staff at the White House who make decisions for the President and Vice President and advise them significantly
 - By entities within the White House such as OMB and the regulatory affairs office internally
 - Documents were watered down by management and top scientists did not agree with the changes
 - The White House was trying to ensure that whatever message was coming out was either for a voting block or some other concerns
 - The White House was in a hurry to open up the country because they were in denial of what was happening
 - The President was saying that we have to fit the findings to his message

This is not 1918. This is 2020. We have massive technology and industrial capacity. That technology and industrial capacity needs to be put to work to stop this disaster from unfolding. A vaccine, social distancing and masks are all reasonable approaches from 1918. However in 2020 we know and can do much more. Why haven't we started?

From this analysis:

1. We know this virus is partially airborne
2. We know that we can live safely outdoors by just social distancing
3. We also know that we have a serious problem with small indoor spaces such as classrooms, bars, restaurants, small retail shops, small offices
4. We also know that large indoor spaces are significantly less risk, but still dangerous
5. We know that upgrading our buildings will make our indoor spaces safe again, it is just a matter of money and policy

The choice is simple. We either go to work and start applying our technology and engineering to transform our indoor spaces or we watch people die as we live in fear for years moving forward. Read this analysis. Look at the proposed legislation. Hold all people in positions of authority accountable. It is your / our life!

The following is an excerpt [16]:

November 10, 2020. ROCK HILL, SC.

The Chester County School District announced in October that they would use ultraviolet lights to help fight the spread of COVID-19. Lewisville Elementary, in Richburg, will be the first in the district to use this technology -- and one of the first in the nation, said district Public Information Officer Chris Christoff.

"We're extremely honored to be among the first to utilize this technology," said Chester County School District Superintendent Antwon Sutton at the time. "We've chosen Lewisville Elementary based on the fact that elementary schools have been identified as more high risk when it comes to exposure."

The technology is already being installed, and the district anticipates completion this month, Christoff said.

Is UV technology safe? Will it be effective? Here's what The Herald found out.

*The lights being used in Chester are called Germicidal Ultraviolet lights, also known as GUV. They will use 254 UV-C light -- 254 being the wavelength. There will be some overhead GUV lights installed throughout the schools, Christoff said. The units, provided by **NetZero USA**, also will include hand-held units, which will be used to disinfect classrooms and surfaces*

GUV of this type is not new technology. Articles on GUV date back to 1947 -- when it was used in a school outside of Philadelphia.

The effectiveness of GUV has been proven. A study done in South Africa, which was published in the U.S. Library of Medicine, states: "Upper room germicidal UV air disinfection with air mixing was highly effective in reducing tuberculosis transmission under hospital conditions." Edward Nardell, a doctor and professor of medicine at Harvard Medical School, contributed to the study. He said it proved "80% efficacy," in stopping the spread of tuberculosis.

GUV does work on COVID-19, the virus caused by the novel coronavirus. It disinfects by destroying the virus in the air. "UV works on every single kind of pathogen there is. It works on COVID," Nardell said.

The reason this technology seems new to us is that it has not been necessary for a while. Since studies in the 1940s, which focused on stopping the spread of measles, the U.S. hasn't needed this technology, Nardell said. Schools that are implementing this technology during the coronavirus pandemic are among the first to use UV light in decades.

GUV is safe as long as it is installed properly. Ceiling fans and proper ventilation are important, Nardell said. He recommends that any school installing this program has an outside professional -- someone who has no stake in the game -- come and check that the system is installed correctly before they turn it on.

If the above guidelines are followed, students will not experience side effects. “There’s not much we don’t know,” Nardell said. “It doesn’t cause skin cancer, it doesn’t cause cataracts, it can’t even give you a good sunburn.” It can cause irritation of the skin and eyes; the eyes are the most sensitive. If students are complaining of eye irritation, Nardell said, the system has not been properly installed.

Other schools are currently using this technology. Cambridge Friend’s School in Cambridge, Mass., installed Upper Room GUV lights (GUV light installed in the ceiling) earlier this year.

It won’t necessarily control the spread of coronavirus, unless exposure is strictly unlimited. In past studies, like the one in Philadelphia, the technology wasn’t effective in stopping the spread of disease because children rode the bus after school. Without the GUV technology, the disease (measles in their case) was quickly spread in other environments. Unless children are being strictly isolated outside of school, they will still be susceptible to the virus, Nardell said. The study in South Africa showed more effectiveness because it took place in hospital conditions where patients were strictly isolated.

It should be most helpful to teachers, who don’t mingle with students outside of school. “You may not protect every kid from this, if they’re touching and in close contact, but you could certainly protect your teachers,” Nardell said.

The big question is what have all organizations done to make everyone more safe from the COVID-19 disaster in 2020 and what will happen in 2021? Will the stupid continue to prevail?

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Quick Summary

There are many stakeholder views that have been offered to society on the COVID-19 disaster as of May 2020 except for the Engineering Stakeholder. This analysis adds the engineering perspective to the current set of stakeholders. Stakeholders not offered in this analysis are those in denial and those focused strictly on making money by returning to the days before the disaster. They are an example of stakeholders that must be removed from the discussion because it is impossible to develop a solution with them at the stakeholder table.

The engineering perspective on the COVID-19 disaster begins with examining the current system space. The stakeholder needs of the people are reasonable and must be met. Healthcare stakeholders are using a 14th century approach to deal with the crisis when they focus on masks and social distancing. Healthcare stakeholders are also relying on a cure or disease management both of which are years away. The Engineering stakeholders were not even at the table as of May 2020 except in support of the healthcare stakeholders. By August 2020 there was some movement on the ventilation engineering perspective but at an extreme management damage control distance. No numbers and actionable solutions have been provided as part of official guidance. Only statements of increasing ventilation have been provided.

Today we rely on our physical structures to live. This means that the physical structures must somehow reduce the concentration or eliminate viruses. During the energy crisis of the 1970's all HVAC systems were modified to reduce the amount of external air to reduce the amount of fuel consumption. This eventually translated to dollars and today there is a heavy emphasis to reduce HVAC airflow because of costs. This must change immediately. The airflow in all buildings must be massively increased. The air must be subjected to proper filtration and when possible to massive amounts of UV-C that will destroy viruses and bacteria. Once these measures are attempted, they need to be tested in lab settings to see if they work and then tuned to get the maximum benefit without compromise. Specifications then need to be developed for HVAC systems for every type of building setting. Proposed legislation text has been provided as part

of this analysis. The same applies to all the engineering solutions offered in all the proposed Decontamination Architectures.

All aircraft and cruise ships must have their HVAC systems tested for virus containment and social distancing must be maintained. The assumption is that these HVAC systems are safe but that may not be the case. This system engineering analysis suggests that the initial virus spread was because of the poor HVAC systems and extremely close social distances of 1 foot on both cruise ships and airplanes. The materials used in these transportation systems also might be suspect. If that is the case, changing these materials will be problematic and similar to what the healthcare stakeholders are doing as they pursue a cure. It is years away. There may be a protocol based on decontamination that may help to reduce the concentration or eliminate the virus. Once again tests need to be performed under controlled lab conditions and then specifications developed for proper system management. Proposed legislation text has been provided as part of this analysis.

Even though massive resources are being applied to develop a successful vaccine, it is clear from a systems perspective that the vaccine will not immediately stop the pandemic. In the best case scenario there is a successful vaccine but it will take 2 or more years for the virus to be removed. In the worst case no vaccine is found. In the middle case there is a vaccine but it will not be 100% effective. This will lengthen the time for the virus to be removed from 2 years to perhaps decades matching what occurred with other efforts to eradicate diseases via vaccination.

Building ventilation is the one area where changes can be quickly implemented and have a direct effect on minimizing or perhaps even stopping the spread of the virus. There has been evidence that our buildings have been spreading illness for decades after the energy crisis when the building ventilation systems reduced the ventilation rates to save on energy costs. Fortunately there were few life threatening diseases that were partially airborne. Mold has been found in HVAC systems causing allergic reactions and people would get sick with the flu or the cold and just complain about the poor air in buildings. Now there is a virus that kills and the ventilation systems of small spaces (e.g. classrooms, restaurants, small office buildings) must be modified because the risk of infection is very high. The large indoor spaces (e.g. big box stores, large office buildings) also must have their ventilation systems modified even though the risk of infection is lower. There also needs to be proper guidance given to people who have a COVID-19 family member in the home. Opening the windows is insufficient and the ventilation must be mechanically augmented with window and or whole house fans. Empirical data from ground transportation systems shows that there is almost no risk of COVID-19 infection. Using the disclosed ventilation rates of ground transportation systems, the same analysis used for buildings was applied to the ground transportation. The ground transportation results confirmed the models and added confidence to the analysis performed on large and small indoor spaces and outdoor venues. It is because of these results that these recommendations are being restated and emphasized.

As of August 2020 we see that most management in the US has ignored human behavior and structured systems that do not account for failures because of non-compliant human behavior. For example, not all people will wear masks, but more importantly people that will wear masks are unable to wear them 100% of the time. The analysis clearly shows that just 1 hour of not wearing a mask in a small indoor space with inadequate ventilation, such as during a meal or an 8 hour work shift will lead to infection. Management has failed to communicate the differences between small indoor spaces, large indoor spaces, and outside venues. Applying the same

approach to these radically different settings is completely inappropriate and has caused the disaster to get worse.

In 3 years all public buildings will be updated in some way because the virus is now in the environment. The worldwide pandemic will end eventually, then the local US epidemic will end, but people will continue to get sick and die from this virus for decades even with the vaccine. This virus was not contained, it is out, so we do not know what the future holds for other strains and infections.

Updating public buildings much like happened in the 1940's, 50s, and 60s will happen in this new century. This generation will relearn what was old knowledge in the past. People don't know that forced air heating was introduced to provide for a healthier environment. They don't know the ceiling level UV lights were found everywhere in bars, restaurants, public restrooms and that you could go to a local store and buy them for your small business for \$25. They don't know that 2 generations ago people needed to figure out how to keep someone alive on an airplane flying above 15,000 feet and that knowledge was used to develop the modern HVAC systems. They also don't know what happened during the energy crisis and how the HVAC systems were changed and became problematic. Finally because everyone became very healthy by the 1970s all the UV lights were thrown away.

As far as the legal approach of having people sign release documents - it will not protect anyone from infection, loss of health, or death. If there is an event, it shows there was no due diligence to provide a safe public space and the release document at that point is useless. To even consider such actions shows a severe decline in the civilization and no systems perspective.

Current and Future Virus Eradication Findings

This systems engineering analysis began on April 14, 2020 and on November 22, 2020 a major connection was made on how the virus might be eradicated. As in most complex system solutions there is no one single approach that will work. The world has been waiting for a vaccine but in order to eradicate the virus traditional engineering must be applied to update the infrastructure. The following table illustrates this finding.

Table 3 - System To Eradicate Current and Future Viruses

| Naturally Immune | Vaccine Effectiveness | Vaccinated | Exposed Population Starting with 328 million | Deaths @ 2% | Deaths @ 3% | Deaths @ 3.5% | UV-C or FAR UV-222 Kill / Inactivate | Deaths @ 3.5% (With UV) | Ventilation Effectiveness 4 AUC | Deaths @ 3.5% (With UV + Ventilation) |
|------------------|-----------------------|------------|--|------------------|-------------|-------------------|--------------------------------------|-------------------------|---------------------------------|---------------------------------------|
| 10% | 70% | 70% | 150,552,000 | 3,011,040 | 4,516,560 | 5,269,320 | 90% | 526,932 | 28% | 379,391 |
| 10% | 90% | 90% | 56,088,000 | 1,121,760 | 1,682,640 | 1,963,080 | 90% | 196,308 | 28% | 141,342 |
| 0% | 70% | 70% | 167,280,000 | 3,345,600 | 5,018,400 | 5,854,800 | 90% | 585,480 | 28% | 421,546 |
| 0% | 90% | 90% | 62,320,000 | 1,246,400 | 1,869,600 | 2,181,200 | 90% | 218,120 | 28% | 157,046 |
| . | . | . | . | . | . | . | . | . | . | . |
| 0% | 0% | 0% | 328,000,000 | 6,560,000 | 9,840,000 | 11,480,000 | 90% | 1,148,000 | 28% | 826,560 |
| 10% | 0% | 0% | 295,200,000 | 5,904,000 | 8,856,000 | 10,332,000 | 90% | 1,033,200 | 28% | 743,904 |

Note: Ventilation works only when it is turned on. The HVAC fan(s) must run 1 hour before and 1 hour after the facility opens to the public.

This table shows that all three approaches of Vaccine, UV, and Ventilation are needed to eradicate the virus. Since the virus is airborne and the risk of outside infection is very small, the UV approach is more effective than the vaccine approach, if done alone. However, as of November 2020, it appears that there will be a viable vaccine. The current systems problem is ensuring that Vaccine, UV, and Ventilation subsystems are rolled out as soon as possible. If we just rely on the vaccine those that do not develop immunity and those that are not vaccinated will continue to be at risk and spread the virus. Relying on just the vaccine will lead to more death / loss of health, increase the time to eradicate the virus, and it will also fail to protect us against future viruses.

Once the vaccine is available this system will exist in most hospitals, some homeless shelters, and many elite buildings because they currently have UV and very effective ventilation systems. The trick is to ensure that this system will exist in all schools, small public buildings like restaurants, bars, retail shops, and in office buildings. The cost to roll out UV across the entire US infrastructure is in section [UV Infrastructure Cost Estimates](#). The analysis showing the history and effectiveness of UV is in Section [Ultraviolet Germicidal Irradiation \(UVGI\) - Open Air](#).

Once the vaccine is introduced it will take years for the virus to be eradicated. As other mitigation strategies are added to the system in the form of different subsystems the eradication time will decrease. The challenge is to determine the eradication time as each subsystem is added to the total system solution.

Table 4 - Virus Eradication Time

| Subsystem | Fully Implemented | Eradication Time |
|---|-------------------|------------------------|
| Vaccine acceptance & distribution with annual vaccinations until virus eradicated | 2 years | V years |
| UV Infrastructure | 1 year | V- UV years |
| Ventilation Recommendations | 1 month | V - UV - VR years |
| Ventilation Upgrades | 1 year | V - UV - VR - VU years |

It is possible that the virus will never be eradicated and instead the focus should be on the number of lives saved with the introduction of each subsystem. This takes the analysis back to the original presentation of lives saved with the use of Vaccine(s), UV, and Ventilation. What is not shown is treatment to improve outcomes.

At what point will herd immunity take effect and translate into stopping the pandemic. Because this virus is so contagious it is likely the herd immunity number will be very high. The following table shows different herd immunity levels and estimates for COVID-19 [1].

Table 5 - Various Disease Herd Immunity Levels

| Disease | Transmission | R0 | HIT or HIL | Comment |
|---|------------------|-------------|------------|---|
| Measles | Airborne | 12-18 | 92-95% | Previous epidemics. |
| Pertussis | Airborne droplet | 12-17 | 92-94% | Previous epidemics. |
| Diphtheria | Saliva | 6-7 | 83-86% | Previous epidemics. |
| Rubella | Airborne droplet | 6-7 | 83-86% | Previous epidemics. |
| Smallpox | Airborne droplet | 5-7 | 80-86% | Previous epidemics. |
| Polio | Fecal-oral route | 5-7 | 80-86% | Previous epidemics. |
| Mumps | Airborne droplet | 4-7 | 75-86% | Previous epidemics. |
| COVID-19 (COVID-19 pandemic) [A] [B] | Airborne droplet | 2.5-4 | 60-75% | These metrics (numbers) do not reflect that this became a massive pandemic. |
| SARS (2002-2004 SARS outbreak) [C] | Airborne droplet | 2-5 | 50-80% | Did not reach pandemic levels. Why? |
| Ebola (Ebola virus epidemic in West Africa) | Bodily fluids | 1.5-2.5 | 33-60% | Why was this contained? Was it because it was not airborne? |
| Influenza (influenza pandemics) | Airborne droplet | 1.5-1.8 [D] | 33-44% | This is a low R0 number yet there are flu pandemics. |

Herd Immunity Threshold (HIT) or Herd Immunity Level (HIL)

R0 basic reproduction number, the average number of new infections caused by each case

Eventually the COVID-19 herd immunity level will stabilize around a number that will be part of history. What is missing from the dialog is will the virus be eliminated even if the pandemic is stopped. The reality is the virus will not be eliminated [2]. All herd immunity suggests is that the rate of transmission will be sufficiently reduced to a level where it is not an epidemic or pandemic. However, people will continue to be infected unless they are naturally immune, they are vaccinated, or they are not exposed because of external factors such as being outside, or when indoors having a very disease safe environment using technology such as effective forced air HVAC systems and or UV systems.

If we fail to contain this disaster the impact is in section [Life Expectancy](#).

So why did it take this long to reach this conclusion?

▼ **April 2020:** From the start of this disaster we were told that this was not an airborne contagion. This analysis like many others went down the path of decontamination.

▼ **May 2020:** Elements about the virus behavior were not making sense. This analysis started to go down the path of ventilation and impacts on airborne virus decontamination.

▼ **June 2020:** This analysis indicated that the virus spread was not initially impacting poor communities and that countries with populations that tend to live outside were having less impact from the virus. This analysis provided numbers on the effects of airborne indoor and outside virus transmission and made connections to empirical data. This was very difficult because the official position was that the virus did not have an airborne element.

▼ **July 2020:** This analysis developed and provided proposed legislation for the US Government to investigate ventilation and UV and roll out solutions to all public schools. It included budget estimates and performance time frames.

▼ **October 2020:** The airborne transmission element of the virus was publicly acknowledged. This analysis was delayed in performing detailed UV analysis until that acknowledgement permeated the social consciousness. Prior to that time this analysis provided high level analysis of UV as part of the Ventilation analysis. This analysis was waiting for organizations chartered with dealing with this disaster to move forward.

▼ **November 2020:** Between October and November the UV analysis was matured and the findings were published. It was clear in June 2020 that it was time to develop the UV analysis, instead proposed legislation was offered in July 2020. That is a loss of 4 months.

▼ **November 22, 2020:** The connection was made and the numbers published showing that the vaccine is not enough to contain the virus in a reasonable time. The solution must include UV and ventilation infrastructure upgrades.

Author Comment: It took this long to reach this conclusion because critical information was suppressed and this led to false paths that delayed the findings. The root cause is compromised management and disregard for the systems perspective.

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[B] Herd Immunity: Understanding COVID-19, University of Chicago, May 19, 2020. National Institute of Health (NIH), US Government. webpage <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7236739/pdf/main.pdf>, November 2020. [Herd Immunity: Understanding COVID-19](#) . local

[C] Different Epidemic Curves for Severe Acute Respiratory Syndrome Reveal Similar Impacts of Control Measures, National Institute for Public Health and the Environment, Bilthoven, the Netherlands, March 29, 2004. National Institute of Health (NIH), US Government. webpage <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7110200/pdf/kwh255.pdf>, November 2020. [Different Epidemic Curves for Severe Acute Respiratory Syndrome Reveal Similar Impacts of Control Measures](#) . local

Properly Opening Schools and Other Public Buildings

03/01/21

These are some key extracts directly from the new CDC Guidance:

1. This is the link to the new CDC guidance on Opening Schools and UV: <https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html>.
2. The CDC guidance now has research results and numbers that are found in this systems analysis.
3. Consider using ultraviolet germicidal irradiation (UVGI) as a supplement to help inactivate SARS-CoV-2, especially if options for increasing room ventilation are limited.
4. \$1500 (approximately): adding upper room UVGI
5. Germicidal Ultraviolet (GUV), or Ultraviolet Germicidal Irradiation (UVGI), is a disinfection tool used in many different settings, such as residential, commercial, educational, and healthcare. The technology uses ultraviolet (UV) energy to inactivate (kill) microorganisms, including viruses, when designed and installed correctly.
6. Upper-room (or upper-air) GUV uses specially designed GUV fixtures mounted on walls or ceilings to create a disinfection zone of ultraviolet (UV) energy that is focused up and away from people. These fixtures disinfect air as it circulates from mechanical ventilation, ceiling fans, or natural air movement.
7. Can be used in any indoor environment; most useful in spaces highly occupied with people who are or may be sick.
8. Far-UV is one of many emerging technologies that have become popular during the COVID-19 pandemic. While standard GUV fixtures emit UV energy at a wavelength around 254 nanometers (nm), far-UV devices use different lamps to emit UV energy at a wavelength around 222 nm.
9. A major difference between the two technologies is that standard GUV systems are specifically designed to avoid exposing people to the UV energy, while many far-UV devices are marketed as safe for exposing people and their direct environment to UV energy. A review of peer-reviewed literature indicates that far-UV wavelengths can effectively inactivate microorganisms, including human coronaviruses, when appropriate UV doses are applied.
10. There is now ammunition that can be used to update the schools and other small public spaces.

More ventilation is NOT the appropriate response.

1. By January 2021 many are wondering what the school ventilation requirements should be to safely open and resume semi normal operations.
2. The appropriate response is specific numbers known as performance requirements understood by engineers, HVAC, and contagious disease specialists in the industry.
3. Once the public is educated then they will also understand the numbers and why they are so important to their safety and health.
4. The only reason the ventilation story broke is because of this systems approach to the research.
 1. Engineers and scientists were signing letters and petitions but they were being ignored because they did not disclose the numbers. The reason they did not disclose numbers is because the numbers are stamped proprietary, they have professional licensees, and they signed non-disclosure agreements because that is what is required in that industry.
 2. This research is based on systems analysis with no industry ties so it was able to disclose and publish the numbers. The numbers are derived using very basic engineering principles and 5th grade math so they can't be dismissed.
 3. Within 24 hours of publishing the numbers, which included small indoor, large indoor, and outside spaces in different scenarios, the story broke in the popular media. Rather than disclose the numbers the term more ventilation was released to the public, whatever that means.
5. This research offers proposed legislation to determine the final numbers and then provides the required budget to do the research to confirm or change the numbers found in this research and then update all the schools. The legislation identified \$100 billion to update all the schools.
6. So this is where we are and that is about the amount of money in the proposed President Biden's American Rescue Plan of 2021 for schools.
7. Now the next step is to make sure the money is not squandered and the proper engineering is performed, even though the public is still in the dark of what is required.

So what is the proper engineering?

1. The basic terms that are used for ventilation are air update changes per hour.
2. Industry uses AUC (air update changes) or ACH (air changes per hour).
3. There are subtle differences where one represents fresh air and one represents filtered air but for this research and analysis they are interchangeable because the filtered air is like the fresh air from a virus perspective. It is a reasonable assumption that the filtration works and the air is clean. This research uses AUC in most of the analysis report.
4. Some of the AUC numbers are:
 1. 25 Hospital operating room
 2. 4 typical house but only if the fans runs 24/7, if HVAC is not running then it is 0
 3. 1 typical classroom today, it is supposed to be 4
 4. 120 typical bar in the 1960's and 1970's when exhaust fans ran
 5. 20-30 ground transportation
 6. 50 -100 what is recommended in this report to stop infection in a small space

So now the problem surfaces, proper engineering gets in the way of costs:

1. The HVAC systems need to go from 1 to 25 AUC, the operating costs will increase, perhaps not the full 25 times, but probably 10 times if only the HVAC system is used.

2. This research suggests numbers need to be 50 - 100 AUC. Until the research in the proposed legislation is performed that is the official unofficial number.
3. This research found that the AUC number was lost to history and it is probably at least 50 years old, until now, and it explains a typical bar from 50+ years ago.

So what can be done?

1. Outside of eliminating the contagion, moving classrooms outside, or opening many windows, the alternative is to use ceiling level UV-C fixtures that were used in the last century.
2. The ceiling level UV-C is a ventilation system and it can offer an eAUC of up to 24.
3. Today there is new technology called Far UV-222 that is an alternative and makes life easier in the long term.
4. Far UV-222 may offer an eAUC from 50 - 100 if carefully designed.
5. So the solution is to use these UV systems + upgraded HVAC systems.
6. The HVAC systems need to be bought up to 6 AUC.
7. In most cases this is just a minor HVAC fan upgrade, assuming it is a modern HVAC system (last 50 years).
8. So the total AUC can be from $24+6 = 30$ to as high as 106. That is the answer.
9. The tech is 80 years old and was used extensively in the last century and is in use today.
10. This analysis has shown that the costs associated with loss of life and or shutdown far outstrip the costs of upgrading the entire infrastructure using existing technology.

Is anyone doing this? Yes, facilities have already done this. These are some of the references from this research:

1. Margate condo first in state to install ultraviolet light sanitizing technology, they say, Press Of Atlantic City, September 09, 2020. webpage https://pressofatlanticcity.com/margate-condo-first-in-state-to-install-ultraviolet-light-sanitizing-technology-they-say/article_5c259798-7c35-5ad8-be85-e5b7a5838aa3.html, January 2021. [Margate condo first in state to install ultraviolet light sanitizing technology, they say](#)
2. Technology at the Forefront for Healthier High-Rise Buildings, The COVID-19 pandemic has real estate developers turning to new tech, like UV light treatments and touchless entrances, to create safer environments for residents, Mansion Global June 07, 2020. webpage <https://www.mansionglobal.com/articles/technology-at-the-forefront-for-healthier-high-rise-buildings-216579>, January 2021. [Technology at the Forefront for Healthier High-Rise Buildings](#)
3. UV lights, ozone cleaners, sanitizers help shelter keep homeless safe, Catholic News Service, June 16, 2020. webpage <https://angelusnews.com/news/nation/uv-lights-ozone-cleaners-sanitizers-help-shelter-keep-homeless-safe/>, January 2021. [UV lights, ozone cleaners, sanitizers help shelter keep homeless safe](#)
4. High school installs ultraviolet light system to keep students safe, WNNC, May 20, 2020. webpage <https://www.wncn.com/article/news/health/coronavirus/queens-grant-high-school-uv-light-system-coronavirus/275-c3e54672-905f-4fab-8e5f-8c58d5ca49f3>, January 2021. [High school installs ultraviolet light system to keep students safe](#)
5. Some SC schools to use ultraviolet light to fight coronavirus. A few things to know. The Herald November 10, 2020. webpage

<https://www.heraldonline.com/news/coronavirus/article247021112.html>, January 2021.
[Some SC schools to use ultraviolet light to fight coronavirus. A few things to know](#)

6. Meanwhile this research disclosed that Philadelphia Schools are proposing cheap fans mounted on wooden boards to be placed in windows and it is very sad. Make no mistake about it, they were contacted by at least a dozen HVAC /UV facilities vendors and 2 or 3 presented their proper engineering solutions, but management selected this approach.

You have to dig deep and protect yourself, family, friends, and community.

1. Don't think that the new administration will remove all the toxic self interest players that led to this disaster.
2. Leaders are still documenting and stating vague untestable requirements like increase ventilation.
3. The proper documentation and statements must disclose the proper performance requirements using numbers and then tell the public the costs.
4. This research is not going to try to get the leaders to educate the public and disclose the numbers.
5. If policy makers don't do the right thing there is nothing that can be done from a technical engineering perspective. It becomes a social problem.
6. Meanwhile a book will be published of this research sometime in early to mid 2021 and future generations will assess and judge.

Technical Systems Engineering Findings

The following is a quick summary of the rest of this system engineering analysis. The findings are out of sequence with the report content. All findings are of equal importance.

This systems analysis suggests that there is no single solution that will stop this virus, instead the virus mitigation system must include multiple complex and highly effective subsystems

1. Building, airplane, and other ventilation systems must be upgraded
2. The 80+ year old UV-C systems must be reintroduced on a massive scale
3. The new FAR UV-222 systems must be introduced on a massive scale
4. Contact tracing must become 100% with no time lag
5. Vaccines must be developed
6. Treatments must continue to be developed
7. It is time to begin counting and publishing not just infections and deaths but also long term health damage by categories
8. It is time to begin calculating and publishing the impact on life expectancy based on different scenarios of the virus presence in the next 20 years

Now that we have a deadly airborne virus we have to address HVAC systems standards and designs

1. Update all the HVAC design ventilation standards to make the buildings more safe
2. Realize that HVAC ventilation may not be enough and UV-C needs to be reintroduced especially in small public spaces
3. New technology like FAR UV-222 may significantly help

4. Developing standards using non-scientific and or non-engineering principles like comfort level is no longer an option
5. Standards were and always should be about safety first
6. Realize that modern HVAC systems in the last century were introduced to deal with sickness and infection spread, plus comfort
7. There was a time in the US when our HVAC systems reduced the spread of illness and significantly contributed to making a healthier population
8. Our modern HVAC systems were changed during the energy crisis in the last century and they started to spread disease rather than stop disease
9. Bottom line is existing building standards with COVID-19 are obsolete and they are making people sick and killing people
10. This research suggests we have no choice but to do this, there are no other options
11. The party is over, it is time to clean up the mess

The systems analysis suggests that classrooms and small spaces like restaurants must have effective ventilation and exhaust mechanisms [[spreadsheet](#)]

1. Multiple analysis approaches were used to come to this conclusion
2. According to a model using Well-Riley probability of infection in a classroom or restaurant the infection probability is between 75% and 99% with existing ventilation standards
3. Each school district must update their classrooms and validate each classroom using a test and evaluation program, a proposed generic design is offered for guidance
4. Each restaurant must update their facilities and validate it using a test and evaluation program, a proposed generic design is offered for guidance
5. Each outdoor classroom and restaurant must ensure proper ventilation or the infection rate is the same as indoors
6. Similar analysis for open outdoor venues with gentle winds and very large indoor facilities shows that life is possible without ventilation updates
7. As of July 2020 Governments are starting to change policies because of concerns that tiny droplets can carry SARS-CoV-2
8. This systems engineering analysis has identified recommended air update rates (see below)

The system boundary is too narrow.

1. Normally there is a system boundary analysis, but that is not needed here
2. The system boundary is not return to work, it is return to life
3. Work is only a small part of the society; do we live to work or do we work to live
4. Consider universities and colleges, schools, houses of worship, entertainment venues, travel, etc.
5. We need to be vigilant and ensure the system boundary is not descoped by those trying to game the system

The stakeholder needs are significant, grave, and must not be silenced with management talking points.

1. All stakeholders must be fully addressed

2. The solution must not be gamed to favor some stakeholders, now is not the time to engage in mass mind control
3. Ignoring the key stakeholders will cause people to die
4. Ignoring the key stakeholders will cause massive legal problems for businesses, colleges and universities, and other organizations
5. China provided a huge amount of important data and released it to the world in very succinct terms via a handbook

The root cause technical analysis is important when developing a return to life system. The technical root cause findings are unexpected.

1. No one is viewing the COVID-19 from a systems perspective
2. The initial COVID-19 spread mechanism traces to cruise ships and airplanes
3. Heating Ventilation and air conditioning systems need to be reexamined for disease control
4. Building materials need to be reexamined in terms of disease control

There are many decontamination approaches.

1. One approach that was previously ubiquitous was the use of ceiling level UV lights
2. UV lights are gone from the consumer industrial base
3. UV lights only exist and are used at the industrial level
4. Hydrogen peroxide spraying may become the norm for the next two years

The potential system solutions include decontamination tools used in broader architecture(s) solutions. [[spreadsheet](#)]

1. There are multiple decontamination tools that can be used
2. The decontamination tools are applied in a layered approach from least to most stringent
3. There are individual companies offering point products for decontamination
4. There are no companies that can offer a total system solution
5. Each user is on their own to develop and integrate a system solution
6. Decontamination includes protocols for protecting the safe space
7. Personal protocols for protecting personal (home) safe space are just as important as the non-personal space (restaurants, stores, dorms, hotels, workspaces, labs, etc.)
8. There are multiple potential architecture solutions that attempt to address all the return to life needs

The return to life systems were started the very first day of the virus outbreak. [[spreadsheet](#)]

1. Life continued as the virus spread
2. Various systems were developed across the planet and by May 2020 there may be sufficient data to determine which return to life systems are more effective
3. These systems are embedded in different countries and in some cases different states and provinces within various countries

As the data from different countries is examined patterns need to be identified. [[spreadsheet](#)]

1. It is easy to dismiss the data as being inaccurate

2. In a systems analysis we must assume the data has the same level of accuracy across all the data points
3. Instead there is a search for a pattern
4. The difference may be due to environment, genes, food, culture, virus mitigation action plan, or another element
5. We know that the environment is not a factor, temperature and humidity are not relevant
6. Some suggest genes may be the source however there are examples suggesting that is not the case when adjacent countries are examined
7. Food like genes can be discounted for the same reason, adjacent countries have significant differences
8. The remaining variables are culture and virus mitigation action plans
9. The data from the various countries led to significant engineering insights

This analysis does offer engineering based solutions to mitigate the spread of the virus.

[\[spreadsheet\]](#)

1. The CDC and WHO offer recommended air flow rates but they suggest that there is no analysis to find the rates needed to stop the spread of disease in a closed building
2. This systems engineering analysis provides recommended air flow rates needed to reduce the risk of infection
3. To work with the new air update rates UV-C lights must be placed into all public HVAC systems
4. Building air update rates must be significantly increased, it is no longer a comfort versus cost issue, it is a grave sickness spread issue
5. Natural ventilation and exhaust fans must be reintroduced into older buildings able to accommodate these systems
6. Just because a venue is outdoors it does not mean the air circulation is safe, it must be laid out and mechanically augmented with careful placement of fans
7. Airplanes must control and direct the air flow between passengers
8. Initial engineering suggests that it is possible to achieve the air flow rates suggested by this systems engineering analysis

This analysis suggests that the indoor ventilation rates in terms of Air Updates Per Hour (AUC) must be increased: [\[spreadsheet\]](#)

1. 20 - 030 AUC this is based on empirical data from ground transportation systems
2. 50 - 100 AUC this is based on various systems engineering paper analysis in this report
3. 120 AUC this is based on a brute force engineering approach for a small bar and restaurant circa 1960's and 1970's
4. As the AUC is increased the risk of infection is reduced, 20-30 AUC will lead to a 1% probability risk of infection rate, 120 AUC the risk approaches 0%

This analysis suggests that a Test and Evaluation effort be established to test various engineering based virus mitigation approaches.

1. Airplane Passenger Compartment Testing
 - o Determine the effectiveness of different air flow modifications in an airplane passenger compartment.
2. Enclosed Space Testing

- Determine the required HVAC airflow rates needed in buildings. Include HVAC the UV-C light levels and filter recommendations.
- 3. Outdoor Space Tent Testing
 - Simple placement of a few fans will significantly change the air exchange rate.
- 4. Outdoor Open Space Testing
 - Simple placement of a few fans will significantly change the air exchange rate.
- 5. Negative Pressure Vents Testing
 - Students at a desk and people at work are personal space situations similar to what is found on an airplane.
 - The same applies to restaurant tables and people waiting in a line with traditional physical walking boundaries.
- 6. National Lab Testing
 - The FAA Technical Center performed similar tests related to airplane fire mitigation in the late 1970's.
 - They have the facilities and capability to immediately ramp up to perform the world class engineering testing to potentially mitigate the spread of the virus.
- 7. Other Engineering Testing
 - Ideas will come.
 - Everyone should be encouraged to perform their own engineering tests and publish their results.

This analysis suggests that the US fails to perform effective contact tracing. Effective contact tracing must:

1. Contact everyone that has been in 1st (100%) and some percentage of 2d, and perhaps 3d degree contact with an infected person
2. Ensure that quarantine is not being violated by daily follow up contacts
3. Ensure that the needs of the people in quarantine are fully addressed (e.g. food, medication, selected services).
4. Provide a citizen friendly website with a map of previous 14 day COVID-19 hotspots so that people know to get tested as soon as possible
5. This can all be done with a single citizen friendly US Government website

Non-Technical Findings - US Government Policy

Key requirements to fix the system.

1. Accept that the system has collapsed
2. The COVID-19 disaster is a symptom not a cause
3. It needs to be fixed to have a safe and effective Return to Life system
4. The cracks in the system were visible for decades
5. Current approaches to correct the system are not working

There is a broader root cause analysis that includes analysis of the US government and its transformation as part of privatization

1. Privatization has changed the role of government
2. The government is hands off and relies on the market to solve problems
3. The government does not marshal resources like in the pre-1980's era

4. No one realizes the system of government has changed, even elected officials

There is a harsh and unfortunate finding.

1. There is no question that after 1945 the US led the world in dealing with massive crisis situations and the world became dependent on the US
2. Is it possible that because of the poor US response when COVID-19 first surfaced that the rest of the world was late to deal with this terrible event
3. Would it have been contained early if the US had a different attitude and policy towards threats like COVID-19
4. History will figure that out, but my guess is that it will be a very harsh accounting
5. Just like the states depended on the Federal Government to detect and marshal resources, the world depended on the US to detect and alert the world to the threat

We are in bigger trouble than we realize because we have a fundamental structural problem in our system that surfaced with privatization of government beginning in the 1980's.

1. The Federal Government is not the same government that we were born into and learned about in school
2. It has been transformed into something else and no one is aware of it, not even the people who are doing massive damage
3. This is a terrifying example of unintended system consequences
4. We can study this further but that will only delay actions that need to happen immediately, we can let history decide
5. It is clear that something has shut down the Federal Government and it needs to be restarted
6. The State Governments are attempting to do this in realtime
7. Meanwhile a return to life system needs to be developed everywhere and this will require our best and brightest to be at the table to make the right decisions and direct proper actions

Special note see section [Second Wave Accountability](#).

1. It is clear as of December 12, 2020 that there is a massive second wave in the US.
2. We have the science and engineering that could have avoided this second wave.
3. Those in positions of authority made the wrong choices.
4. It is time for accountability to be documented.

Stakeholder Analysis

All systems analysis begins with identifying the system stakeholders and their needs. The following stakeholders and their perspectives are offered to begin to understand the COVID-19 disaster return to life needs.

Lessons From China

When it became clear that they were dealing with a serious epidemic China did the following things [1]:

1. Hospitals were separated into COVID and non-COVID hospitals.
2. In areas where separate hospitals were not possible, existing hospitals were modified to have COVID and non-COVID areas with complete physical separation to ensure no cross contamination.
3. As a healthcare worker entered and exited a COVID area, there was a physical transition boundary with a third party watching the staff person put on and remove the protective gear.
4. Healthcare workers were separated into COVID and non-COVID staff with NO mixing between the 2 groups.
5. COVID positive children were separated from their parents and placed into recovery centers.
5. During the shelter in place time the streets were constantly being sprayed with disinfecting agents. (see note 1)

This is not new or exotic knowledge. This is a failsafe architecture that attempts to minimize failure propagation. This is standard procedure for highly infectious and dangerous diseases. The difference is that it was not isolated to a small lab or hospital with a single patient, it was established on a massive scale within a functioning society.

Why is this important for understanding a Return to Life system?

It clearly shows the extremely dangerous situation and the care that must be applied when establishing a Return to Life system. The same failsafe architecture that minimizes failure propagation also must be used for the Return to Life system.

Note 1: It appears that the virus eventually falls to the ground and is picked up by shoes and part of the protocol included the cleaning of shoes with disinfecting agents.

References:

[1] Handbook of COVID-19 Prevention and Treatment, Compiled According to Clinical Experience, The First Aliate Hospital, Zhejiang University School of Medicine, China, March 19, 2020, March 24, 2020. webpage <https://asprtracie.hhs.gov/technical-resources/resource/7844/handbook-of-covid-19-prevention-and-treatment>, March 2020; <https://www.alsgbi.org/wp-content/uploads/2020/03/COVID-19-Prevention-and-Treatments-in-a-hospital.pdf>, March 2020. [U.S. Department of Health & Human Services . Handbook of COVID-19 Prevention and Treatment](#) PDF from ALSGBI . [local](#) (PDF)

Return to Work Needs

Eventually people will start to go back to work. So, what are their system needs going forward?

1. We now know the virus is partially airborne, what have you done to update the facility ventilation systems?
2. What is the facility ventilation air update rate per hour?
3. Have you installed UV-C ceiling lights?

4. Have you installed UV-C in the HVAC ducts and if so what are the specifications?
5. Which government authority certified that the HVAC system was properly upgraded to deal with the virus?
6. Will there be public view displays of the chemicals used, where they were used, and data sheets of all the chemicals?
7. Which areas were not sanitized and why to justify the inaction?
8. Which government authority(s) and independent labs certified that all the areas were properly sanitized, and all are now free of COVID-19?
9. How will government / company personal protection equipment be distributed to the employees as part of their legal responsibility to ensure a safe workplace?
10. What measures will be taken to ensure that no one entering the facility has COVID-19?
11. Will the population returning to work be phased into each physical location and what will be the phase in criteria?
12. Will the most vulnerable be the last to return to work after the physical space has shown that there are no COVID-19 cases?
13. What time frame will be used to show that a physical space is free from COVID-19 (2, 4, 6, 8 weeks) prior to the return of the most vulnerable?
14. How often will the staff be tested and how will the testing be accomplished?

Stakeholder Needs and Requirements - System Complexity

The following is an example of the system complexity that cruise ships will face as they restart their operations. The same applies to airlines. These stakeholder requirements easily transfer to all workplace and public space settings.

1. Have you done anything to clean each of your ships?
2. Which products have you used to disinfect the Coronavirus from your ships' cabins, dining rooms, kitchens and common areas? Please, be specific by areas.
3. Can you provide me copies of the chemical data sheets of each of the products used?
4. Can you provide me a copy of the Government Authorization to use these products?
5. Can you provide scientific evidence conducted by one or more independent Labs with expertise in infectious diseases stating their effectiveness in eliminating the Coronavirus 100%? How long will the treatment last? Please explain.
7. Which Government Authorities certified the effectiveness of each product? Please be specific and indicate which countries approved each of the products.

7. Can you confirm that the products and process comply with the best health standards by: WHO, EPA, OSHA, CDC, and other health Authorities?
8. Have you implemented any health recognized protocol to assure ALL possible guests are free of Coronavirus before they enter the Port Terminal? Also as they enter the ship for check in? Be specific at each entrance. Please also answer this question on how you performed the same process for crew members and entertainment staff.
9. Have you implemented any process to improve you staff health practices to eliminate their contact with guests, to eliminate guest contamination?
10. Can you provide evidence of the Coronavirus tests performed on each crew member before they enter to the ship, and that all of them are 100% Coronavirus free before departing?
11. Can you explain which of the different options of Coronavirus test are you using?
12. Can you post those results in a public area to be available for inspection by any of the guests at any time?
13. Can you provide evidence of the certifications or approval to proceed by the Medical Labs that performed those tests?
14. Can you sign a Legal document, Sworn Statement, stating all the facilities are 100% free of Coronavirus or any other infectious virus at the moment we enter for check in?
15. Can you sign a Legal document, Sworn Statement, stating each of the crew members and entertainment personnel are 100% free of Coronavirus?
16. Can you sign a Legal Document, Sworn Statement, stating each in transit guests and boarding guests are free of Coronavirus?
17. Can you provide evidence stating that each food and beverage provider is 100% free of Coronavirus?
18. If the ship enters ports, will they be free of reported Coronavirus a minimum of 6 months prior to arrival? Please, provide evidence verified by a neutral and recognized Government Authority.
19. The issue is not just the ship or airplane but broader and includes all social interaction while on travel.
 - Travel to and from the airport or seaport in a bus or van
 - Walking through airports or seaports
 - Eating in restaurants at the airports or seaports
 - Using rental cars and public transportation
 - Staying in hotels
 - Engaging in tourist, business, family, friends, and other activities

Estimates as of June 2020 are that air travel will not return to previous levels for 2 years - the summer of 2022. The FAA in 2009 found that commercial aviation accounts for approximately 5% of U.S. gross domestic product and contributes \$1.3 trillion in annual economic activity as well as helps generate and support 10 million jobs annually.

WHO Guidance

Any government that wants to start lifting restrictions must first meet six conditions:

1. Disease transmission is under control
2. Health systems are able to detect, test, isolate and treat every case and trace every contact
3. Hot spot risks are minimized in vulnerable places, such as nursing homes
4. Schools, workplaces and other essential places have established preventive measures
5. The risk of importing new cases can be managed
6. Communities are fully educated, engaged and empowered to live under a new normal

Students and Teachers Returning Back to School

The stakeholder needs of students and teachers when returning back to school are grave. Unlike the other stakeholder needs, which were developed before this systems engineering analysis started during early April 2020, the students and teachers needs were developed starting on June 21, 2020. Much has been learned from an engineering perspective during that time period and it has been reflected in the Students and Teachers Returning Back to School needs.

As of June 2020 there are some countries that introduced the following elements to try and mitigate the risks of infection.

1. As elementary school children (grades 1-2) enter the school building there is a mat with liquid disinfectant. They jump up and down to disinfect their shoes. As they cross over into the school building they wipe their shoes on another dry mat.
2. Immediately to the left of the entry there is a row of sinks. The students are directed by 2 adults to the sinks to wash their hands.
3. While eating lunch the desks face the classroom wall and each desk has a partition to the left and right.
4. High school age children are seated 4 to a group. They are separated with clear plexiglass. The desk tables have their laptops, smartphones, and other school related items. The 4 group student pods are separated by more than 6 feet.

These mitigations are not based on a systems perspective, science, and or engineering. They are management actions designed to provide an image that the problem is being addressed. However, they provide a false sense of security and may even lead to more virus spread because the system still has massive hazards that are not addressed.

After decades of neglect the public schools need massive upgraded and new infrastructure.

1. Provide hygiene infrastructure including upgraded restrooms for teachers and students and increased restroom capacity for teachers.

2. Provide massive new mechanical ventilation systems in restrooms, classrooms, and common rooms.
3. Provide UV-C ceiling lights and UV-C lights in HVAC systems along with appropriate air filters and associated daily inspection and immediate maintenance when needed.
4. Open the all the windows and doors to enable massive natural ventilation.
5. Provide new equipment and supplies directly related to the COVID-19 disaster including equipment for the school nurses, teachers, and administrators.
6. Provide new desks and equipment to maximize the effectiveness of social distancing.
7. Provide massive online in classroom live teaching computing infrastructure to support rotating student groups of 5 days in class and 10 days online classes until the infection rate significantly drops.
8. Change the school schedule including shutting down during seasons of high illness such as the Winter months.
9. Provide extremely healthy lunch menus to strengthen and maximize the immune systems of the students, teachers, and administrators. This may mean stopping all the outsourcing of food preparation and reopening the massive kitchen facilities that were once part of the schools from the last century.
10. Provide new course material to allow the students to understand how we may have arrived at this point, what is being done, and what they can do now and in the future when they become adults in hopefully a functioning high quality future society.

Masks and social distancing is not possible. The infrastructure must be modified.

1. Wearing a mask with no break for 7 to 8 hours is not possible.
2. Children and teenagers wearing a mask at bus stops unlikely, in bus unlikely, in cafeteria not possible, during gym not possible, during classroom changes unlikely, in classroom will destroy learning experience
3. Children and teenagers social distancing at bus stops unlikely, in bus unlikely, in cafeteria not possible, during gym not possible, during classroom changes unlikely, in classroom not possible
3. Special needs children and teenagers wearing a mask and social distancing is not possible.
4. Bullies will place students in grave risk by engaging in dangerous behavior (spitting, coughing, etc.).
5. When possible move all classroom activity outside. (the stakeholders now know some of the engineering analysis and want these solutions)

6. Open all the windows and doors and help natural ventilation with fans everywhere. (the stakeholders now know some of the engineering analysis and want these solutions)
7. HVAC Infrastructure must be modified to allow for massive air exchanges. (the stakeholders now know some of the engineering analysis and want these solutions)
8. Add UV-C ceiling lights and update HVAC systems with UV-C lights. (the stakeholders now know some of the engineering analysis and want these solutions)

Observation: Pushing all the responsibility to the lowest level, the individual, is no longer a viable management strategy. Actual investment and work must happen or children, teachers, and others will get sick and die.

The politics and gaming of the system to siphon off taxpayer funds must be disclosed.

1. Stop the efforts to sabotage and dismantle public schools in hopes of monetizing the taxpayer dollars. Taxpayer money must be immediately channeled back into extremely safe high quality public education that is fully transparent.
2. All funding gaps must be addressed by the Federal Government as part of the COVID-19 disaster. Many states are not permitted to carry a deficit unlike the Federal Government. This means they are completely incapable of dealing with this massive disaster.
3. Inform the students and parents about the school budgets and how tax money is spent on outsourcing and private schools by sending home quarterly reports much like companies produce. Incorporate this into new course material to allow the students to understand privatization and how it affects their education and the taxpayer resources. Call it a civics class.

As a direct result of these stakeholder needs this analysis produced proposed legislation text: **TITLE: COVID-19 Funding for Facility Ventilation Upgrade Recommendations and to Upgrade all Public Schools.** For the full text see section [Proposed Legislation](#). This proposed legislation was sent to multiple representatives and various media outlets starting in July 2020. There was no reply and there is no evidence of any movement in this area as of October 2020.

Other Requirements

1. In the US, employers are required by law to provide a safe work environment.
2. In the US, employers are required by law to provide safety equipment to ensure the safety of people working in hazardous conditions.
3. Useless and confusing information must be removed from all official guidance provided by all official organizations everywhere. Focus on what must be done to stop sickness and death is critical.
4. The backup VA hospital system must be fixed immediately to allow for the massive spike in sick people overwhelming some hospitals in the US. (see note 1)
5. The US Federal Government is in a collapsed condition and it must be restarted and reinvigorate with competent people immediately (see note 2).

6. The US Federal Government must stop breaking the laws of the land while dealing with the COVID-19 disaster.

7. Restarting the US Federal Government will take a minimum of 1 year. The crisis assets locked in the Federal Government must begin to be transferred to the States immediately. This includes professional staff, equipment, and money. (see note 3)

Note 1: In accordance with the law, the US Veterans Administration (VA) hospital system is a backup to the civilian hospital system. It is clear that the system is broken, and the backup is not working properly.

Note 2: In mid-March 2020, multiple Federal Government organizations issued direction to civil servants and contractors that they should clean their workspaces using their own personal products. This is a clear violation of US law and shows that OSHA is compromised and cannot be depended upon to protect the people from dangerous incompetent management. It also shows that government is very large with many elements, some of which are very competent and effective but unfortunately other elements are in a collapsed condition. It is clearly having massive problems in meeting the needs of the people.

Note 3: The States have taken on the burden of dealing with this crisis. However, all the money and resources are centralized in the Federal Government because that has been the approach used since World War II. As each day passes where the US Federal Government is in a collapsed condition, more people get sick and die and the crisis becomes worse with massive unintended consequences that are gravely damaging the entire civilization.

Stakeholders List

Table 6 - Stakeholder List

| | | |
|--|---|---|
| <ul style="list-style-type: none"> • Uninfected People • Deceased People (from the very young to the very old) • Infected Hospitalized People • Short Term Health Affected People • Long Term Health Affected People • Healthcare Providers • Insurance Companies (health, life, liability) • Essential Workers • Telecommuters • Day Care Facilities • Schools | <ul style="list-style-type: none"> • Manufacturing Companies • Distribution Companies • Service Companies • Retail Companies • Travel Companies • Leisure Companies • Research Institutions • Pharmaceutical Companies • Non-Profits • Open Source Community • The World Health Organization (WHO) • The Entire World | <ul style="list-style-type: none"> • Centers for Disease Control (CDC) • Federally Funded Research and Development Centers (FFRDC) • Department Of Defense (DOD) • Department Of Transportation (DOT) • Federal Aviation Administration (FAA) • Federal Government • State Government • Local Government • Democrats • Independents |
|--|---|---|

| | | |
|----------------|----------------|---------------|
| • Universities | Outside The US | • Republicans |
|----------------|----------------|---------------|

Virus Defense System

The purpose of a defense system is to defend against a threat. There are many defense systems in our society like Air Defense and Missile Defense systems. These systems were developed and matured after World War II. They rely heavily on systems engineering practices because of their complexity and potential massive loss of life should something go wrong. There are other defense systems, some are consciously developed and maintained and some just naturally evolve and exist as part of the civilization. Home security systems are an example of a simple defense system to defend against the threat of a home intruder and computer communications firewalls defend against computer viruses.

The threat in this case is a virus or other unknown contagion. The question then is do we have a Virus and or Contagion Defense System. The short answer is yes. It was consciously developed and matured through the decades. It is currently part of what we know as the Centers For Disease Control (CDC).

After World War II the US policy and tone was set by a major analysis that was requested by President Roosevelt called Science the Endless Frontier. This analysis identified many areas for the US Federal Government to address and many equate it with the founding of the National Science Foundation. However, its reach was far and wide and it can be easily pointed to as why the modern CDC exists. The CDC roots go back to the Office of National Defense Malaria Control Activities (1942). Its evolution goes from the Office of Malaria Control in War Areas (1942–46), Communicable Disease Center (1946–67), National Communicable Disease Center (1967–70), Center for Disease Control (1970–80), and currently Centers for Disease Control (1980–92). The US took the domestic and international lead role in the international Contagion Defense System beginning in 1942. These are some of the key CDC events representing their activities and role:

1940s

- **1942 – Office of National Defense Malaria Control Activities.**
- 1946 – The Communicable Disease Center is organized in Atlanta, Georgia.
- 1948 – CDC gained worldwide recognition for the quality and quantity of its contributions to the taxonomy of the Enterobacteriaceae.
- **1949 – CDC Initiated programs to fight biological warfare, an exotic new threat to health.**

1950s

- 1950 – Conducted the first investigation of an epidemic of polio in Paulding County, Ohio.
- 1951 – The Epidemic Intelligence Service was established to help protect against biological warfare and manmade epidemics.
- **1952 – Reported it is ready to combat possible biological warfare.**

- 1953 – CDC reported first case of rabies in a bat.
- 1955 – CDC established the Polio Surveillance Program.
- 1956 – Found the first practical use for the fluorescent technique to identify pathogens that might be used in biological warfare (Dr. William Cherry).
- 1957 – National guidelines for influenza vaccine were developed.
- **1958 – CDC team traveled overseas, for the first time, to Southeast Asia to respond to an epidemic of cholera and smallpox.**
- 1959 – CDC developed the fluorescent antibody test for rabies, first used in a field trial with 100 percent accuracy (Dr. Robert Kissling).

1960s

- 1960 – The Tuberculosis Program moved from the Public Health Service to CDC.
- 1961 – CDC took over publication of Morbidity and Mortality Weekly Report (MMWR).
- 1962 – CDC played a key role in one of the greatest triumphs of public health: the eradication of smallpox.
- 1963 – CDC tested the newly developed jet injector vaccine for smallpox.
- 1964 – CDC linked smoking to lung cancer.
- **1965 – New surveillance systems added to the original National Surveillance Program of 1952 included measles, shigellosis, tetanus, and trichinosis.**
- 1966 – CDC announced a national measles eradication campaign at the American Public Health Association meeting.
- 1967 – The Foreign Quarantine Service, one of the oldest and most prestigious units of the Public Health Service, joined CDC.
- 1968 – CDC investigated an unidentified, highly infectious respiratory disease in Pontiac, Michigan, later identified as Legionellosis (also known by its two forms, Legionnaires' disease and Pontiac fever).
- 1969 – CDC constructed a "biocontainment lab" to protect scientists while they work with deadly and infectious pathogens.

1970s

- 1971 – The National Center for Health Statistics conducted the first National Health and Nutrition Examination Survey, taking a snapshot of the health status of Americans.
- 1973 – Morbidity and Mortality Weekly Report (MMWR) reported that emissions of lead in residential areas constitute a public health threat, contrary to popular assumption at the time.
- 1975 – The last victim of variola major smallpox, the more severe form of the disease, was reported.
- **1976 – CDC investigated two outbreaks of a previously unknown deadly hemorrhagic fever, later known as Ebola, in Zaire and Sudan.**
- 1977 – Global eradication of smallpox was achieved.
- 1978 – Alcorn County, Mississippi, reported cases of the first outbreak of tuberculosis resistance to previously effective drugs.

1980s

- 1980 – Morbidity and Mortality Weekly Report published the first report on the newly recognized toxic shock syndrome, an illness associated with tampon use.

- 1981 – The first diagnosis of the fatal disease later known as AIDS was described in the June 5, 1981, issue of MMWR.
- 1982 – Advised of the possible risk of Reye syndrome associated with the use of aspirin by children with chickenpox and flu-like symptoms.
- 1984 – CDC studied Vietnam veterans who were exposed to Agent Orange during combat and later fathered babies; no increased risk of birth defects was found.
- 1988 – CDC established the National Center for Chronic Disease Prevention and Health Promotion.

1990s

- 1990 – CDC reported the possible transmission of HIV from a dentist to a patient in Florida during an invasive procedure.
- 1992 – The National Academy of Sciences reported on a dangerous new phenomenon: the emergence of new and virulent diseases that are resistant to antibiotics.
- 1996 – CDC, in partnership with the International Society for Travel Medicine, initiated the GeoSentinel surveillance network to improve travel medicine.
- 1999 – CDC's Laboratory Response Network was established.

2000s

- 2000 – CDC identified an outbreak of HIV-related tuberculosis among young transgender people in New York and Boston.
- **2001 – CDC learned of the first of the 2001 anthrax attacks.**
- 2003 – Severe acute respiratory syndrome (SARS) was first reported in Asia. CDC provided guidance for surveillance, clinical and laboratory evaluation, and reporting.
- 2005 – Rubella was eliminated in the United States.
- **2006 – CDC to evaluate community strategies to reduce impact of pandemic influenza.**

2010s

- **2013 – CDC releases first report to categorize threats by hazard level.**
- 2014 – CDC established a Modeling Task Force capable of generating estimates of risk for importation of cases of Ebola from West African countries like Mali to the United States.

In addition to the CDC there is the Department of Homeland Security (DHS), U.S. Department of Health & Human Services (HHS), Biomedical Advanced Research and Development Authority (BARDA) and National Center for Medical Intelligence (NCMI).

Unlike Air Defense or Missile Defense, the concept of a Virus Defense System or Contagion Defense System does not appear in simple Internet searches. The documents are probably stamped at some classification level [1]. It is unclear why that would be the case because we know from Air Defense and Missile Defense systems that it is important to disclose their existence and basic operations for the world to understand the implications and effectiveness of these systems. In Air Defense or Missile Defense the performance numbers tend to be classified. Crimson Contagion is an example why these systems need to be disclosed and studied [2].

Crimson Contagion was a joint exercise conducted January to August 2019, to test the capacity of the federal government and twelve states to respond to a severe pandemic of influenza originating in China. The simulation was conducted months prior to the start of the COVID-19 pandemic. The scenario was tourists returning from China spread a respiratory virus in the United States, beginning in Chicago. In less than two months the virus had infected 110 million Americans, killing more than half a million. The report issued at the conclusion of the exercise outlines the government's limited capacity to respond to a pandemic, with federal agencies lacking the funds, coordination, and resources to facilitate an effective response to the virus. [1]

This analysis does not examine existing Virus and or Contagion Defense Systems because there appears to be no public information. However, the virus defense system exists. It is either a consciously developed system or a system that naturally evolved, but it exists. This analysis draws from modern Air and Missile Defense systems public information to develop a conceptual virus defense system. It then provides an assessment of the performance of the system (circa December 2020).

Functional Analysis

A systems engineering analysis includes identification and understanding of the system functions. Typically similar systems are examined to provide guidance and inform the potential functions for the system under analysis. One of systems to consider is air defense because it shares many of the characteristics of a system that must deal with and eliminate a virus contagion. These characteristics will become self-evident once the air defense functions are listed and briefly described. The following are the key functions and descriptions in a typical air defense system and the resulting virus defense functions.

Table 7 - Virus Defense Functions

| Air Defense Functions | Air Defense Description | Virus Defense Functions | Virus Defense Description |
|------------------------------|---|--------------------------------|--|
| Surveillance | The system is constantly watching the skies to determine if there are unusual target flight patterns. | Surveillance | The system is constantly watching the planet to determine if there are unusual contagion patterns. |
| Identification | When an unusual target flight pattern is detected there is an attempt to identify the target as known, unknown, or a threat. | Identification | When an unusual contagion pattern is detected there is an attempt to identify the contagion as known, unknown, or a threat. |
| Threat Assessment | If the target is unknown it is assessed to determine if it is a threat. This may include making visual contact to assess the situation. | Threat Assessment | If the unusual contagion pattern is unknown it is assessed to determine if it is a threat. This may include making physical contact to assess the situation. |

| Air Defense Functions | Air Defense Description | Virus Defense Functions | Virus Defense Description |
|------------------------------|--|--------------------------------|--|
| Weapons Assignment | Based on an assessment of the target threat a weapon or weapons are assigned to deal with the threat. | Resources Assignment | Based on an assessment of the contagion threat appropriate resources are assigned to deal with the threat. The resources include tools, techniques, methods, processes, money, medications, infrastructure and other items available in the arsenal to fight the contagion. |
| Intercept | The weapon or weapons are sent to intercept the threat as quickly as possible. | Deployment | The tool or tools are sent to intercept the unusual contagion pattern as quickly as possible. |
| Assessment | Once the intercept is complete an assessment is performed to determine the success of the encounter. The first encounter is a visual confirmation and reassessment to a known target is typically all that is needed. In the case of war the intercept that follows is meant to remove the threat and an assessment of the event is performed. | Assessment | Once the deployment is complete an assessment is performed to determine the success of the encounter. The first encounter of a visual confirmation and reassessment to a known contagion is typically all that is needed. In the case of a new contagion threat the deployment that follows is meant to remove the threat and an assessment of the event is performed. |

What the above table describes is a typical Situational Awareness Command and Control system. This system concept based on doctrine, computers, communications, and massive technology started during World War II, was heavily matured during the 1950's with the Semi-Automatic Ground Environment (SAGE) system and now exists everywhere from civilian air traffic control systems to emergency response systems. The following figure is a potential virus defense system functional block diagram.

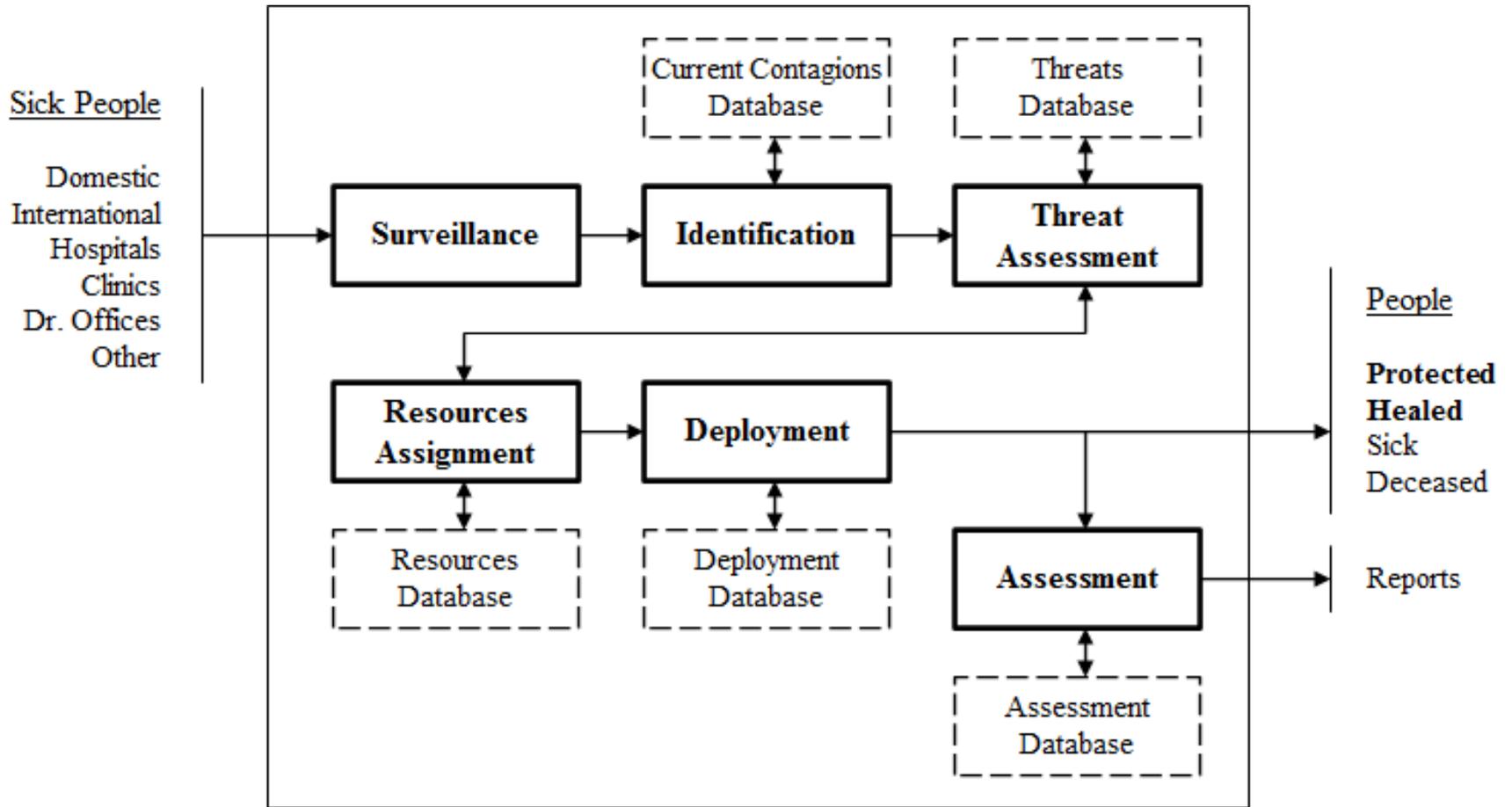


Figure 7 - Virus Defense System Functional Block Diagram

The epidemic or pandemic functional decomposition is:

- | | |
|------------------------------|----------------------------------|
| 1.0 Surveillance | 5.0 Deployment |
| 2.0 Identification | 5.1 Containment |
| 3.0 Threat Assessment | 5.2 Exposure Elimination |
| 3.1 Threat Modeling Analysis | 5.3 Treatment |
| 3.2 Threat Data & Analysis | 5.4 Eradication |
| 4.0 Resources Assignment | 6.0 Assessment |
| 4.1 Containment | 6.1 Performance Monitoring |
| 4.2 Exposure Elimination | 6.2 Presentation & Visualization |
| 4.3 Treatment | |
| 4.4 Eradication | |

Subsystems

The functions are implemented in one or more subsystems. The subsystems can be automated using machines, manual performed by people, or both automated and manual. Placing the functions in one or more subsystems is called a functional allocation. Once a functional allocation is performed a conceptual architecture surfaces and performance can be determined. Different allocations result in different conceptual architectures each with their own performance characteristics. The potential subsystems for this system are:

- US Government Subsystem
- World Health Organization (WHO) Subsystem
- Non US Nation State Resources Subsystem
- Academic Resources Subsystem
- Business Resources Subsystem
- US Press Subsystem

As in all complex systems there are primary subsystems and secondary subsystems that are used as backup should the primary subsystem fail. Many do not realize that there is always a system regardless if there was a conscious effort to establish a system. The system can be very effective or poor. The contagion defense system evolved probably for the most part unconsciously over decades. The system basically started after World War II.

Performance Assessment

The following table shows the epidemic or pandemic system functions and subsystems that implement the functions with an assessment of the system performance in 2020. We see that prior to the pandemic the world viewed certain subsystems as having a primary role in implementing certain functions. We also see there were many primary subsystem failures and the secondary subsystems needed to perform the function.

Table 8 - Virus Defense Functions Assessment

| Functions / Subsystems Allocation | US Gov Subsystem | WHO Subsystem | Non US Nation State Resources Subsystem | Academic Resources Subsystem | Business Resources Subsystem | US Press Subsystem | Comment |
|--|-------------------------|----------------------|--|-------------------------------------|-------------------------------------|---------------------------|---|
| Surveillance | Primary failed | Secondary | Secondary | Secondary | Secondary | Secondary | China performed this function. |
| Identification | Primary failed | Secondary | Secondary | Secondary | Secondary | Secondary | China performed this function. |
| Threat Assessment | Primary failed | Secondary | Secondary | Secondary | - | Primary failed | China performed this function. US press is fragmented and failed to invalidate disinformation and propaganda sources before they became entrenched. |
| Resources Assignment | Primary failed | Secondary | Primary | - | - | - | US government failed to perform this function. |
| Deployment | Primary US failed | - | Primary | - | Secondary | - | US government failed to perform this function. |
| Assessment | Primary failed | Primary failed | Primary | Primary | - | Primary failed | US government failed to perform this function. US press is fragmented and failed to invalidate disinformation and propaganda sources before they became entrenched. US government failed to pull FCC licenses from 24/7 disinformation and propaganda sources. WHO was influenced by US and ignored findings from China, Italy, academics and others. |

The above conceptual architecture shows that either the primary functional allocations must change, resulting in a different conceptual architecture, or the US Gov and US Press Subsystems must be fixed and quickly.

The following table shows the possible epidemic or pandemic functions, a functional decomposition, and resources that have been implemented by date. It is a more detailed assessment of the system functional performance.

Table 9 - Virus Defense Functions and Resources

| Functions | Lower Level Functions & Resources | March 2020 | October 2020 | December 2020 | Comment |
|-------------------|--|--|--|--|---|
| Surveillance | Surveillance - US CDC - US Press | Completed No No | - | - | This was performed by China. |
| Identification | Identification - Genetic Sequencing - Transmission Method | Completed Rejected | - Yes | - Yes | This was performed by China. The US knew that the transmission method was airborne in January 2020 but did not disclose the information and engaged in disinformation and propaganda to deflect away from the issue. |
| Threat Assessment | Threat Modeling Analysis - Small indoor space - Large indoor space - Outside venues - Transportation Systems | Rejected Rejected Rejected Rejected | Partial Partial Partial Partial | Partial Partial Partial Partial | The performance numbers were not published and distributed by the US government. Only analysis from independent research like this report developed, published and distributed the findings. The findings did not match any of the management talking points from all the US institutions. Management engaged in damage control and only provided vague guidance that reflected the findings of the performance numbers in some instances and in other instance like airplane risks were counter to the findings. This left the population with no real guidance on how to proceed. |
| Threat | Threat Data & Analysis | | | | The data is not being provided by the US to the |

| Functions | Lower Level Functions & Resources | March 2020 | October 2020 | December 2020 | Comment |
|-----------------------------------|--|---|---|---|---|
| Assessment | <ul style="list-style-type: none"> - Small indoor space - Large indoor space - Outside venues - Transportation Systems | No No No No | No No No No | No No No No | people. The only data that is available is from international research reports. The CDC and NIH typically have those research reports on their websites suggesting there is no capability within the US to capture this data and perform the analysis. The US research appears to be irrelevant or just duplicates of small elements of existing research. |
| Resource Assignment Deployment | <ul style="list-style-type: none"> Containment - Testing - Contact Trace & Quarantine - Travel Restrictions - Public Indoor Space Shutdown - Schools Shutdown - Surface Decontamination - Masks - Social Distance - Open Air UV Systems - HVAC Systems - Open Air Ventilation | Insufficient No Too late Yes Yes Yes Rejected Rejected No No No | Insufficient Partial International No Rejected Yes Rejected Rejected No No No | Insufficient Partial International No Rejected Yes Rejected Rejected No No No | The US failed to contain the virus. A large portion of the US population rejected masks and social distance recommendations because the US Government turned the guidance into a political issue. There was no proper existing HVAC settings guidance. Contact tracing and quarantine only worked in Hawaii. Because the virus transmission is also airborne all the surface cleaning and plastic shields was ineffective at stopping the virus. There was no proper engineering science based reopening plan, only massive pressure to reopen. There was no desire to roll out airborne infrastructure mitigation solutions like Open Air UV and HVAC system upgrades. |
| Resource Assignment Deployment | <ul style="list-style-type: none"> Exposure Elimination - Surface Decontamination - Masks - Social Distance - Open Air UV Systems - HVAC Systems - Open Air Ventilation | Yes Rejected Rejected No No No | Yes Rejected Rejected No No No | Yes Rejected Rejected No No No | In October 2020 it was admitted that the virus spread is airborne. This was known by the US Government in January of 2020 but the information was suppressed and denied. Between January and October schools and many small indoor spaces could have been upgraded with proper UV and HVAC systems. |

| Functions | Lower Level Functions & Resources | March 2020 | October 2020 | December 2020 | Comment |
|-----------------------------------|---|--------------------------------|--------------------------------|---------------------------------|---|
| Resource Assignment Deployment | Treatment - Drugs - Blood Plasma - Physical Placement - Oxygen Delivery - Intubation | Yes No Yes Yes Yes | Yes No Yes Yes Yes | Yes Yes Yes Yes Yes | Many treatments were pioneered in China and Italy. Eventually treatments were developed from around the world. Healthcare professionals networked on their own to share treatments and results. |
| Resource Assignment Deployment | Eradication - Vaccines - Open Air UV Systems - Proper HVAC Systems | No No No | No No No | No No No | As of December 2020 many falsely think this virus will be quickly eradicated with vaccines. Management damage control talking points are still in control of the mass message. History and this systems analysis shows that this is an incorrect assumption. To reduce the time to eradicate this virus and protect against future virus attacks this analysis suggests that the infrastructure must be modified. |
| Assessment | Performance Monitoring - Infections - Deaths - Long Term Health Damage | Yes Yes No | Yes Yes No | Yes Yes No | As of December 2020 the only system performance numbers provided to the public are infections and deaths. Numbers associated with long term health by damaged body subsystems are not being provided. |
| Assessment | Presentation & Visualization - Infections - Deaths - Long Term Health Damage | Yes Yes No | Yes Yes No | Yes Yes No | As of December 2020 the only system performance numbers presented to the public are infections and deaths. Numbers associated with long term health by damaged body subsystems are not being provided. |

Note: Yes = Resources deployed, No = Resources not deployed, Rejected = rejected by many because of US Government leadership.

What this functional analysis shows is the massive breakdown in the US Virus Defense System. The lessons learned and technologies to deal with the virus are almost 100 years old and they were not used. The biggest issues from this analysis are:

- The system performance numbers for various living scenarios are not being disclosed
- Open air UV systems are not even being discussed
- Proper HVAC guidance is not being provided
- Long term health damage numbers are not being disclosed
- The performance numbers of various transportation systems are not being disclosed
- Management damage control talking points have been in control rather than science, engineering, and common sense

Nature abhors a vacuum. Because the US failed to disclose real performance numbers the Internet has been filled with disinformation and propaganda. A civilization is not sustainable with carefully crafted management talking points aimed at damage control and protecting narrow interests like airline revenues especially in times of massive disaster. For example, the analysis clearly shows that a social distance of 1 foot as found when seated on an airplane will lead to infection. The airlines are clearly on record stating that the goal is to book all seats on a flight. A reasonable approach would be to book seats that provide 6 or more feet of social distancing. This translates to 1 person every other row or every third row. Given that the original infection spread was accelerated via air travel, to allow that condition to reappear by October 2020 is outrageous behavior. This is a triple failure. The first failure is with the airline companies, the second failure is with the FAA that failed to roll out emergency regulations because of deregulation dogma, and the third failure is with the people who refuse to follow their common sense. Estimates are that 9.4 million people traveled by air for the Thanksgiving Holiday [3].

There are suggestions that in 2021 there will be renewed emphasis on US research and a return to respecting the findings of scientists, engineers, and common sense. Basic research occurs in academia and science directed research at solving societal problems occurs in federal laboratories [4].

This is an unusual functional analysis. When it was started this final path was not the intent. The goal was to just disclose the functions and show the relationship between the functions. Instead, once the system became visible via the functional analysis, it was natural to begin to assess the performance of each function performed by the various subsystems. The subsystems for this system are social subsystems and so the result is a social assessment of the situation.

After this analysis made its first pass there was an intense effort to try and find the actual Virus Defense System. Instead what was found was the critical role of the CDC in bio-defense beginning in the 1950's and the Crimson Contagion national level exercise performed from January to August 2019 [1] [2].

References:

[1] Before Virus Outbreak, a Cascade of Warnings Went Unheeded, New York Times, March 22, 2020. webpage <https://www.nytimes.com/2020/03/19/us/politics/trump-coronavirus-outbreak.html>, December 2020. [Before Virus Outbreak, a Cascade of Warnings Went Unheeded](#)

[2] [Crimson Contagion](#) https://en.wikipedia.org/wiki/Crimson_Contagion, December 2020.

[3] Sunday was the busiest day for US air travel since the pandemic began, CNN [www.cnn.com](https://www.cnn.com/travel/article/thanksgiving-travel-volume-2020-pandemic/index.html), November 30, 2020. webpage <https://www.cnn.com/travel/article/thanksgiving-travel-volume-2020-pandemic/index.html>, December 2020. [Sunday was the busiest day for US air travel since the pandemic began](https://www.cnn.com/travel/article/thanksgiving-travel-volume-2020-pandemic/index.html)

[4] Memo for President Biden: Five steps to getting more from science, Going back to normal is not enough. A revamp is required. Nature, November 8, 2020. webpage <https://www.nature.com/articles/d41586-020-03148-w>, December 2020. [Memo for President Biden: Five steps to getting more from science, Going back to normal is not enough](https://www.nature.com/articles/d41586-020-03148-w)

Death Rates

On March 11, 2020 the WHO declared the coronavirus outbreak a pandemic. US Total confirmed Infections and Deaths from the US Center for Disease Control are below [1]

The table shows total reported cases and deaths. It also includes a projection for different herd immunity levels. When the herd immunity levels are compared with the death rates we see the number of years for herd immunity to take effect. Either the herd immunity percentages are too high (50%-75%), the affected population is too high (328 million), the infection rate is too slow, or the infection will be with us for a very long time (8-31 years).

These numbers do not reflect innate immunity. Innate immunity also called native immunity is the ability of an organism to resist infection because of its genetic makeup [2]. Native immunity to COVID-19 is being studied and the numbers are 12% to 21%. This would reduce the potential affected population and reduce all the numbers in the table by the same factor. Also the case fatality rates is a big factor. Changing the number from 3.5% to 3.02% is an additional 15% reduction. These two assumptions would reduce the numbers by 35%.

The numbers are very bad. Virus mutation could change all these numbers. A virus can mutate to a less dangerous form as it tries to survive in the eco system. It is unclear if that will happen in this case. Virus containment could also change these numbers. Currently virus containment in the US is based on masks, social distancing, and limited tracking. Based on the numbers from the US, it appears that the virus will not be contained. The big question is at what point will virus containment become impossible.

Table 10 - Infection and Death Rates (Actual and Projections)

| Date | Total Cases | Daily Cases | Total Deaths | Case fatality rates (%) | Daily Deaths | 50% herd immunity years | 60% herd immunity years | 75% herd immunity years | % into pandemic (328 million) | Comments |
|----------------|------------------------|-------------|--------------------|-------------------------|--------------|-------------------------|-------------------------|-------------------------|-------------------------------|--|
| March 11, 2020 | 1000 | 1000 ▲ | 29 | 2.9 | - | - | - | - | - | CDC [1]. TV news is <u>reporting</u> the US COVID-19 cases and death rates. |
| April 01, 2020 | 184,770 | 8,751 ▲ | 3,746 | 2.0 | 177 ▲ | 89 | 107 | 133 | 0.06 | CDC [1]. TV news is <u>displaying</u> the US COVID-19 cases and death rates. |
| May 01, 2020 | 1,062,446 | 29,256 ▲ | 62,406 | 5.9 | 1955 ▲ | 8 | 10 | 12 | 0.32 | CDC [1]. TV news is <u>displaying</u> the US COVID-19 cases and death rates. Deaths exceed World War I Battle Deaths 53,402 [7] Deaths exceed Korean War Battle Deaths of 33,739 [7] Deaths exceed Vietnam War Battle Deaths of 47,434 [7] |
| June 01, 2020 | 1,761,503 | 22,550 ▼ | 103,700 | 5.9 | 1332 ▼ | 12 | 14 | 18 | 0.54 | CDC [1]. TV news STOPPED displaying and reporting the US COVID-19 cases and death rates Instead the news is dominated by protests that erupted by May 29, 2020 over the murder of an American citizen by police in Minneapolis, Minnesota on May 25, 2020. The TV images of the murder were broadcast around the world. [3] Deaths exceed Korean + Vietnam Wars Battle Deaths [7] |
| June 10, 2020 | 1,956,421 1,979,893 | 21,658 ▼ | 110,925 112,006 | 5.7 5.7 | 803 ▼ | 20 | 24 | 29 | 0.60 0.60 | CDC [1]. After 2 weeks of demonstrations over the murder of an American citizen by |

| Date | Total Cases | Daily Cases | Total Deaths | Case fatality rates (%) | Daily Deaths | 50% herd immunity years | 60% herd immunity years | 75% herd immunity years | % into pandemic (328 million) | Comments |
|--------------------|------------------------|-------------|--------------------|-------------------------|--------------|-------------------------|-------------------------|-------------------------|-------------------------------|---|
| | | | | | | | | | | police in Minneapolis, Minnesota. The second line is data from Johns Hopkins University & Medicine Cases [4]. |
| July 01, 2020 | 2,581,229 2,638,338 | 29,753 ▲ | 126,739 127,485 | 4.9 4.8 | 753 ▼ | 21 | 25 | 31 | 0.79 0.80 | CDC [1]. The second line is data from Johns Hopkins University & Medicine Cases [4]. |
| August 01, 2020 | 4,473,974 4,563,262 | 61,056 ▲ | 151,499 153,320 | 3.4 3.4 | 799 ▲ | 20 | 24 | 30 | 1.36 1.39 | CDC [1]. The second line is data from Johns Hopkins University & Medicine Cases [4]. Deaths exceed World War I + Korean + Vietnam Wars Battle Deaths [7] |
| September 01, 2020 | 6,004,443 6,068,139 | 49,370 ▼ | 183,050 184,450 | 3.0 3.0 | 1018 ▲ | 15 | 19 | 23 | 1.83 1.85 | CDC [1]. The second line is data from Johns Hopkins University & Medicine Cases [4]. Deaths exceed World War I + Korean + Vietnam Wars Battle Deaths [7] |
| October 01, 2020 | 7,213,419 7,268,298 | 40,299 ▼ | 206,402 207,605 | 2.9 2.9 | 778 ▼ | 20 | 24 | 30 | 2.20 2.22 | CDC [1]. The second line is data from Johns Hopkins University & Medicine Cases [4]. Deaths exceed World War I + Korean + Vietnam Wars Battle Deaths [7] |
| November 01, 2020 | 9,105,230 9,198,700 | 61,026 ▲ | 229,932 230,934 | 2.5 2.5 | 759 ▼ | 21 | 25 | 31 | 2.78 2.80 | CDC [1]. The second line is data from Johns Hopkins University & Medicine Cases [4]. |

| Date | Total Cases | Daily Cases | Total Deaths | Case fatality rates (%) | Daily Deaths | 50% herd immunity years | 60% herd immunity years | 75% herd immunity years | % into pandemic (328 million) | Comments |
|-------------------|--------------------------|--------------|--------------------|--|--------------|-------------------------|-------------------------|-------------------------|-------------------------------|--|
| | | | | | | | | | | Deaths exceed World War I + Korean + Vietnam Wars Battle Deaths [7] |
| December 01, 2020 | 3,447,627 13,706,356 | 144,747 ▲ | 267,302 270,450 | 2.0 2.0 Note: lags infection level | 1246 ▲ | 13 | 15 | 19 | 4.10 4.18 | CDC [1]. The second line is data from Johns Hopkins University & Medicine Cases [4]. Deaths exceed World War I + Korean + Vietnam Wars Battle Deaths [7] 0 vaccinations [8] |
| January 01, 2021 | 19,663,976 20,104,003 | 199,655 ▲ | 341,199 347,542 | 2.5 2.5 | 2384 ▲ | 7 | 8 | 10 | 6.00 | CDC [1]. The second line is data from Johns Hopkins University & Medicine Cases [4]. Deaths exceed World War II, Deaths exceed World War I + Korean + Vietnam Wars [7] 2.8 million vaccinations [8] |
| February 01, 2021 | 25,921,703 26,188,167 | 201,862 ▲ | 438,035 441,331 | 3.3 3.2 | 3124 ▲ | 5 5 | 6 6 | 8 8 | 7.90 7.98 | CDC [1]. The second line is data from Johns Hopkins University & Medicine Cases [4]. Deaths exceed World War II, Deaths exceed World War I + Korean + Vietnam Wars [7] 31 million vaccinations [8] |

| Date | Total Cases | Daily Cases | Total Deaths | Case fatality rates (%) | Daily Deaths | 50% herd immunity years | 60% herd immunity years | 75% herd immunity years | % into pandemic (328 million) | Comments |
|----------------|--------------------------|-------------|--------------------|-------------------------|--------------|-------------------------|-------------------------|-------------------------|-------------------------------|---|
| March 01, 2021 | 28,405,925 28,657,233 | 88,722 ▼ | 511,839 514,302 | 2.6 2.6 | 2636 ▼ | 6 6 | 7 7 | 9 9 | 8.66 8.74 | CDC [1]. The second line is data from Johns Hopkins University & Medicine Cases [4]. CDC Cases . Johns Hopkins University & Medicine Cases Deaths exceed World War II [7] Deaths exceed World War I + Korean + Vietnam Wars [7] 75 million vaccinations [8] |
| | | | | | | | | | | |
| | | | | | | | | | | Projections Let us hope and pray that something happens to stop this massive disaster |
| 2+ years | 164,000,000 | | 5,740,000 | 3.5 | | | | | | 50% herd immunity 328 million people |
| 2+ years | 196,800,000 | | 6,888,000 | 3.5 | | | | | | 60% herd immunity 328 million people |
| 2+ years | 246,000,000 | | 8,610,000 | 3.5 | | | | | | 75% herd immunity 328 million people |
| see video | see video | | see video | see video | | | | | | COVID19 Trend Analysis Case Study Other projections: [5] |

The following data is as of April 2020. Notice the US data has not been updated since March 2020. It is interesting to see that the old traditional retirement age of 55 appears to be a point of inflection. [6]

Table 11 - Case fatality rates (%) by age and country

| Age | 0-9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80-89 | 90+ |
|----------------------------|-----|-------|-------|-------|-------|-------|-------|-------|-------|------|
| Canada as of 25 April | 0.0 | | 0.1 | | 0.5 | | 5.2 | | 16.2 | |
| China as of 11 February | 0.0 | 0.2 | 0.2 | 0.2 | 0.4 | 1.3 | 3.6 | 8.0 | 14.8 | |
| Denmark as of 26 April | 0.2 | | | | | | 4.4 | 15.4 | 24.8 | 41.0 |
| Israel as of 26 April | 0.0 | 0.0 | 0.0 | 1.0 | 0.5 | 1.5 | 8.6 | 24.8 | 34.3 | 29.3 |
| Italy as of 23 April | 0.2 | 0.0 | 0.1 | 0.4 | 0.9 | 2.6 | 10.0 | 24.9 | 30.8 | 26.1 |
| Netherlands as of 25 April | 0.0 | 0.3 | 0.1 | 0.2 | 0.5 | 1.5 | 7.6 | 23.2 | 30.0 | 29.3 |
| Portugal as of 24 April | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.6 | 2.8 | 8.5 | 16.5 | |
| S. Korea as of 30 April | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.8 | 2.6 | 10.4 | 24.3 | |
| Spain as of 25 April | 0.3 | 0.4 | 0.3 | 0.3 | 0.5 | 1.3 | 4.4 | 13.2 | 20.3 | 20.2 |
| Sweden as of 26 April | 0.0 | 0.0 | 0.4 | 0.4 | 1.0 | 2.3 | 6.9 | 21.2 | 30.0 | 34.0 |
| Switzerland as of 25 April | 0.9 | 0.0 | 0.0 | 0.1 | 0.0 | 0.5 | 2.7 | 10.1 | 24.0 | |
| WA state as of 25 April | 0.0 | | 0.2 | | 1.3 | | 8.9 | | 29.9 | |

Table 12 - Case fatality rates (%) by age in the United States

| Age | 0-19 | 20-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|------------------------------|------|---------|---------|---------|---------|----------|-----------|
| United States as of 16 March | 0.0 | 0.1-0.2 | 0.5-0.8 | 1.4-2.6 | 2.7-4.9 | 4.3-10.5 | 10.4-27.3 |

| Age | 0-19 | 20-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|-----|------|-------|-------|-------|-------|-------|-----|
|-----|------|-------|-------|-------|-------|-------|-----|

Note: The lower bound includes all cases. The upper bound excludes cases that were missing data.

Note: The lower bound includes all cases. The upper bound excludes cases that were missing data.

Estimate of infection fatality rates and probability of severe disease course (%) by age based on cases from China

Table 13 - Infection Fatality Rates and Probability of Severe Disease Course

| | 0-9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80+ |
|-----------------------|---------------------------|--------------------------|------------------------|-----------------------|----------------------|--------------------|------------------|------------------|-----------------|
| Severe disease | 0.0 (0.0-0.0) | 0.04 (0.02-0.08) | 1.0 (0.62-2.1) | 3.4 (2.0-7.0) | 4.3 (2.5-8.7) | 8.2 (4.9-17) | 11 (7.0-24) | 17 (9.9-34) | 18 (11-38) |
| Death | 0.0016 (0.00016-0.025) | 0.0070 (0.0015-0.050) | 0.031 (0.014-0.092) | 0.084 (0.041-0.19) | 0.16 (0.076-0.32) | 0.60 (0.34-1.3) | 1.9 (1.1-3.9) | 4.3 (2.5-8.4) | 7.8 (3.8-13) |

Total infection fatality rate is estimated to be 0.66% (0.39-1.3). Infection fatality rate is fatality per all infected individuals, regardless of whether they were diagnosed or had any symptoms. Numbers in parentheses are 95% credible intervals for the estimates.

The following table has the battle deaths of US wars. [7] It is provided to offer a systems perspective of the situation.

Table 14 - US Wars Battle Deaths

| US Wars | Battle Deaths | US Wars | Battle Deaths |
|-----------------------------------|---------------|-----------------------------------|---------------|
| American Revolution (1775-1783) | 4,435 | World War I (1917-1918) | 53,402 |
| War of 1812 (1812-1815) | 2,260 | World War II (1941 –1945) | 291,557 |
| Indian Wars (approx. 1817-1898) | 1,000 | Korean War (1950-1953) | 33,739 |
| Mexican War (1846-1848) | 1,733 | Vietnam War (1964-1975) | 47,434 |
| Civil War (1861-1865) Union | 140,414 | Desert Shield/Storm (1990-1991) | 148 |
| Civil War (1861-1865) Confederate | 74,524 | | |
| Spanish-American War (1898-1902) | 385 | America’s Wars Total (1775 -1991) | 651,031 |

References:

[1] [CDC Cases](https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html), webpage https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html, various dates.

[2] [Immunity](https://en.wikipedia.org/wiki/Immunity_(medical)), webpage https://en.wikipedia.org/wiki/Immunity_(medical), May 2020.

[3] [Murder by Police Sparked World Wide Demonstrations During COVID-19 Disaster](https://en.wikipedia.org/wiki/Killing_of_George_Floyd), webpage https://en.wikipedia.org/wiki/Killing_of_George_Floyd, June 2020.

[4] [Johns Hopkins University & Medicine Cases](https://coronavirus.jhu.edu/map.html), webpage https://coronavirus.jhu.edu/map.html, various dates.

[5] [COVID19 Trend Analysis Case Study](#), COVID19 Trend Analysis Case Study, Richard Grandrino, Drexel University, June 2020.

[6] [Coronavirus disease 2019](https://en.wikipedia.org/wiki/Coronavirus_disease_2019), webpage https://en.wikipedia.org/wiki/Coronavirus_disease_2019, April 2020.

Death Rates By Country

The reality is that the return to life systems were started the very first day of the virus outbreak. Life continued as the virus spread. Various systems were developed across the planet and by May 2020 there may be sufficient data to determine which return to life systems are more effective. These systems are embedded in different countries and in some cases different states and provinces within various countries.

Two views of this data are offered. The first is a Performance Scale and the other is an attempt to understand it by including additional data so that patterns might be detected.

Excess mortality is the number of deaths occurring in each crisis above and beyond normal conditions. The is accomplished by comparing data from previous years. Data is available from Our World In Data [1] and The Human Mortality Database [2] . local [\[spreadsheet\]](#).

The following data is not based on Excess Mortality, instead it is based on COVID-19 death records.

Data View 1 - Performance Scale

Data May 25, 2020 AM Johns Hopkins University & Medicine [3]

Global Deaths 355,629

More than 1,000,000

More than 100,000

US 100,411 . . 153,320 (8/1/2020)

More than 10,000

United Kingdom 37,542 . Italy 33,072 . France 28,599 . Spain 27,117 . Brazil 25,598 .

More than 1,000

Belgium 9,364 . Mexico 8,597 . Germany 8,428 . Iran 7,564 . Canada 6,876 . Netherlands 5,890 . China 4,638 . India 4,534 . Turkey 4,431 . Sweden 4,220 . Peru 3,983 . Russia 3,968 . Ecuador 3,275 . Switzerland 1,917 . Ireland 1,631 . Indonesia 1,473 . Portugal 1,356 . Romania 1,227 . Pakistan 1,225 . Poland 1,028 .

More than 100

Philippines 904 . Japan 858 . Chile 841 . Egypt 816 . Colombia 803 . Ukraine 658 . Austria 645 . Algeria 623 . Denmark 565 . South Africa 552 . Bangladesh 544 . Hungary 505 . Argentina 500 . Dominican Republic 474 . Saudi Arabia 425 . Czechia 317 . Panama 315 . Finland 313 . Israel 281 . Bolivia 274 . Moldova 274 . Korea, South 269 . United Arab Emirates 255 . Nigeria 254 . Serbia 240 . Norway 235 . Afghanistan 227 . Belarus 214 . Morocco 202 . Sudan 195 . Honduras 194 . Cameroon 175 . Iraq 175 . Kuwait 175 . Greece 173 . Bosnia and Herzegovina 151 . Bulgaria 133 . North Macedonia 119 . Malaysia 115 . Luxembourg 110 . Slovenia 108 . Australia 103 . Croatia 101 .

More than 10

Armenia 98 . Cuba 82 . Mali 70 . Congo (Kinshasa) 68 . Guatemala 68 . Somalia 67 . Estonia 66 . Lithuania 66 . Chad 64 . Niger 63 . Thailand 57 . Kenya 55 . Azerbaijan 54 . Burkina Faso 53 . Yemen 53 . Andorra 51 . Tunisia 48 . Tajikistan 47 . Sierra Leone 45 . San Marino 42 . El Salvador 39 . Oman 39 . Senegal 38 . Kazakhstan 37 . Nicaragua 35 . Ghana 34 . Albania 33 . Haiti 33 . Cote d'Ivoire 31 . Kosovo 30 . Qatar 30 . Slovakia 28 . Liberia 27 . Lebanon 26 . Latvia 23 . Singapore 23 . New Zealand 22 . Uruguay 22 . Tanzania 21 . Guinea 20 . Congo

(Brazzaville) 19 . Djibouti 18 . Cyprus 17 . Kyrgyzstan 16 . Mauritania 16 . Bahrain 15 . Gabon 14 . Uzbekistan 14 . Diamond Princess 13 . Togo 13 . Equatorial Guinea 12 . Georgia 12 . Sao Tome and Principe 12 . Bahamas 11 . Guyana 11 . Paraguay 11 . Venezuela 11 . Iceland 10 . Costa Rica 10 . Mauritius 10 . South Sudan 10 . Sri Lanka 10 .

Less than 10

Jamaica 9 . Jordan 9 . Montenegro 9 . Trinidad and Tobago 8 . Barbados 7 . Guinea-Bissau 7 . Malta 7 . Taiwan* 7 . Zambia 7 . Burma 6 . Ethiopia 6 . Maldives 5 . Angola 4 . Cabo Verde 4 . Libya 4 . Malawi 4 . Monaco 4 . Nepal 4 . Syria 4 . Zimbabwe 4 . Antigua and Barbuda 3 . Benin 3 . West Bank and Gaza 3 . Belize 2 . Brunei 2 . Comoros 2 . Eswatini 2 . MS Zaandam 2 . Madagascar 2 . Botswana 1 . Burundi 1 . Central African Republic 1 . Gambia 1 . Liechtenstein 1 . Mozambique 1 . Suriname 1 . Western Sahara 1 .

Data View 2 - Performance Scale With Additional Data

May 26, 2020 PM Worldmeters [4]

As the data is examined patterns need to be identified. It is easy to dismiss the data as being inaccurate. However, in a systems analysis we must assume the data has the same level of accuracy across all the data points. Instead there is a search for a pattern. The difference may be due to environment, genes, food, culture, virus mitigation action plan, or another element. We know that the environment is not a factor, temperature and humidity are not relevant. Some suggest genes may be the source however there are examples suggesting that is not the case when adjacent countries are examined. Food like genes can be discounted for the same reason, adjacent countries have significant differences. The remaining variables are culture and virus mitigation action plans. [[spreadsheet](#)]

| # | Country | Deaths (Sorted by) | Cases/1M | Deaths/1M | Population | Observations |
|---|---------|--------------------|----------|-----------|---------------|--|
| | World | 351,601 | 728 | 45.1 | 7,750,747,910 | |
| 1 | USA | 100,545 | 5,215 | 304 | 330,811,717 | The US is geographically very diverse. Examining the numbers by state may offer some insights. For example, Hawaii always has trade winds and perhaps people tend to live outside rather than in enclosed office buildings. As an island(s) state the culture may be more sensitive to pandemics and they may have a very effective virus mitigation |

| # | Country | Deaths (Sorted by) | Cases/1M | Deaths/1M | Population | Observations |
|----|-------------|--------------------------|----------|-----------|---------------|--------------|
| | | | | | | plan. |
| 2 | UK | 37,048 | 3,909 | 546 | 67,851,047 | |
| 3 | Italy | 32,955 | 3,813 | 545 | 60,470,230 | |
| 4 | France | 28,530 | 2,800 | 437 | 65,259,581 | |
| 5 | Spain | 27,117 | 6,060 | 580 | 46,753,049 | |
| 6 | Brazil | 24,512 | 1,842 | 115 | 212,409,786 | |
| 7 | Belgium | 9,334 | 4,960 | 806 | 11,584,702 | |
| 8 | Germany | 8,498 | 2,164 | 101 | 83,757,965 | |
| 9 | Mexico | 7,633 | 552 | 59 | 128,796,145 | |
| 10 | Iran | 7,508 | 1,663 | 90 | 83,883,203 | |
| 11 | Canada | 6,639 | 2,298 | 176 | 37,709,091 | |
| 12 | Netherlands | 5,856 | 2,661 | 342 | 17,131,215 | |
| 13 | China | 4,634 | 58 | 3 | 1,439,323,776 | |
| 14 | Turkey | 4,397 | 1,884 | 52 | 84,247,422 | |
| 15 | India | 4,349 | 109 | 3 | 1,378,641,054 | |
| 16 | Sweden | 4,125 | 3,412 | 409 | 10,093,058 | |
| 17 | Russia | 3,807 | 2,483 | 26 | 145,928,485 | |
| 18 | Peru | 3,788 | 3,941 | 115 | 32,924,686 | |
| 19 | Ecuador | 3,203 | 2,121 | 182 | 17,615,358 | |
| 20 | Switzerland | 1,915 | 3,557 | 221 | 8,648,347 | |
| 21 | Ireland | 1,615 | 5,015 | 327 | 4,932,204 | |
| 22 | Indonesia | 1,418 | 85 | 5 | 273,231,828 | |
| 23 | Portugal | 1,342 | 3,040 | 132 | 10,199,497 | |

| # | Country | Deaths (Sorted by) | Cases/1M | Deaths/1M | Population | Observations |
|----|--------------------|--------------------|----------|-----------|-------------|---|
| 24 | Romania | 1,216 | 957 | 63 | 19,249,480 | |
| 25 | Pakistan | 1,197 | 262 | 5 | 220,438,956 | |
| 26 | Poland | 1,024 | 583 | 27 | 37,850,537 | |
| 27 | Philippines | 886 | 134 | 8 | 109,431,787 | |
| 28 | Japan | 846 | 131 | 7 | 126,512,743 | It is possible that as an extremely high technology society they may have a very effective virus mitigation action plan. |
| 29 | Chile | 806 | 4,082 | 42 | 19,099,822 | |
| 30 | Egypt | 797 | 184 | 8 | 102,130,974 | Personal Observation circa 1995: The people in Egypt live outside. The car windows are always rolled down and the high rise apartments have no windows. |
| 31 | Colombia | 776 | 453 | 15 | 50,828,154 | |
| 32 | Ukraine | 644 | 493 | 15 | 43,757,987 | |
| 33 | Austria | 643 | 1,839 | 71 | 9,001,347 | |
| 34 | Algeria | 617 | 199 | 14 | 43,767,938 | |
| 35 | Denmark | 563 | 1,974 | 97 | 5,790,221 | |
| 36 | South Africa | 524 | 410 | 9 | 59,232,433 | |
| 37 | Bangladesh | 522 | 223 | 3 | 164,524,398 | |
| 38 | Hungary | 499 | 390 | 52 | 9,662,656 | |
| 39 | Argentina | 490 | 293 | 11 | 45,154,246 | |
| 40 | Dominican Republic | 468 | 1,409 | 43 | 10,836,968 | |

| # | Country | Deaths (Sorted by) | Cases/1M | Deaths/1M | Population | Observations |
|----|--------------|--------------------------|----------|-----------|-------------|--|
| 41 | Saudi Arabia | 411 | 2,207 | 12 | 34,757,706 | |
| 42 | Czechia | 317 | 845 | 30 | 10,707,069 | |
| 43 | Panama | 313 | 2,657 | 73 | 4,307,725 | |
| 44 | Finland | 312 | 1,196 | 56 | 5,539,893 | |
| 45 | Israel | 281 | 1,822 | 31 | 9,197,590 | |
| 46 | S. Korea | 269 | 219 | 5 | 51,264,961 | It is unclear if people live outside in S. Korea. It is possible that as an extremely high technology society they may have a very effective virus mitigation action plan. |
| 47 | Moldova | 267 | 1,810 | 66 | 4,034,845 | |
| 48 | Bolivia | 261 | 571 | 22 | 11,656,694 | |
| 49 | UAE | 253 | 3,147 | 26 | 9,878,250 | |
| 50 | Nigeria | 249 | 41 | 1 | 205,584,173 | |
| 51 | Serbia | 239 | 1,284 | 27 | 8,740,651 | |
| 52 | Norway | 235 | 1,548 | 43 | 5,417,027 | |
| 53 | Afghanistan | 220 | 305 | 6 | 38,834,157 | |
| 54 | Belarus | 208 | 4,028 | 22 | 9,449,619 | |
| 55 | Morocco | 202 | 206 | 5 | 36,866,123 | |
| 56 | Honduras | 182 | 424 | 18 | 9,888,260 | |
| 57 | Cameroon | 175 | 205 | 7 | 26,473,989 | |
| 58 | Greece | 173 | 277 | 17 | 10,427,777 | Greece takes great pride in the virus mitigation action plan that they enacted very early in the COVID-19 outbreak. One news report showed that they even spray |

| # | Country | Deaths (Sorted by) | Cases/1M | Deaths/1M | Population | Observations |
|----|------------------------|--------------------------|----------|-----------|------------|--|
| | | | | | | their outdoor beach lounges with disinfectant. |
| 59 | Kuwait | 172 | 5,294 | 40 | 4,264,055 | |
| 60 | Sudan | 170 | 91 | 4 | 43,738,792 | |
| 61 | Iraq | 169 | 121 | 4 | 40,125,564 | |
| 62 | Bosnia and Herzegovina | 149 | 736 | 45 | 3,282,698 | |
| 63 | Bulgaria | 130 | 351 | 19 | 6,953,227 | |
| 64 | North Macedonia | 116 | 967 | 56 | 2,083,382 | |
| 65 | Malaysia | 115 | 235 | 4 | 32,323,664 | |
| 66 | Luxembourg | 110 | 6,393 | 176 | 624,919 | |
| 67 | Slovenia | 108 | 707 | 52 | 2,078,911 | |
| 68 | Australia | 102 | 280 | 4 | 25,469,872 | |
| 69 | Croatia | 101 | 546 | 25 | 4,107,599 | |
| 70 | Armenia | 91 | 2,498 | 31 | 2,962,710 | |
| 71 | Cuba | 82 | 173 | 7 | 11,327,273 | |
| 72 | Mali | 70 | 53 | 3 | 20,186,088 | |
| 73 | DRC | 68 | 27 | 0.8 | 89,256,655 | |
| 74 | Somalia | 67 | 108 | 4 | 15,844,234 | |
| 75 | Estonia | 65 | 1,383 | 49 | 1,326,450 | |
| 76 | Lithuania | 65 | 601 | 24 | 2,725,640 | |
| 77 | Niger | 63 | 39 | 3 | 24,105,596 | |
| 78 | Chad | 62 | 43 | 4 | 16,373,575 | |

| # | Country | Deaths (Sorted by) | Cases/1M | Deaths/1M | Population | Observations |
|-----|--------------------|--------------------------|----------|-----------|------------|--------------|
| 79 | Guatemala | 59 | 210 | 3 | 17,880,705 | |
| 80 | Thailand | 57 | 44 | 0.8 | 69,783,058 | |
| 81 | Azerbaijan | 52 | 435 | 5 | 10,130,034 | |
| 82 | Kenya | 52 | 25 | 1.0 | 53,644,375 | |
| 83 | Burkina Faso | 52 | 40 | 2 | 20,840,103 | |
| 84 | Andorra | 51 | 9,877 | 660 | 77,253 | |
| 85 | Yemen | 49 | 8 | 2 | 29,755,574 | |
| 86 | Tunisia | 48 | 89 | 4 | 11,806,151 | |
| 87 | Tajikistan | 47 | 343 | 5 | 9,514,637 | |
| 88 | Channel Islands | 45 | 3,218 | 259 | 173,702 | |
| 89 | Sierra Leone | 44 | 95 | 6 | 7,959,753 | |
| 90 | San Marino | 42 | 19,632 | 1,238 | 33,924 | |
| 91 | Kazakhstan | 37 | 478 | 2 | 18,753,881 | |
| 92 | Oman | 37 | 1,594 | 7 | 5,092,460 | |
| 93 | Senegal | 36 | 189 | 2 | 16,695,568 | |
| 94 | El Salvador | 36 | 315 | 6 | 6,483,000 | |
| 95 | Nicaragua | 35 | 115 | 5 | 6,616,547 | |
| 96 | Ghana | 34 | 230 | 1 | 31,003,853 | |
| 97 | Albania | 33 | 358 | 11 | 2,878,095 | |
| 98 | Haiti | 31 | 93 | 3 | 11,388,384 | |
| 99 | Ivory Coast | 30 | 94 | 1 | 26,307,273 | |
| 100 | Qatar | 28 | 16,414 | 10 | 2,875,978 | |

| # | Country | Deaths (Sorted by) | Cases/1M | Deaths/1M | Population | Observations |
|-----|---------------------|--------------------------|----------|-----------|------------|--------------|
| 101 | Slovakia | 28 | 277 | 5 | 5,459,389 | |
| 102 | Lebanon | 26 | 167 | 4 | 6,828,287 | |
| 103 | Liberia | 26 | 53 | 5 | 5,044,844 | |
| 104 | Isle of Man | 24 | 3,953 | 282 | 84,989 | |
| 105 | Singapore | 23 | 5,533 | 4 | 5,845,767 | |
| 106 | Latvia | 22 | 558 | 12 | 1,888,068 | |
| 107 | Uruguay | 22 | 227 | 6 | 3,472,561 | |
| 108 | New Zealand | 21 | 312 | 4 | 4,818,333 | |
| 109 | Tanzania | 21 | 9 | 0.4 | 59,545,671 | |
| 110 | Guinea | 20 | 250 | 2 | 13,093,597 | |
| 111 | Mayotte | 20 | 6,005 | 74 | 272,102 | |
| 112 | Cyprus | 17 | 778 | 14 | 1,206,488 | |
| 113 | Kyrgyzstan | 16 | 225 | 2 | 6,512,990 | |
| 114 | Congo | 16 | 88 | 3 | 5,503,335 | |
| 115 | Sint Maarten | 15 | 1,798 | 350 | 42,827 | |
| 116 | Bahrain | 14 | 5,526 | 8 | 1,694,805 | |
| 117 | Uzbekistan | 14 | 98 | 0.4 | 33,419,241 | |
| 118 | Djibouti | 14 | 2,502 | 14 | 986,520 | |
| 119 | Gabon | 14 | 1,008 | 6 | 2,220,060 | |
| 120 | Martinique | 14 | 525 | 37 | 375,293 | |
| 121 | Guadeloupe | 14 | 402 | 35 | 400,117 | |
| 122 | Diamond Princess | 13 | | | 0 | |

| # | Country | Deaths (Sorted by) | Cases/1M | Deaths/1M | Population | Observations |
|-----|--------------------------|--------------------------|----------|-----------|------------|--------------|
| 123 | Togo | 13 | 47 | 2 | 8,257,779 | |
| 124 | Mauritania | 13 | 58 | 3 | 4,636,268 | |
| 125 | Equatorial Guinea | 12 | 746 | 9 | 1,397,760 | |
| 126 | Georgia | 12 | 183 | 3 | 3,989,889 | |
| 127 | Sao Tome and Principe | 12 | 2,016 | 55 | 218,731 | |
| 128 | Venezuela | 11 | 43 | 0.4 | 28,443,500 | |
| 129 | Paraguay | 11 | 123 | 2 | 7,123,619 | |
| 130 | Guyana | 11 | 177 | 14 | 786,181 | |
| 131 | Bahamas | 11 | 255 | 28 | 392,867 | |
| 132 | Iceland | 10 | 5,290 | 29 | 341,024 | |
| 133 | Sri Lanka | 10 | 62 | 0.5 | 21,404,496 | |
| 134 | Costa Rica | 10 | 188 | 2 | 5,089,461 | |
| 135 | Mauritius | 10 | 263 | 8 | 1,271,565 | |
| 136 | Jordan | 9 | 70 | 0.9 | 10,192,951 | |
| 137 | Jamaica | 9 | 188 | 3 | 2,959,906 | |
| 138 | Montenegro | 9 | 516 | 14 | 628,058 | |
| 139 | Bermuda | 9 | 2,231 | 144 | 62,299 | |
| 140 | South Sudan | 8 | 72 | 0.7 | 11,180,404 | |
| 141 | Trinidad and Tobago | 8 | 83 | 6 | 1,399,048 | |
| 142 | Guinea- Bissau | 7 | 600 | 4 | 1,962,975 | |
| 143 | Zambia | 7 | 50 | 0.4 | 18,327,041 | |

| # | Country | Deaths (Sorted by) | Cases/1M | Deaths/1M | Population | Observations |
|-----|------------------------|--------------------------|----------|-----------|-------------|--------------|
| 144 | Taiwan | 7 | 19 | 0.3 | 23,812,627 | |
| 145 | Barbados | 7 | 320 | 24 | 287,341 | |
| 146 | Ethiopia | 6 | 6 | 0.05 | 114,654,045 | |
| 147 | Malta | 6 | 1,384 | 14 | 441,429 | |
| 148 | Myanmar | 6 | 4 | 0.1 | 54,373,757 | |
| 149 | Maldives | 5 | 2,665 | 9 | 539,547 | |
| 150 | Hong Kong | 4 | 142 | 0.5 | 7,490,925 | |
| 151 | Nepal | 4 | 27 | 0.1 | 29,081,827 | |
| 152 | Cabo Verde | 4 | 702 | 7 | 555,377 | |
| 153 | Syria | 4 | 7 | 0.2 | 17,454,561 | |
| 154 | Malawi | 4 | 5 | 0.2 | 19,075,919 | |
| 155 | Monaco | 4 | 2,499 | 102 | 39,214 | |
| 156 | Angola | 4 | 2 | 0.1 | 32,751,429 | |
| 157 | Zimbabwe | 4 | 4 | 0.3 | 14,840,631 | |
| 158 | Palestine | 3 | 84 | 0.6 | 5,088,625 | |
| 159 | Benin | 3 | 17 | 0.2 | 12,088,427 | |
| 160 | Aruba | 3 | 946 | 28 | 106,722 | |
| 161 | Libya | 3 | 11 | 0.4 | 6,861,713 | |
| 162 | Saint Martin | 3 | 1,036 | 78 | 38,597 | |
| 163 | Antigua and Barbuda | 3 | 255 | 31 | 97,848 | |
| 164 | Madagascar | 2 | 21 | 0.07 | 27,613,258 | |
| 165 | Eswatini | 2 | 225 | 2 | 1,158,954 | |

| # | Country | Deaths (Sorted by) | Cases/1M | Deaths/1M | Population | Observations |
|-----|---------------------------|--------------------------|----------|-----------|------------|--------------|
| 166 | Belize | 2 | 45 | 5 | 396,870 | |
| 167 | MS Zaandam | 2 | | | 0 | |
| 168 | CAR | 1 | 139 | 0.2 | 4,820,985 | |
| 169 | Reunion | 1 | 513 | 1 | 894,679 | |
| 170 | French Guiana | 1 | 1,289 | 3 | 297,835 | |
| 171 | Mozambique | 1 | 7 | 0.03 | 31,158,631 | |
| 172 | Brunei | 1 | 323 | 2 | 437,059 | |
| 173 | Cayman Islands | 1 | 2,041 | 15 | 65,644 | |
| 174 | Comoros | 1 | 100 | 1 | 867,624 | |
| 175 | Liechtenstein | 1 | 2,151 | 26 | 38,117 | |
| 176 | Burundi | 1 | 4 | 0.08 | 11,851,274 | |
| 177 | Botswana | 1 | 15 | 0.4 | 2,346,588 | |
| 178 | Gambia | 1 | 10 | 0.4 | 2,409,159 | |
| 179 | Curaçao | 1 | 110 | 6 | 164,028 | |
| 180 | Turks and Caicos | 1 | 310 | 26 | 38,663 | |
| 181 | Montserrat | 1 | 2,204 | 200 | 4,992 | |
| 182 | Suriname | 1 | 19 | 2 | 586,106 | |
| 183 | Western Sahara | 1 | 15 | 2 | 595,744 | |
| 184 | British Virgin Islands | 1 | 265 | 33 | 30,211 | |
| 185 | Rwanda | | 26 | | 12,917,314 | |

| # | Country | Deaths (Sorted by) | Cases/1M | Deaths/1M | Population | Observations |
|-----|---------------------------|--------------------------|----------|-----------|------------|--------------|
| 186 | Vietnam | | 3 | | 97,250,965 | |
| 187 | Uganda | | 6 | | 45,578,341 | |
| 188 | Faeroe Islands | | 3,828 | | 48,845 | |
| 189 | Gibraltar | | 4,571 | | 33,692 | |
| 190 | Mongolia | | 43 | | 3,272,806 | |
| 191 | Cambodia | | 7 | | 16,695,214 | |
| 192 | French Polynesia | | 214 | | 280,748 | |
| 193 | Macao | | 69 | | 648,427 | |
| 194 | Eritrea | | 11 | | 3,541,383 | |
| 195 | Bhutan | | 35 | | 770,749 | |
| 196 | Timor-Leste | | 18 | | 1,315,796 | |
| 197 | Grenada | | 204 | | 112,472 | |
| 198 | Namibia | | 8 | | 2,536,074 | |
| 199 | Laos | | 3 | | 7,264,685 | |
| 200 | Fiji | | 20 | | 895,801 | |
| 201 | New Caledonia | | 63 | | 285,223 | |
| 202 | Saint Lucia | | 98 | | 183,545 | |
| 203 | St. Vincent Grenadines | | 162 | | 110,906 | |
| 204 | Dominica | | 222 | | 71,969 | |
| 205 | Saint Kitts and Nevis | | 282 | | 53,162 | |

| # | Country | Deaths (Sorted by) | Cases/1M | Deaths/1M | Population | Observations |
|-----|-----------------------|--------------------|----------|-----------|---------------|--------------|
| 206 | Falkland Islands | | 3,747 | | 3,469 | |
| 207 | Greenland | | 211 | | 56,761 | |
| 208 | Vatican City | | 14,981 | | 801 | |
| 209 | Seychelles | | 112 | | 98,287 | |
| 210 | Papua New Guinea | | 0.9 | | 8,929,153 | |
| 211 | Caribbean Netherlands | | 229 | | 26,199 | |
| 212 | St. Barth | | 608 | | 9,874 | |
| 213 | Anguilla | | 200 | | 14,990 | |
| 214 | Lesotho | | 0.9 | | 2,140,560 | |
| 215 | Saint Pierre Miquelon | | 173 | | 5,797 | |
| | Total: | 351,601 | 728.3 | 45.1 | 7,750,747,910 | |

References:

[1] [Our World In Data](https://ourworldindata.org/excess-mortality-covid), webpage <https://ourworldindata.org/excess-mortality-covid>, various dates.

[2] [The Human Mortality Database](https://www.mortality.org), webpage <https://www.mortality.org>, various dates.

[3] [Johns Hopkins University & Medicine](https://coronavirus.jhu.edu/map.html), webpage <https://coronavirus.jhu.edu/map.html>, May 25, 2020.

[4] [Worldmeters](https://www.worldometers.info/coronavirus), webpage <https://www.worldometers.info/coronavirus>, May 26, 2020.

US Failure to Contain the Virus

As of July 2020 the US failed to contain the virus.

Many states following political dogma from zealots rather than medical advice are seeing massive increases in the virus spread. Hospitals are starting to be overwhelmed in these states.

They did not follow reopening guidance where disease transmission is under control, specifically that they have a 14 day decline in the infection rate. The Governors ignored the daily infection data provided by their medical professionals. Instead they engaged in catastrophically flawed management practices of just pushing an agenda regardless of the harm and the harm in this case is grave harm [1]. The people were not wearing masks in public settings, they were not social distancing, and they consciously decided to attend venues with large crowds inside close indoor spaces.

It should be noted that as the summer months approached people in the sunbelt tend to move from outdoor into air conditioned indoor venues. The combination of the indoor venues and disregard for guidance from the medical professions is what led to the sudden increase in the infection rates.

On January 9, 2020 the Chinese Center for Disease Control and Prevention reported that a new coronavirus, severe acute respiratory syndrome coronavirus-2 (SARS-Cov-2), had been identified as the cause of COVID-19, and the genomic sequence was made public. In early December 2019 the Chinese Government identified a cluster of people infected with pneumonia and no clear causes. Chinese scientists linked what they thought was a pneumonia like illness to a new strain of coronavirus that was given the initial designation 2019 Novel Coronavirus (2019-nCoV). Some of the first symptoms appeared on December 10, 2019. The initial 24 cases were traced to the Huanan Seafood Wholesale Market in Wuhan. On January 10, 2020 the first death and 41 clinically confirmed infections caused by the coronavirus were reported [2].

Lock down in China:

- January 23, 2020 transport in Wuhan, Huanggang and Ezhou severely restricted, including closure of public transit, trains, airports, and major highways.
- January 24, 2020 travel restrictions enacted in 12 additional prefecture-level cities in Hubei.
- February 13, 2020 the Chinese government issues extension of order to shut down all non-essential companies, including manufacturing plants, in Hubei Province until at least February 20, 2020.
- February 20, 2020 the Chinese government issues extension of order to shut down all non-essential companies, including manufacturing plants, and all schools in Hubei Province until at least March 10, 2020.

Italy was the first European nation to be affected by COVID-19 [3]. The virus was first confirmed to have spread to Italy on January 31, 2020 when two Chinese tourists in Rome tested positive for the virus. On January 31, 2020 the Italian government suspended all flights to and from China and declared a state of emergency [4].

Quarantine

On June 24, 2020 the Governors from the states of New Jersey, New York and Connecticut implemented a 14-day quarantine program for travelers coming from coronavirus hotspot states. Anyone arriving in New York, New Jersey and Connecticut from any of the states listed, regardless of the amount of time spent in that state starting June 25, 2020 should self-quarantine for 14 days. This includes travel by train, bus, car, plane and any other method of transportation. The state of New York established fines for people who enter from certain states and don't

voluntarily quarantine for 14 days will be subject to fines and a mandatory quarantine. The fines will be 2,000 for the first violation, 5,000 for the second and up to 10,000 if they cause harm. [5].

1. Quarantine 6/24/2020: Alabama, Arkansas Arizona, Florida, North Carolina, South Carolina, Texas, Utah - 8 states
2. Quarantine 6/30/2020: Alabama, Arkansas, Arizona, California, Florida, Georgia, Iowa, Idaho, Louisiana, Mississippi, North Carolina, Nevada, South Carolina, Tennessee, Texas, Utah - 16 states
3. Quarantine 7/07/2020: Alabama, Arkansas, Arizona, California, Delaware, Florida, Georgia, Iowa, Idaho, Kansas, Louisiana, Mississippi, North Carolina, Nevada, Oklahoma, South Carolina, Tennessee, Texas, Utah - 19 states
4. Quarantine 7/22/2020: Alabama, Alaska, Arkansas, Arizona, California, Delaware, Florida, Georgia, Iowa, Idaho, Indiana, Kansas, Louisiana, Maryland, Mississippi, Missouri, Montana, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, Wisconsin, Note: Minnesota was removed from the list on 7/21/20. - 31 states
5. Quarantine 7/28/2020: Alabama, Alaska, Arkansas, Arizona, California, Delaware, District of Columbia, Florida, Georgia, Iowa, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Puerto Rico, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, Wisconsin. - 35 states + 1 U.S. territory.

The state of Hawaii had this policy in place for months. All tourists in Hawaii are required to quarantine for 14 days in designated locations. If they violate their quarantine they are escorted to the airport and put on the next flight out of Hawaii [6]. A press release was issued on March 21, 2020.

Press Release Mar 21, 2020

HONOLULU – Gov. David Y. Ige issued a second supplemental emergency proclamation ordering all individuals, both residents and visitors, arriving or returning to the State of Hawaii to a mandatory 14-day self-quarantine. The mandate — the first such action in the nation — applies to all arrivals at state airports from the continental U.S. and international destinations and extends to other private and commercial aircrafts.

“With the majority of Hawaii’s COVID-19 cases linked to travel, it is critical that we further mitigate the spread of the virus by both residents and visitors who are coming from out-of-state,” said Gov. Ige. “This plan was developed in collaboration with our county mayors and Hawaii’s business, community and visitor industry leaders.”

All visitors and residents arriving through Hawaii’s airports will be required to complete a Hawaii Department of Agriculture form that will be distributed onboard their flight. They will retain the form when disembarking the aircraft. Upon arrival, they will go through a checkpoint and present the completed form with a valid identification. Checkpoint staff will validate the form and issue documentation that certifies they cleared the checkpoint. The form also includes information on the mandatory requirements for the 14-day quarantine along with penalties.

The mandatory 14-day self-quarantine orders are:

1. *Proceed directly from the airport to your designated quarantine location, which is the location identified and affirmed by you on the mandatory State of Hawaii Department of Agriculture Plants and Animals Declaration Form.*
 2. *Remain in your designated quarantine location for a period of 14 days or the duration of your stay in the State of Hawaii, whichever is shorter.*
 - *If you are a resident, your designated quarantine location is your place of residence.*
 - *If you are a visitor, your designated quarantine location is your hotel room or rented lodging.*
 - *You can only leave your designated quarantine location for medical emergencies or to seek medical care.*
-
1. *Do not visit any public spaces, including but not limited to pools, meeting rooms, fitness centers or restaurants.*
 2. *Do not allow visitors in or out of your designated quarantine location other than a physician, healthcare provider, or individual authorized to enter the designated quarantine location by the Director of HIEMA.*
 3. *Comply with any and all rules or protocols related to your quarantine as set forth by your hotel or rented lodging.*
 4. *If you become ill with a fever or cough:*
 - *Continue to stay in designated quarantine location, avoid contact with others and contact a healthcare provider for further instructions on treatment or testing.*
 - *If you are older or have any medical conditions (e.g., immune compromise, diabetes, asthma), consult your regular healthcare provider.*
 - *If you feel you need medical care, contact healthcare provider and inform them of your travel history.*
 - *If you need urgent medical care (e.g., have difficulty breathing), call 9-1-1 and let the dispatcher know your travel history).*

Failure to follow this order is a misdemeanor and punishable by a maximum fine of 5,000, or imprisonment of not more than one year, or both. Enforcement will be handled by each of Hawaii's four counties.

The mandate will go into effect at 12:01 a.m. on Thursday, March 26, 2020.

“These actions are extreme, but they will help flatten the curve and lay the groundwork for a quicker recovery. We need everyone to comply with these quarantine orders to help protect Hawaii's residents,” added Ige.

###

On March 11, 2020 the number of cases in US was 29. On April 1, 2020 the number of cases was 3,746. Both these numbers are manageable using contact tracing where all the people that may have been exposed to the virus could have been contacted and quarantined. [7]

The Canadian response is a whole Government response as evidenced by their citizen friendly website [8]. Early in the outbreak citizens that traveled by air were able to enter their flight numbers and they would be provided information if they were at risk of virus infection. A

Canadian Quarantine Act was passed on March 24, 2020. Compliance and enforcement is as follows: [9]

Compliance and enforcement of the Quarantine Act

The Government of Canada is working with federal and provincial partners to promote and verify compliance of the emergency order with active communication and spot checks.

If you are permitted to enter Canada, you will be:

- *asked if you have a cough, fever or difficulty breathing*
- *required to acknowledge that you must:*
 - *isolate for 14 days if you have symptoms of COVID-19 or*
 - *quarantine (self-isolate) for 14 days if you do not have symptoms*
- *asked if you have a suitable place to isolate or quarantine (self-isolate)*
 - *a suitable place is one where you will have basic necessities, such as food and medication, and where you will not have contact with vulnerable people*
- *given instructions about your obligations under the emergency order*

Violating any instructions provided to you when you entered Canada is an offence under the Quarantine Act and could lead to up to:

- *6 months in prison and/or*
- *750,000 in fines*

Further, a person who causes a risk of imminent death or serious bodily harm to another person while wilfully or recklessly contravening this act or the regulations could be liable for:

- *a fine of up to 1,000,000 or*
- *imprisonment of up to 3 years or*
- *both*

The Contraventions Act has been changed to give police (including RCMP, provincial and local police) more power to enforce the Quarantine Act. They can now issue tickets to people who do not comply with the act. Fines range from 275 to 1000.

Surveillance Systems

The CDC manages a very large number of health surveillance systems that includes collecting data from local and state health officials through the National Notifiable Diseases Surveillance System ([NNDSS](#)). The CDC also gathers information from medical facilities and public health departments on potentially dangerous health symptoms before they have been diagnosed by medical experts in the National Syndromic Surveillance Program ([NSSP](#)). The CDC US epidemiologist embedded in China's public-health system position was eliminated just months before the coronavirus outbreak began. As a result, the CDC could only get information from Chinese authorities, who covered up the severity of the crisis. Chinese police reprimanded a doctor who warned of the outbreak. He later died of the virus [12].

By mid-January, the US intelligence community started briefing the President on the outbreak. The Director of National Intelligence Dan Coats told Congress in January 2019 that a large-scale outbreak could lead to massive rates of death and disability, severely affect the world economy, strain international resources, and increase calls on the United States for support [12] [13].

Pandemic detection within the intelligence community is performed by agencies like the National Center for Medical Intelligence (NCMI). It is part of the Department of Defense and it tracks emerging diseases, bioterrorist threats and the medical capabilities of other countries. The NCMI has access to information that is not available to the CDC, WHO, or anyone else outside of the intelligence community. Its staff includes virologists, epidemiologists, toxicologists, medical doctors, veterinarians and other experts with medical experience from the military services. In normal times NCMI serves the US military and uses the information to monitor potential health threats to US military stationed abroad [14] [15].

US Response:

- On December 10, 2020 the US was alerted to the potential health threat
- On January 23, the US knew that the health threat was grave
- On January 31, 2020 the US shuts down flights from China but NOT from Europe, Flights between the US and Italy continue during the massive outbreak in Italy
- March 11, 2020 Nearly all travel from Europe to the United States is suspended for 30 days

The WHO has been warning for years about the possibility of a new pandemic. In 2018 the group published a list of disease threats, including one called Disease X, where a serious international epidemic could be caused by an unknown pathogen [12].

Data is starting to suggest that the US performance to the pandemic is very poor. The issue is that the virus has spread and containment must still be a top priority. This is based on many elements in the system and one of the key elements is contact tracing, however the US is performing poorly on contact tracing [10] [11].

Contact Tracing

In Florida 5 out of 27 COVID-19 positive cases received a call from health authorities asking for their contacts [10]. In New York City 3,000 contact tracers only had close contact information from 42% of people who tested positive for Covid-19. San Francisco has been able to reach an average of 83% of Covid-19 cases and their contacts [11].

The following are key contact tracing system requirements:

- CTR-1 Contact everyone that has been in 1st (100%) and some percentage of 2d, and perhaps 3d degree contact with an infected person. This is important because people can be a-symptomatic and still spread the virus. For example a worker is exposed for 6 hours every day and lives with a spouse (2d degree). The spouse goes into work and interacts with one or more people 6 hours per day (3d degree).
- CTR-2 Ensure that quarantine is not being violated by daily follow up contacts. You cannot trust people in a crisis. The system must be failsafe.

- CTR-3 Ensure that the needs of the people in quarantine are fully addressed (e.g. food, medication, selected services). This is intuitively obvious.
- CTR-4 Provide a citizen friendly website with a map of previous 14 day COVID-19 hotspots so that people know to get tested as soon as possible. This is basic situational awareness.
- CTR-5 This can all be done with a single citizen friendly US Government website. Cannot rely on fragmented information. No one knows where to go or what to do.

As of February 2021 this is how organizations are handling COVID-19 events detected in their facilities.

Major University known for its Engineering program in Philadelphia, PA

February 01, 2021

Dear Faculty Colleagues,

As we increase variety and amount of activities on-campus and with the establishment of our own COVID-19 testing regiment, we wish to remind you of some key do's and don'ts that the University has put into place to ensure that our community remains safe.

If you believe you have been in contact with someone who has tested positive for infection with COVID-19...

Do's:

- *Notify your immediate supervisor (do not reveal names) of the potential exposure.*
- *Remove yourself from the workplace.*
- *Determine if this is a true exposure:*
 - *Students should contact the Student Health Center by phone or through the University Health Tracker app*
 - *Faculty and staff should notify their primary care physician and then immediately after calling your provider contact covid19health contact email*
- *While waiting for guidance, quarantine.*
- *If deemed a true exposure you will be asked to quarantine for 14 days regardless of negative COVID-19 test, unless advised differently by the university COVID-19 team.*
- *Monitor symptoms via University Health Tracker app.*
- *Faculty and staff will receive further guidance regarding FMLA and the return-to-work process following notification to covid19health contact email.*

Don'ts:

- *Don't discuss health conditions or share name(s) or contact info of positive case(s).*
- *Don't attempt to contact trace.*
- *Don't provide any medical advice or impose any quarantine(s) unless directed by a health care professional.*

- *Don't return to work until cleared by University's Occupational Health Provider.*

If you have been in contact with someone else who was in contact with a positive or presumed positive case...

Do's:

- *Continue to work as normal following all established protocols ("contact of a contact" does not trigger investigation nor quarantine).*
- *Monitor symptoms via University Health Tracker app.*
- *Students who develop symptoms must call student health*
- *Employees who develop symptoms must contact their primary care provider and then notify covid19health contact email.*

Don'ts:

- *Don't discuss health conditions or share name(s) or contact info of positive case(s).*
- *Don't attempt to contact trace*

If you learn that a student or employee has tested positive or had a potential exposure...

Do's

- *Advise the student to contact Student Health (phone) and/or the employee to contact covid19health contact email.*
- *Recognize that some students or employees may need to quarantine for 14 days since last exposure.*
- ***Understand that contract tracing will be handled by the Student Health Center and trained contact tracers.***

Don'ts

- *Don't discuss/share health conditions or contact info of positive cases.*
- *Do not start or forward any communications that may have names or medical information included.*
- *Don't attempt to contact trace.*
- *Don't provide any medical advice or impose any quarantine(s) unless directed by a medical professional.*
- *Don't tell employee/student to return to work/class until cleared by University's Occupational Health provider or Student Health, respectively.*

On-campus COVID-19 Testing

- *Student COVID-19 testing requirements*
 - *All students that meet ANY of the following criterion MUST undergo weekly surveillance testing which started January 25th:*
 - *Live in University-affiliated housing or buildings connected to campus properties regardless of the operator,*

- *Have been approved to participate in on-campus research and scholarly activities*
 - *Take face-to-face classes, including simulation labs.*
- *Students living in off-campus housing who are only taking remote classes are strongly recommended to regularly participate in COVID-19 testing even if they are without any symptoms and feel well. This is especially encouraged for students with three or more roommates.*
- *COVID-19 testing is available on campus Monday through Friday via the Health Check app. , even if they are without any symptoms and feel well. Additional information regarding testing, including when and how to schedule a test, can be found on University's Covid-19 Testing, Reporting and Contact-Tracing webpage.*
- *Please remember that if you test positive for COVID-19, a representative from Student Health- in conjunction with the Philadelphia Department of Public Health- will contact you to gain further information in order to identify exposure location and to **properly and confidentially identify and contact any individuals who may have been exposed. Please note that contact tracers will never reveal your identity and diagnosis.***
- *If you have been in contact with a University community member who has tested positive for COVID-19, a member of the University's contact tracing team will call you and provide instructions. Should you receive a call from (phone number), please answer the phone. Failure to participate in contact tracing may result in disciplinary action by the University.*

Please continue to adhere to these protocols. It is your responsibility and obligation to yourself, your family, and your fellow University Community member to be ever vigilant to ensure we are collectively doing all that we can to keep our community safe.

On behalf of Universities' Return Oversight Committee,

This system does not satisfy the key contact tracing requirements of:

- CTR-2 Ensure that quarantine is not being violated by daily follow up contacts and
- CTR-1 Contact everyone that has been in 1st (100%) and some percentage of 2d, and perhaps 3d degree contact with an infected person.

Age 55 Home Owners Association

January 28, 2021

The Board of Trustees has extended the Clubhouse hours from 7am to 8pm.

Face coverings are required while in the Clubhouse and social distancing measures must be employed.

Please make sure you sign in and out and have a fully executed COVID-19 waiver on file with the office.

Thank you and be well!

February 02, 2021

Good Morning Everyone,

The Clubhouse is CLOSED until further notice. Unfortunately, one of our neighbors has tested positive for COVID-19. For contact tracing purposes, this resident was in the Clubhouse on the 27th, 28th, 29th and 30th. To protect the privacy of this individual, I can not divulge any more information. I'm sure you all join me in wishing our neighbor and friend a speedy recovery. Thank you for your patience and cooperation.

Notice that the system relies 100% on previous contact tracing history and does not anticipate if the individual ignores quarantine and comes in contact with other residents in the community. This system does not satisfy the key contact tracing requirements of:

- CTR-2 Ensure that quarantine is not being violated by daily follow up contacts and
- CTR-1 Contact everyone that has been in 1st (100%) and some percentage of 2d, and perhaps 3d degree contact with an infected person.

Both systems, the Age 55 Community and the University, are based on the shutdown of any normal external human communications. This normal human communications existed in 1918 and exists in many other countries in 2020 and 2021. This system relies entirely on the official contact tracing mechanisms and the contact tracing mechanisms only track previous contacts. Further it relies on the trust of the individuals to first get tested and then to maintain quarantine. This is a broken system and the evidence is the US COVID-19 disaster. The virus was not stopped it was only managed at some catastrophic level.

Within the age 55 community during 2020 residents requested the board to investigate installing UV systems in the clubhouse HVAC system and in the rooms. The response was short and swift, the board rejected the request. The reason was these systems cause cancer. There was no discussion or attempt to follow up on the request. In 2021 the residents requested the board to again investigate these systems by contacting companies and the response was these systems cost too much money, no details were given. Once again no follow up or discussion. Like everyone else in the society the system that they are using is based on legal assessments and management damage control [1]. Attempts to solve the problem are not even on the table. In this case there are infection specialists, doctors, engineers, and scientists in the community and all were ignored, just like in the rest of the society.

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Root Cause Analysis - Technical Perspective

Any return to work system needs to include a root cause analysis from a technical perspective. There is a separate root cause analysis that is beyond the technical perspective. These are some considerations when trying to find the root cause from a technical perspective:

1. Why did COVID-19 happen now
2. Typically initial disease outbreaks happen among the poorest in poor countries
3. The COVID-19 initial outbreak happened among the traveling affluent
4. The poor in poor countries initially called COVID-19 the rich traveling persons disease
5. Cruise ships were hit hard by the COVID-19 outbreak

The COVID-19's global spread happening among the relatively rich was offered by multiple popular media circa March 2020 [1]. As time moves on this will disappear from the historical records but it is critical information. This suggests that the mechanism associated with the spread may have been airplanes and cruise ship. They both have ventilation systems and conditions where people are tightly packed together. On a cruise ship the 1 foot social distancing is voluntary while on an airplane the 1 foot social distancing is involuntary. Transmission of influenza, tuberculosis, and severe acute respiratory syndrome (SARS) have been observed on commercial airliners [2] [3]. Airplanes have dense seating but cruise ships are open air settings with internal settings similar to what is found in any city with hotel sleeping arrangements. This includes shopping, restaurants, swimming pools, open air and theater entertainment. The common elements between these two transportation systems are the material used in physical structure and the Heating Ventilation and Cooling (HVAC) systems. In September 2020 two studies were release that showed COVID-19 can spread on airline flights [4] [5] [6].

1. Was there a system change
2. Have the HVAC systems in aircraft, ships, and buildings changed
3. Did previous generations impacted by the Spanish Flu, Polio, etc. use material in the HVAC systems physical structure that killed viruses and bacterial
4. Did previous generations impacted by the Spanish Flu, Polio, etc. use UV lights in HVAC systems and public areas like restrooms (70 year old tech)
5. Did the living spaces use materials that minimized bacterial and virus accumulation
6. Are micron filters useless without these broader considerations
7. Is there forgotten knowledge

Observations:

1. Old brick and aluminum siding houses never had green mold accumulation on the exterior
2. Old houses that used paint over concrete based shingles never had green mold accumulation

3. New houses with vinyl siding have massive green mold accumulation that needs to be treated with house wash twice a year
4. New communities use vinyl siding and more that 75% of the houses are just green with mold - they are never power washed or house washed
5. Is this an unintended consequence of using materials that will not harm the environment
6. Cruise ship cabin surfaces show COVID-19 contamination after 2 weeks, why

When developing systems in the previous century knowing the system environment was critical. One of the environments was fungus and salt fog. The systems had special conformal coating and or used special materials. Otherwise the systems would be overcome by the environment and stop functioning. Moving forward, should a back to work system include:

1. Physical structure modifications using old fungus, bacteria, virus, resistant materials
2. HVAC system modifications based on old forgotten design concepts that minimized fungus, bacteria, and virus exposure
3. UV lights reintroduced into restrooms and other areas of high contamination risks

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Return To Life Systems Performance

As of December 28, 2020 it is possible to examine the different Return To Life Systems that have been established around the world.

It appears that New Zealand may have the most successful system but it required that it closed its borders to all out of country travelers. Initially they stopped the virus internally. They then opened their borders. When the virus entered their country they shut down their borders again with no new cases since that final outbreak. New Zealand's response to the virus has been among the most successful, together with actions taken by China, Taiwan and Thailand early on in the pandemic. The country of 5 million had 25 deaths and managed to stamp out the spread of COVID-19, allowing people to return to workplaces, schools and packed sports stadiums without restrictions [1].

Prime Minister Jacinda Ardern in interviews stated that the only two options countries were considering were (1) herd immunity or (2) flattening the curve. Initially the Prime Minister opted for the latter because the prevailing view was that elimination was impossible. Elimination was the third option that no one was considering. Her thinking quickly changed after the chief science adviser showed a graph of what flattening the curve would look like and the healthcare capacity for New Zealand. The curve wasn't sitting under the hospital and health capacity line. The Prime Minister knew that flattening the curve wasn't sufficient and the third option of elimination must be attempted. Prime Minister Ardern said she didn't worry that elimination might be impossible, because even if New Zealand didn't get there, the approach would still save lives [1].

The bottom line is that New Zealand went beyond flattening the curve. The choice was to save the most lives as quickly as possible and in the process the virus was eliminated. As always be careful what choice you pick. She and New Zealand picked well.

The following is a snapshot of various country Return To Life Systems performance. It is based on the number of deaths per 1 million people. [[spreadsheet](#) Per Dec 28]

The following table shows selected countries doing better than the world average. They are tagged as G for Green. The full list of countries in this category is provided further in this section.

Table 15 - Return To Life Systems Performance Green

| Country | Total Cases | New Cases | Total Deaths | New Deaths | Total Recovered | Active Cases | Serious, Critical | Tot Cases / 1M pop | Deaths / 1M pop | Total Tests | Tests / 1M pop | Population | Tot Test per Pop | P |
|-------------|-------------|-----------|--------------|------------|-----------------|--------------|-------------------|--------------------|-----------------|-------------|----------------|---------------|------------------|---|
| Taiwan | 793 | 8 | 7 | | 654 | 132 | | 33 | 0.3 | 124,021 | 5,203 | 23,837,991 | 0.5% | G |
| Vietnam | 1,451 | 10 | 35 | | 1,303 | 113 | | 15 | 0.4 | 1,431,631 | 14,643 | 97,767,309 | 1.5% | G |
| Thailand | 6,285 | 144 | 60 | | 4,180 | 2,045 | 1 | 90 | 0.9 | 1,217,873 | 17,427 | 69,886,134 | 1.7% | G |
| China | 86,976 | 21 | 4,634 | | 82,003 | 339 | 5 | 60 | 3 | 160,000,000 | 111,163 | 1,439,323,776 | 11.1% | G |
| Singapore | 58,529 | 5 | 29 | | 58,386 | 114 | | 9,966 | 5 | 5,236,487 | 891,638 | 5,872,885 | 89.2% | G |
| New Zealand | 2,144 | | 25 | | 2,069 | 50 | | 429 | 5 | 1,394,812 | 278,845 | 5,002,100 | 27.9% | G |
| Sri Lanka | 41,603 | 549 | 194 | 3 | 33,221 | 8,188 | | 1,939 | 9 | 1,204,350 | 56,128 | 21,457,360 | 5.6% | G |
| Ghana | 54,401 | | 333 | | 53,180 | 888 | 13 | 1,733 | 11 | 656,754 | 20,924 | 31,387,415 | 2.1% | G |
| S. Korea | 57,680 | 808 | 819 | 11 | 39,268 | 17,593 | 295 | 1,125 | 16 | 4,038,307 | 78,733 | 51,290,915 | 7.9% | G |
| Hong Kong | 8,672 | 61 | 139 | 2 | 7,526 | 1,007 | 51 | 1,152 | 18 | 4,943,667 | 656,811 | 7,526,775 | 65.7% | G |
| Japan | 220,236 | 2,924 | 3,252 | 39 | 184,662 | 32,322 | 661 | 1,744 | 26 | 4,725,966 | 37,423 | 126,285,250 | 3.7% | G |
| Australia | 28,337 | 25 | 909 | 1 | 25,733 | 1,695 | | 1,105 | 35 | 11,126,082 | 433,860 | 25,644,423 | 43.4% | G |
| UAE | 202,863 | 1,027 | 660 | 3 | 179,925 | 22,278 | | 20,391 | 66 | 20,440,219 | 2,054,550 | 9,948,758 | 205.5% | G |
| Norway | 47,276 | 217 | 429 | 8 | 37,658 | 9,189 | 27 | 8,687 | 79 | 2,754,609 | 506,175 | 5,442,011 | 50.6% | G |
| Philippines | 470,650 | 766 | 9,124 | 15 | 438,780 | 22,746 | 708 | 4,267 | 83 | 6,679,776 | 60,564 | 110,292,627 | 6.1% | G |
| India | 10,224,271 | 15,546 | 148,180 | 240 | 9,805,908 | 270,183 | 8,944 | 7,373 | 107 | 168,818,054 | 121,746 | 1,386,641,760 | 12.2% | G |
| Denmark | 155,826 | 2,479 | 1,204 | 30 | 114,841 | 39,781 | 113 | 26,856 | 208 | 10,264,912 | 1,769,133 | 5,802,228 | 176.9% | G |
| Kuwait | 149,653 | | 931 | | 145,579 | 3,143 | 36 | 34,792 | 216 | 1,243,422 | 289,077 | 4,301,347 | 28.9% | G |

The following table shows selected countries doing worse than the world average. They are tagged as Y for Yellow. The full list of countries in this category is provided further in this section.

Table 16 - Return To Life Systems Performance Yellow

| Country | Total Cases | New Cases | Total Deaths | New Deaths | Total Recovered | Active Cases | Serious, Critical | Tot Cases / 1M pop | Deaths / 1M pop | Total Tests | Tests / 1M pop | Population | Tot Test per Pop | P |
|--------------|-------------|-----------|--------------|------------|-----------------|--------------|-------------------|--------------------|-----------------|-------------|----------------|-------------|------------------|---|
| World | 81,370,893 | 237,043 | 1,776,284 | 4,761 | 57,484,045 | 22,110,564 | 105,289 | 10,439 | 227.9 | | | | | Y |
| Turkey | 2,162,775 | 15,197 | 20,135 | 257 | 2,037,433 | 105,207 | 4,251 | 25,510 | 237 | 23,958,818 | 282,591 | 84,782,714 | 28.3% | Y |
| Germany | 1,665,534 | 10,212 | 30,838 | 336 | 1,255,700 | 378,996 | 5,535 | 19,848 | 367 | 33,708,381 | 401,694 | 83,915,659 | 40.2% | Y |
| Russia | 3,078,035 | 27,787 | 55,265 | 487 | 2,471,309 | 551,461 | 2,300 | 21,087 | 379 | 89,516,176 | 613,270 | 145,965,290 | 61.3% | Y |
| Canada | 554,295 | 2,275 | 14,970 | 7 | 459,096 | 80,229 | 715 | 14,624 | 395 | 13,438,585 | 354,541 | 37,904,174 | 35.5% | Y |
| Ukraine | 1,030,374 | 4,385 | 17,849 | 75 | 665,729 | 346,796 | 177 | 23,630 | 409 | 5,472,989 | 125,516 | 43,603,742 | 12.6% | Y |
| South Africa | 1,004,413 | | 26,735 | | 844,874 | 132,804 | 546 | 16,832 | 448 | 6,445,318 | 108,009 | 59,673,704 | 10.8% | Y |
| Greece | 135,931 | 475 | 4,672 | 66 | 9,989 | 121,270 | 467 | 13,073 | 449 | 3,283,621 | 315,797 | 10,397,879 | 31.6% | Y |

The following table shows selected countries doing significantly worse than the world average. They are tagged as O for Orange. The full list of countries in this category is provided further in this section.

Table 17 - Return To Life Systems Performance Orange

| Country | Total Cases | New Cases | Total Deaths | New Deaths | Total Recovered | Active Cases | Serious, Critical | Tot Cases / 1M pop | Deaths / 1M pop | Total Tests | Tests / 1M pop | Population | Tot Test per Pop | P |
|-------------|-------------|-----------|--------------|------------|-----------------|--------------|-------------------|--------------------|-----------------|-------------|----------------|-------------|------------------|---|
| Netherlands | 770,400 | 7,415 | 11,042 | 44 | N/A | N/A | 651 | 44,912 | 644 | 5,770,408 | 336,398 | 17,153,526 | 33.6% | O |
| Poland | 1,261,010 | 3,211 | 27,147 | 29 | 1,005,376 | 228,487 | 1,599 | 33,337 | 718 | 7,078,555 | 187,134 | 37,826,168 | 18.7% | O |
| Sweden | 396,048 | | 8,279 | | N/A | N/A | 302 | 39,096 | 817 | 4,272,532 | 421,764 | 10,130,157 | 42.2% | O |
| Switzerland | 438,284 | 10,087 | 7,361 | 151 | 317,600 | 113,323 | 432 | 50,461 | 847 | 3,559,277 | 409,788 | 8,685,645 | 41.0% | O |
| Brazil | 7,486,094 | 1,809 | 191,207 | 61 | 6,515,370 | 779,517 | 8,318 | 35,097 | 896 | 28,600,000 | 134,083 | 213,300,138 | 13.4% | O |
| Argentina | 1,583,297 | | 42,650 | | 1,407,926 | 132,721 | 3,313 | 34,875 | 939 | 4,683,310 | 103,159 | 45,398,764 | 10.3% | O |

| Country | Total Cases | New Cases | Total Deaths | New Deaths | Total Recovered | Active Cases | Serious, Critical | Tot Cases / 1M pop | Deaths / 1M pop | Total Tests | Tests / 1M pop | Population | Tot Test per Pop | P |
|---------|-------------|-----------|--------------|------------|-----------------|--------------|-------------------|--------------------|-----------------|-------------|----------------|-------------|------------------|---|
| Mexico | 1,383,434 | 6,217 | 122,426 | 400 | 1,038,766 | 222,242 | 3,913 | 10,675 | 945 | 3,511,534 | 27,096 | 129,595,093 | 2.7% | O |
| France | 2,559,686 | | 62,746 | | 189,941 | 2,306,999 | 2,659 | 39,172 | 960 | 34,273,124 | 524,498 | 65,344,575 | 52.4% | O |

The following table shows selected countries doing massively worse than the world average. They are tagged as R for Red. The full list of countries in this category is provided further in this section.

Table 18 - Return To Life Systems Performance Red

| Country | Total Cases | New Cases | Total Deaths | New Deaths | Total Recovered | Active Cases | Serious, Critical | Tot Cases / 1M pop | Deaths / 1M pop | Total Tests | Tests / 1M pop | Population | Tot Test per Pop | P |
|---------|-------------|-----------|--------------|------------|-----------------|--------------|-------------------|--------------------|-----------------|-------------|----------------|-------------|------------------|---|
| USA | 19,589,952 | 16,105 | 341,332 | 194 | 11,501,001 | 7,747,619 | 28,689 | 59,014 | 1,028 | 246,804,411 | 743,487 | 331,955,077 | 74.3% | R |
| UK | 2,329,730 | 41,385 | 71,109 | 357 | N/A | N/A | 1,529 | 34,230 | 1,045 | 52,257,588 | 767,804 | 68,061,074 | 76.8% | R |
| Spain | 1,869,610 | | 49,824 | | N/A | N/A | 1,907 | 39,980 | 1,065 | 27,016,086 | 577,715 | 46,763,700 | 57.8% | R |
| Peru | 1,007,657 | | 37,474 | | 945,603 | 24,580 | 1,144 | 30,355 | 1,129 | 5,463,577 | 164,586 | 33,195,820 | 16.5% | R |
| Italy | 2,056,277 | 8,585 | 72,370 | 445 | 1,408,686 | 575,221 | 2,565 | 34,034 | 1,198 | 26,114,818 | 432,236 | 60,417,968 | 43.2% | R |
| Belgium | 638,877 | 847 | 19,200 | 42 | 43,873 | 575,804 | 492 | 55,007 | 1,653 | 6,816,200 | 586,875 | 11,614,401 | 58.7% | R |

This shows that there are other countries that have also been successful at containing the virus and they should also be part of the study efforts. These are the shown above countries that performed better than the world average:

Burundi Eritrea Taiwan Tanzania Vietnam Thailand Papua New Guinea Fiji Western Sahara **China** Burkina Faso Benin Niger Singapore Uganda Ivory Coast Mozambique **New Zealand** Nigeria DRC Guinea Rwanda South Sudan Chad Brunei Somalia Togo Comoros Mauritius Sri Lanka Madagascar Tajikistan Sierra Leone Malawi Ghana Angola Mali Cuba CAR Malaysia Ethiopia **S. Korea** Liberia Cameroon Botswana Uzbekistan Hong Kong Congo Haiti Yemen Zambia Senegal Zimbabwe Guinea-Bissau Lesotho Barbados Nicaragua **Japan** Saint Lucia Gabon Cayman Islands Kenya Sudan British Virgin Islands Australia Venezuela Syria Bangladesh Pakistan Uruguay Réunion Myanmar Gambia Antigua and Barbuda Afghanistan Equatorial Guinea Djibouti Nepal Algeria **UAE** Mauritania Egypt Namibia Monaco Sao Tome and Principe Indonesia Norway Iceland Philippines Curaçao Qatar Maldives Trinidad and Tobago Cyprus Finland Jamaica St. Barth India Martinique Caribbean Netherlands Kazakhstan Eswatini Belarus Turks and Caicos Estonia Bermuda Saudi Arabia Gibraltar Morocco Mayotte Cabo Verde Montserrat El Salvador Suriname Bahrain Kyrgyzstan Lebanon Denmark Libya Guyana Kuwait Dominican Republic

Many of these countries have populations that tend to live outside, have small populations, and or are island nations. However, some share many social and economic characteristics of the worst performing countries like the United States and they are industrialized with daily life engaged inside buildings. This data suggests that the following Return to Life Systems need to be closely studied:

- New Zealand
- Japan
- Australia
- UAE

It is clear that their buildings and air travel characteristics need to be studied. It is not just about the social aspect of respecting the virus and practicing virus mitigation approaches like social distancing, masks, and quarantine. It is possible that the virus mitigation practices will only work when there is first safe air travel and second safe indoor living spaces. This analysis and empirical data shows that air travel is a massive source of virus spread and the countries with the worst return to life systems performance, like the US, do engage in massive air travel. The R0 while on an airplane can be as high as 22, which is massive [3].

The other countries performance are as follows:

Green: 122 (better than world average)

Burundi Eritrea Taiwan Tanzania Vietnam Thailand Papua New Guinea Fiji Western Sahara China Burkina Faso Benin Niger Singapore Uganda Ivory Coast Mozambique New Zealand Nigeria DRC Guinea Rwanda South Sudan Chad Brunei Somalia Togo Comoros Mauritius Sri Lanka Madagascar Tajikistan Sierra Leone Malawi Ghana Angola Mali Cuba CAR Malaysia Ethiopia S. Korea Liberia Cameroon Botswana Uzbekistan Hong Kong Congo Haiti Yemen Zambia Senegal Zimbabwe Guinea-Bissau Lesotho Barbados Nicaragua Japan Saint Lucia Gabon Cayman Islands Kenya Sudan British Virgin Islands Australia Venezuela Syria

Bangladesh Pakistan Uruguay RÅ©union Myanmar Gambia Antigua and Barbuda Afghanistan Equatorial Guinea Djibouti Nepal Algeria UAE Mauritania Egypt Namibia Monaco Sao Tome and Principe Indonesia Norway Iceland Philippines CuraÅ§ao Qatar Maldives Trinidad and Tobago Cyprus Finland Jamaica St. Barth India Martinique Caribbean Netherlands Kazakhstan Eswatini Belarus Turks and Caicos Estonia Bermuda Saudi Arabia Gibraltar Morocco Mayotte Cabo Verde Montserrat El Salvador Suriname Bahrain Kyrgyzstan Lebanon Denmark Libya Guyana Kuwait Dominican Republic

Yellow: 36

French Guiana Turkey Azerbaijan Palestine Guatemala Oman Isle of Man Paraguay Honduras Latvia Saint Martin Iraq Channel Islands Slovakia Serbia Israel Germany Jordan Tunisia Russia French Polynesia Guadeloupe Canada Albania Costa Rica Ukraine Bahamas Ireland South Africa Greece Aruba Lithuania Malta Belize Sint Maarten Georgia

Orange: 23

Netherlands Iran Portugal Austria Poland Moldova Luxembourg Bolivia Ecuador Romania Sweden Colombia Switzerland Chile Panama Brazil Croatia Liechtenstein Armenia Argentina Mexico Hungary France

Red: 14

USA Bulgaria Czechia UK Spain Andorra Montenegro Peru North Macedonia Italy Bosnia and Herzegovina Slovenia Belgium San Marino

No Data: 25

Mongolia Diamond Princess Bhutan Faeroe Islands Cambodia Seychelles Grenada St. Vincent Grenadines Dominica Macao Timor-Leste Laos New Caledonia Saint Kitts and Nevis Falkland Islands Vatican City Greenland Solomon Islands Saint Pierre Miquelon Anguilla MS Zaandam Marshall Islands Wallis and Futuna Samoa Vanuatu

References:

[1] There's a job to be done': New Zealand's leader explains success against Covid-19, Associated Press, Politico, December 16, 2020. webpage <https://www.politico.com/news/2020/12/16/new-zealand-coronavirus-success-446192>, December 2020. [There's a job to be done': New Zealand's leader explains success against Covid-19](https://www.politico.com/news/2020/12/16/new-zealand-coronavirus-success-446192)

[2] [Worldmeters](https://www.worldometers.info/coronavirus), webpage <https://www.worldometers.info/coronavirus>, December 28, 2020.

[3] See section [Airplanes and Airports](#).

Life Expectancy

There is data available now to start to make predictions about impacts on life expectancy if the virus is not stopped and treatments do not reduce death rates. The implications are significant.

Those that are 20, 30, 40, and 50 will eventually transition into the higher death rate categories. However, even before that transition the probability of death from COVID-19 is very high for the young with significant impact.

The following analysis shows the US Life Expectancy for 2017 [1]. It has been augmented to include the effects of COVID-19. The COVID-19 death probability numbers selected are based on the numbers provided in the Death Rates section of this document. The best way to understand the data is to pick the number of lives and then look at the age. For example, before COVID-19 at male age 80 there are 50,344 male lives remaining and with COVID-19 when we look at male lives remaining 50,363 the age is 68. That is a loss of 12 years because of COVID-19 if nothing works to stem the pandemic. This is similar to the 1918 Influenza pandemic where the life expectancy was reduced by 12 years.

Table 19 - Life Expectancy

| Exact age | Male Death probability a | Male Number of lives b | Male Life expectancy | Female Death probability a | Female Number of lives b | Female Life expectancy | Male COVID Death probability | Male Number of Lives COVID Only | Male Number of Lives All Causes |
|-----------|--------------------------|------------------------|----------------------|----------------------------|--------------------------|------------------------|------------------------------|---------------------------------|---------------------------------|
| 0 | 0.006569 | 100,000 | 76.18 | 0.0055130 | 100,000 | 80.95 | | | |
| 1 | 0.000444 | 99,343 | 75.69 | 0.0003820 | 99,449 | 80.39 | 0 | 100,000 | 100,000 |
| 2 | 0.000291 | 99,299 | 74.72 | 0.0002180 | 99,411 | 79.42 | 0 | 99,343 | 98,686 |
| 3 | 0.000226 | 99,270 | 73.74 | 0.0001660 | 99,389 | 78.44 | 0 | 99,299 | 98,598 |
| 4 | 0.000173 | 99,248 | 72.76 | 0.0001430 | 99,373 | 77.45 | 0 | 99,270 | 98,540 |
| 5 | 0.000158 | 99,230 | 71.77 | 0.0001270 | 99,358 | 76.47 | 0 | 99,248 | 98,496 |
| 6 | 0.000147 | 99,215 | 70.78 | 0.0001160 | 99,346 | 75.48 | 0 | 99,230 | 98,460 |
| 7 | 0.000136 | 99,200 | 69.79 | 0.0001060 | 99,334 | 74.48 | 0 | 99,215 | 98,430 |
| 8 | 0.000121 | 99,187 | 68.80 | 0.0000980 | 99,324 | 73.49 | 0 | 99,200 | 98,400 |
| 9 | 0.000104 | 99,175 | 67.81 | 0.0000910 | 99,314 | 72.50 | 0.003 | 99,187 | 98,374 |
| 10 | 0.000092 | 99,164 | 66.82 | 0.0000860 | 99,305 | 71.51 | 0.003 | 98,877 | 98,052 |
| 11 | 0.000097 | 99,155 | 65.82 | 0.0000890 | 99,296 | 70.51 | 0.003 | 98,867 | 98,031 |
| 12 | 0.000134 | 99,146 | 64.83 | 0.0001020 | 99,288 | 69.52 | 0.003 | 98,858 | 98,013 |
| 13 | 0.000210 | 99,132 | 63.84 | 0.0001280 | 99,277 | 68.52 | 0.003 | 98,849 | 97,995 |
| 14 | 0.000317 | 99,112 | 62.85 | 0.0001640 | 99,265 | 67.53 | 0.003 | 98,835 | 97,967 |
| 15 | 0.000433 | 99,080 | 61.87 | 0.0002050 | 99,248 | 66.54 | 0.003 | 98,815 | 97,927 |
| 16 | 0.000547 | 99,037 | 60.90 | 0.0002460 | 99,228 | 65.56 | 0.003 | 98,783 | 97,863 |
| 17 | 0.000672 | 98,983 | 59.93 | 0.0002850 | 99,204 | 64.57 | 0.003 | 98,740 | 97,777 |
| 18 | 0.000805 | 98,917 | 58.97 | 0.0003190 | 99,175 | 63.59 | 0.003 | 98,686 | 97,669 |
| 19 | 0.000941 | 98,837 | 58.02 | 0.0003500 | 99,144 | 62.61 | 0.003 | 98,620 | 97,537 |
| 20 | 0.001084 | 98,744 | 57.07 | 0.0003830 | 99,109 | 61.63 | 0.001 | 98,540 | 97,377 |
| 21 | 0.001219 | 98,637 | 56.13 | 0.0004170 | 99,071 | 60.66 | 0.001 | 98,645 | 97,389 |
| 22 | 0.001314 | 98,517 | 55.20 | 0.0004460 | 99,030 | 59.68 | 0.001 | 98,538 | 97,175 |
| 23 | 0.001357 | 98,387 | 54.27 | 0.0004690 | 98,986 | 58.71 | 0.001 | 98,418 | 96,935 |
| 24 | 0.001362 | 98,254 | 53.35 | 0.0004870 | 98,939 | 57.74 | 0.001 | 98,289 | 96,676 |
| 25 | 0.001353 | 98,120 | 52.42 | 0.0005050 | 98,891 | 56.76 | 0.001 | 98,156 | 96,410 |

| Exact age | Male Death probability a | Male Number of lives b | Male Life expectancy | Female Death probability a | Female Number of lives b | Female Life expectancy | Male COVID Death probability | Male Number of Lives COVID Only | Male Number of Lives All Causes |
|-----------|--------------------------|------------------------|----------------------|----------------------------|--------------------------|------------------------|------------------------------|---------------------------------|---------------------------------|
| 26 | 0.001350 | 97,987 | 51.49 | 0.0005250 | 98,841 | 55.79 | 0.001 | 98,022 | 96,142 |
| 27 | 0.001353 | 97,855 | 50.56 | 0.0005510 | 98,789 | 54.82 | 0.001 | 97,889 | 95,876 |
| 28 | 0.001371 | 97,722 | 49.63 | 0.0005850 | 98,735 | 53.85 | 0.001 | 97,757 | 95,612 |
| 29 | 0.001399 | 97,588 | 48.69 | 0.0006260 | 98,677 | 52.88 | 0.001 | 97,624 | 95,346 |
| 30 | 0.001432 | 97,452 | 47.76 | 0.0006720 | 98,615 | 51.92 | 0.002 | 97,490 | 95,078 |
| 31 | 0.001464 | 97,312 | 46.83 | 0.0007200 | 98,549 | 50.95 | 0.002 | 97,257 | 94,709 |
| 32 | 0.001497 | 97,170 | 45.90 | 0.0007660 | 98,478 | 49.99 | 0.002 | 97,117 | 94,429 |
| 33 | 0.00153 | 97,024 | 44.96 | 0.0008060 | 98,403 | 49.02 | 0.002 | 96,976 | 94,146 |
| 34 | 0.001568 | 96,876 | 44.03 | 0.0008460 | 98,323 | 48.06 | 0.002 | 96,830 | 93,854 |
| 35 | 0.001617 | 96,724 | 43.10 | 0.0008910 | 98,240 | 47.10 | 0.002 | 96,682 | 93,558 |
| 36 | 0.001682 | 96,568 | 42.17 | 0.0009460 | 98,153 | 46.15 | 0.002 | 96,531 | 93,255 |
| 37 | 0.001759 | 96,405 | 41.24 | 0.0010130 | 98,060 | 45.19 | 0.002 | 96,375 | 92,943 |
| 38 | 0.001852 | 96,236 | 40.31 | 0.0010940 | 97,960 | 44.23 | 0.002 | 96,212 | 92,617 |
| 39 | 0.001963 | 96,057 | 39.39 | 0.0011900 | 97,853 | 43.28 | 0.002 | 96,044 | 92,280 |
| 40 | 0.002092 | 95,869 | 38.46 | 0.0012960 | 97,737 | 42.33 | 0.005 | 95,865 | 91,922 |
| 41 | 0.002246 | 95,668 | 37.54 | 0.0014130 | 97,610 | 41.39 | 0.005 | 95,390 | 91,259 |
| 42 | 0.002436 | 95,453 | 36.62 | 0.0015490 | 97,472 | 40.45 | 0.005 | 95,190 | 90,858 |
| 43 | 0.002669 | 95,221 | 35.71 | 0.0017060 | 97,321 | 39.51 | 0.005 | 94,976 | 90,429 |
| 44 | 0.002942 | 94,967 | 34.81 | 0.0018810 | 97,155 | 38.57 | 0.005 | 94,745 | 89,966 |
| 45 | 0.003244 | 94,687 | 33.91 | 0.0020690 | 96,972 | 37.65 | 0.005 | 94,492 | 89,459 |
| 46 | 0.003571 | 94,380 | 33.02 | 0.0022700 | 96,772 | 36.72 | 0.005 | 94,214 | 88,901 |
| 47 | 0.003926 | 94,043 | 32.13 | 0.0024860 | 96,552 | 35.81 | 0.005 | 93,908 | 88,288 |
| 48 | 0.004309 | 93,674 | 31.26 | 0.0027160 | 96,312 | 34.89 | 0.005 | 93,573 | 87,616 |
| 49 | 0.004719 | 93,270 | 30.39 | 0.0029600 | 96,050 | 33.99 | 0.005 | 93,206 | 86,880 |
| 50 | 0.005156 | 92,830 | 29.53 | 0.0032260 | 95,766 | 33.09 | 0.015 | 92,804 | 86,074 |
| 51 | 0.005622 | 92,352 | 28.68 | 0.0035050 | 95,457 | 32.19 | 0.015 | 91,438 | 84,268 |
| 52 | 0.006121 | 91,832 | 27.84 | 0.0037790 | 95,123 | 31.30 | 0.015 | 90,967 | 83,319 |
| 53 | 0.006656 | 91,270 | 27.01 | 0.0040400 | 94,763 | 30.42 | 0.015 | 90,455 | 82,287 |
| 54 | 0.007222 | 90,663 | 26.19 | 0.0043010 | 94,380 | 29.54 | 0.015 | 89,901 | 81,171 |
| 55 | 0.007844 | 90,008 | 25.38 | 0.0045920 | 93,974 | 28.67 | 0.015 | 89,303 | 79,966 |
| 56 | 0.008493 | 89,302 | 24.57 | 0.0049200 | 93,543 | 27.80 | 0.015 | 88,658 | 78,666 |
| 57 | 0.009116 | 88,544 | 23.78 | 0.0052660 | 93,083 | 26.93 | 0.015 | 87,962 | 77,264 |
| 58 | 0.00969 | 87,736 | 22.99 | 0.0056300 | 92,592 | 26.07 | 0.015 | 87,216 | 75,760 |
| 59 | 0.010253 | 86,886 | 22.21 | 0.0060280 | 92,071 | 25.22 | 0.015 | 86,420 | 74,156 |
| 60 | 0.010872 | 85,995 | 21.44 | 0.0064790 | 91,516 | 24.37 | 0.076 | 85,583 | 72,469 |
| 61 | 0.011591 | 85,060 | 20.67 | 0.0070010 | 90,923 | 23.52 | 0.076 | 79,459 | 65,454 |
| 62 | 0.012403 | 84,075 | 19.90 | 0.0076020 | 90,287 | 22.68 | 0.076 | 78,595 | 63,655 |
| 63 | 0.013325 | 83,032 | 19.15 | 0.0082940 | 89,600 | 21.85 | 0.076 | 77,685 | 61,760 |
| 64 | 0.01437 | 81,925 | 18.40 | 0.0090820 | 88,857 | 21.03 | 0.076 | 76,722 | 59,754 |
| 65 | 0.015553 | 80,748 | 17.66 | 0.0099900 | 88,050 | 20.22 | 0.076 | 75,699 | 57,624 |

| Exact age | Male Death probability a | Male Number of lives b | Male Life expectancy | Female Death probability a | Female Number of lives b | Female Life expectancy | Male COVID Death probability | Male Number of Lives COVID Only | Male Number of Lives All Causes |
|-----------|--------------------------|------------------------|----------------------|----------------------------|--------------------------|------------------------|------------------------------|---------------------------------|---------------------------------|
| 66 | 0.016878 | 79,492 | 16.93 | 0.0110050 | 87,171 | 19.42 | 0.076 | 74,611 | 55,359 |
| 67 | 0.018348 | 78,151 | 16.21 | 0.0120970 | 86,211 | 18.63 | 0.076 | 73,451 | 52,943 |
| 68 | 0.019969 | 76,717 | 15.51 | 0.0132610 | 85,168 | 17.85 | 0.076 | 72,212 | 50,363 |
| 69 | 0.021766 | 75,185 | 14.81 | 0.0145290 | 84,039 | 17.09 | 0.076 | 70,887 | 47,604 |
| 70 | 0.02384 | 73,548 | 14.13 | 0.0159910 | 82,818 | 16.33 | 0.232 | 69,471 | 44,656 |
| 71 | 0.026162 | 71,795 | 13.47 | 0.0176620 | 81,494 | 15.59 | 0.232 | 56,485 | 30,033 |
| 72 | 0.028625 | 69,917 | 12.81 | 0.0194860 | 80,054 | 14.86 | 0.232 | 55,139 | 26,934 |
| 73 | 0.031204 | 67,915 | 12.18 | 0.0214670 | 78,494 | 14.14 | 0.232 | 53,696 | 23,613 |
| 74 | 0.033997 | 65,796 | 11.55 | 0.0236580 | 76,809 | 13.44 | 0.232 | 52,159 | 20,074 |
| 75 | 0.0372 | 63,559 | 10.94 | 0.0262230 | 74,992 | 12.76 | 0.232 | 50,531 | 16,327 |
| 76 | 0.040898 | 61,195 | 10.34 | 0.0291590 | 73,026 | 12.09 | 0.232 | 48,813 | 12,372 |
| 77 | 0.04504 | 58,692 | 9.76 | 0.0323310 | 70,896 | 11.44 | 0.232 | 46,998 | 8,193 |
| 78 | 0.049664 | 56,048 | 9.20 | 0.0357250 | 68,604 | 10.80 | 0.232 | 45,075 | 3,767 |
| 79 | 0.054844 | 53,265 | 8.66 | 0.0394690 | 66,153 | 10.18 | 0.232 | 43,045 | -907 |
| 80 | 0.060801 | 50,344 | 8.13 | 0.0438280 | 63,542 | 9.58 | 0.3 | 40,908 | |
| 81 | 0.067509 | 47,283 | 7.62 | 0.0488960 | 60,757 | 9.00 | 0.3 | 35,241 | |
| 82 | 0.074779 | 44,091 | 7.14 | 0.0545770 | 57,786 | 8.43 | 0.3 | 33,098 | |
| 83 | 0.082589 | 40,794 | 6.68 | 0.0609090 | 54,633 | 7.89 | 0.3 | 30,864 | |
| 84 | 0.091135 | 37,424 | 6.23 | 0.0680190 | 51,305 | 7.37 | 0.3 | 28,556 | |
| 85 | 0.10068 | 34,014 | 5.81 | 0.0760540 | 47,815 | 6.87 | 0.3 | 26,197 | |
| 86 | 0.111444 | 30,589 | 5.40 | 0.0851480 | 44,179 | 6.40 | 0.3 | 23,810 | |
| 87 | 0.123571 | 27,180 | 5.02 | 0.0953950 | 40,417 | 5.94 | 0.3 | 21,412 | |
| 88 | 0.137126 | 23,822 | 4.65 | 0.1068570 | 36,561 | 5.52 | 0.3 | 19,026 | |
| 89 | 0.152092 | 20,555 | 4.31 | 0.1195570 | 32,655 | 5.12 | 0.3 | 16,675 | |
| 90 | 0.168426 | 17,429 | 4.00 | 0.1335020 | 28,751 | 4.75 | 0.293 | 14,389 | |
| 91 | 0.186063 | 14,493 | 3.70 | 0.1486850 | 24,912 | 4.40 | 0.293 | 12,322 | |
| 92 | 0.204925 | 11,797 | 3.44 | 0.1650880 | 21,208 | 4.08 | 0.293 | 10,247 | |
| 93 | 0.224931 | 9,379 | 3.19 | 0.1826850 | 17,707 | 3.79 | 0.293 | 8,340 | |
| 94 | 0.245995 | 7,270 | 2.97 | 0.2014420 | 14,472 | 3.53 | 0.293 | 6,631 | |
| 95 | 0.266884 | 5,481 | 2.78 | 0.2204060 | 11,557 | 3.29 | 0.293 | 5,140 | |
| 96 | 0.287218 | 4,018 | 2.61 | 0.2392730 | 9,010 | 3.08 | 0.293 | 3,875 | |
| 97 | 0.306593 | 2,864 | 2.46 | 0.2577140 | 6,854 | 2.89 | 0.293 | 2,841 | |
| 98 | 0.324599 | 1,986 | 2.33 | 0.2753760 | 5,088 | 2.72 | 0.293 | 2,025 | |
| 99 | 0.340829 | 1,341 | 2.21 | 0.2918990 | 3,687 | 2.56 | 0.293 | 1,404 | |
| 100 | 0.35787 | 884 | 2.09 | 0.3094130 | 2,610 | 2.41 | 0.293 | 948 | |
| 101 | 0.375764 | 568 | 1.98 | 0.3279780 | 1,803 | 2.27 | 0.293 | 625 | |
| 102 | 0.394552 | 354 | 1.88 | 0.3476560 | 1,211 | 2.13 | 0.293 | 402 | |
| 103 | 0.41428 | 215 | 1.77 | 0.3685160 | 790 | 2.00 | 0.293 | 250 | |
| 104 | 0.434993 | 126 | 1.68 | 0.3906270 | 499 | 1.87 | 0.293 | 152 | |
| 105 | 0.456743 | 71 | 1.58 | 0.4140640 | 304 | 1.75 | 0.293 | 89 | |

| Exact age | Male Death probability a | Male Number of lives b | Male Life expectancy | Female Death probability a | Female Number of lives b | Female Life expectancy | Male COVID Death probability | Male Number of Lives COVID Only | Male Number of Lives All Causes |
|-----------|--------------------------|------------------------|----------------------|----------------------------|--------------------------|------------------------|------------------------------|---------------------------------|---------------------------------|
| 106 | 0.47958 | 39 | 1.49 | 0.4389080 | 178 | 1.64 | 0.293 | 50 | |
| 107 | 0.503559 | 20 | 1.40 | 0.4652430 | 100 | 1.53 | 0.293 | 28 | |
| 108 | 0.528737 | 10 | 1.32 | 0.4931570 | 53 | 1.43 | 0.293 | 14 | |
| 109 | 0.555174 | 5 | 1.24 | 0.5227470 | 27 | 1.33 | 0.293 | 7 | |
| 110 | 0.582933 | 2 | 1.16 | 0.5541110 | 13 | 1.23 | 0.293 | 4 | |
| 111 | 0.61208 | 1 | 1.09 | 0.5873580 | 6 | 1.14 | 0.293 | 1 | |
| 112 | 0.642683 | 0 | 1.02 | 0.6225990 | 2 | 1.06 | 0.293 | 1 | |
| 113 | 0.674818 | 0 | 0.95 | 0.6599550 | 1 | 0.98 | 0.293 | 0 | |
| 114 | 0.708559 | 0 | 0.89 | 0.6995530 | 0 | 0.90 | 0.293 | 0 | |
| 115 | 0.743986 | 0 | 0.82 | 0.7415260 | 0 | 0.83 | 0.293 | 0 | |
| 116 | 0.781186 | 0 | 0.76 | 0.7811860 | 0 | 0.76 | 0.293 | 0 | |
| 117 | 0.820245 | 0 | 0.71 | 0.8202450 | 0 | 0.71 | 0.293 | 0 | |
| 118 | 0.861257 | 0 | 0.65 | 0.8612570 | 0 | 0.65 | 0.293 | 0 | |
| 119 | 0.90432 | 0 | 0.60 | 0.9043200 | 0 | 0.60 | 0.293 | 0 | |

a. Probability of dying within one year.

b. Number of survivors out of 100,000 born alive.

Note: The period life expectancy at a given age for 2017 represents the average number of years of life remaining if a group of persons at that age were to experience the mortality rates for 2017 over the course of their remaining life.

A picture is worth a thousand words. The following graph shows the remaining lives per year before and after COVID-19 using the previous data. We don't know what multiple infections over a life time will do to further reduce life expectancy. We also do not know the types and levels of health loss due to this infection. There will be people that will be partially and permanently disabled. Others will suffer with loss of health and reduced life quality.

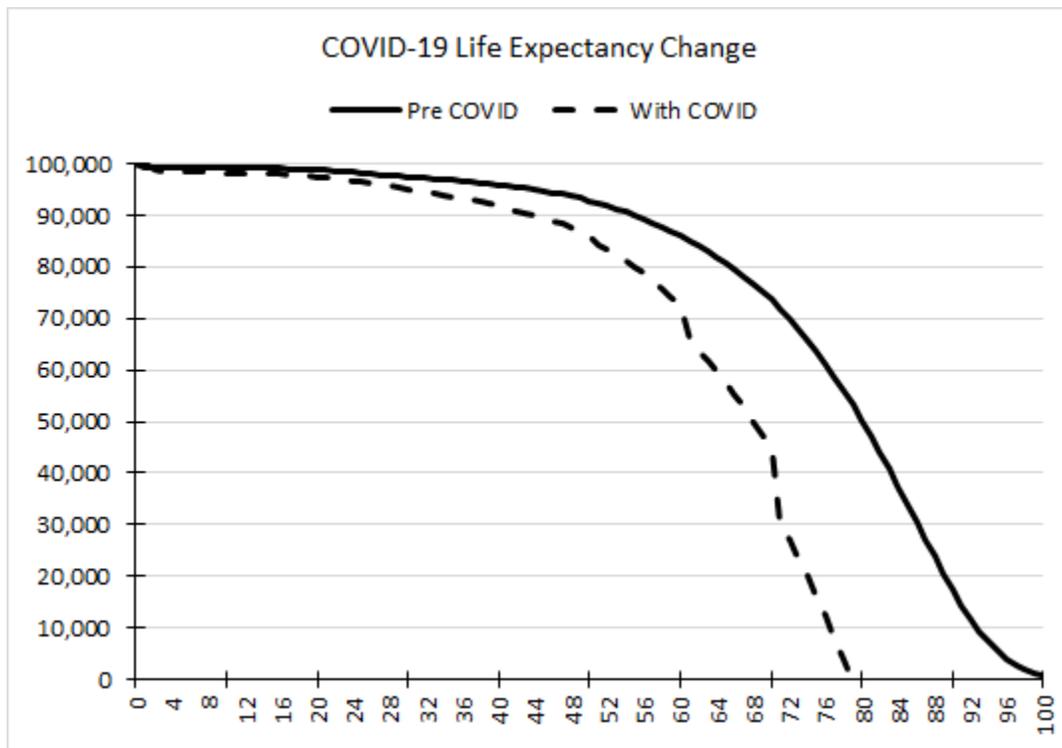


Figure 8 - COVID-19 Life Expectancy Change

The political management talking points in 2020 by the current US administration in power were that the virus impacts only the old and sick. This was offered to the masses. Some accepted it blindly and some knew better. This was a gross misrepresentation and massive social injustice to future generations. [2]

This is a wakeup call that massive resources need to be applied to stop this pandemic. This systems analysis suggests that there is no single solution that will stop this virus. Instead the virus mitigation system must include multiple complex and highly effective subsystems and upgrades that need to start immediately.

1. Building, airplane, and other ventilation systems must be upgraded
2. The 80+ year old UV-C systems must be reintroduced on a massive scale
3. The new FAR UV-222 systems must be introduced on a massive scale
4. Contact tracing must become 100% with no time lag
5. Vaccines must be developed
6. Treatments must continue to be developed
7. It is time to begin counting and publishing not just infections and deaths but also long term health damage by categories
8. It is time to begin calculating and publishing the impact on life expectancy based on different scenarios of the virus presence in the next 20 years

Waiting for a vaccine and treatments is irresponsible. The vaccine analysis shows that it may take decades to remove the virus from the population unless we somehow change previous history where the vaccine approaches 90% effectiveness and we approach 90% vaccination levels. Both of which are individually unlikely and in combination impossible. It is an incomplete system solution.

The infrastructure modifications must begin immediately. In the previous century we used new forced air ventilation systems and UV-C systems that were properly designed and managed to minimize infection. That generation lived through measles, polio, 1918, and general illness and infections from many viruses and bacteria. As an elementary school child I learned about this struggle from the previous generation. It began with basic hygiene and clean running water and sewage management. They built a modern world that led to a very healthy population by the 1960s and 1970s [3].

The following table shows the effects of a vaccine, then the effects with the addition of UV, and finally the effects with the addition of ventilation. We have the technology, the projected decline in life expectancy shown in this analysis does not need to happen. [4]

Table 20 - Life Expectancy & Technology

| Population | Naturally Immune % | Vaccine Effectiveness % | Vaccinated % | Exposed Population | Deaths @ 2% | Deaths @ 3% | Deaths @ 3.5% | UV-C or FAR UV-222 Kill / Inactivate | Deaths @ 3.5% (With UV) | Ventilation Effectiveness 4 AUC | Deaths @ 3.5% (With UV + Ventilation) | Comment |
|-------------|--------------------|-------------------------|--------------|--------------------|------------------|-------------|-------------------|--------------------------------------|-------------------------|---------------------------------|---------------------------------------|--|
| 328,000,000 | 10% | 70% | 70% | 150,552,000 | 3,011,040 | 4,516,560 | 5,269,320 | 90% | 526,932 | 28% | 379,391 | Likely vaccine result with some natural immunity |
| 328,000,000 | 10% | 90% | 90% | 56,088,000 | 1,121,760 | 1,682,640 | 1,963,080 | 90% | 196,308 | 28% | 141,342 | Unlikely vaccine result with some natural immunity |
| 328,000,000 | 0% | 70% | 70% | 167,280,000 | 3,345,600 | 5,018,400 | 5,854,800 | 90% | 585,480 | 28% | 421,546 | Likely vaccine result with no natural immunity |
| 328,000,000 | 0% | 90% | 90% | 62,320,000 | 1,246,400 | 1,869,600 | 2,181,200 | 90% | 218,120 | 28% | 157,046 | Unlikely vaccine result with no natural immunity |
| | | | | | | | | | | | | |
| 328,000,000 | 0% | 0% | 0% | 328,000,000 | 6,560,000 | 9,840,000 | 11,480,000 | 90% | 1,148,000 | 28% | 826,560 | No vaccine, natural herd immunity |
| 328,000,000 | 10% | 0% | 0% | 295,200,000 | 5,904,000 | 8,856,000 | 10,332,000 | 90% | 1,033,200 | 28% | 743,904 | No vaccine, natural herd immunity |

Note: Ventilation works only when it is turned on. The HVAC fan(s) must run 1 hour before and 1 hour after the facility opens to the public.

Things have changed in the 21st century. In the previous century they did not know what to do, they had to study and learn and it was hard. In this century we have the technology but we have a massive social problem where we refuse to do what needs to be done because of self-interest. If this does not stop and the system perspective is not adopted our children and grandchildren will curse this generation for cutting their lives short. That is assuming that this does not lead to social unrest as the virus keeps resurfacing. For those that view this as a good thing to reduce the stress of over population - understand that it is no fun living through revolutions and war as the natural system tries to correct itself. Make no mistake about it, this pandemic left unchecked will destabilize the world.

References

[1] US SSA Actuarial Life Table - 2017 period life table, US Social Security Administration. webpage <https://www.ssa.gov/OACT/STATS/table4c6.html>, November 2020. [US SSA Actuarial Life Table - 2017 period life table](#)

[2] See section [System Collapse](#).

[3] Science The Endless Frontier, US Government Office of Scientific Research and Development, United States Government Printing Office, Washington: 1945. webpage <https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm>, November 2020. [Science The Endless Frontier](#) . [local](#)

[4] See section [Vaccine Systems Perspective](#).

Long Term Health Effects

COVID-19 disease severity and lingering symptoms [1]:

- Most people with COVID-19 experience mild symptoms or moderate illness.
- Approximately 10-15% of cases progress to severe disease, and about 5% become critically ill.
- Typically people recover from COVID-19 after 2 to 6 weeks. Mild cases are 2 weeks and severe cases are 6 weeks.
- For some people, some symptoms may linger or recur for weeks or months following initial recovery. This can also happen in people with mild disease. People are not infectious to others during this time.
- Some patients develop medical complications that may have lasting health effects.

Lingering symptoms reported by participants of a multi-state phone study in the USA [1] [2]:

- Fatigue
- Cough, congestion or shortness of breath
- Loss of taste or smell
- Headache, body aches
- Diarrhea, nausea
- Chest or abdominal pain
- Confusion

What we know about people who feel they do not fully recover from COVID-19 [1] [2]:

- COVID-19 can sometimes result in prolonged illness, even in young adults and children without underlying chronic medical conditions.
- There are many case reports from people who do not regain their previous health following COVID-19.
- Little is known about the clinical course of COVID-19 following milder illness.
- In a telephone survey of symptomatic adults who had a positive outpatient test result for SARS-CoV-2, 35% had not returned to their usual state of health when interviewed 2–3 weeks after testing.¹
- Among those 18 to 34 years in good health, 20% (1 in 5) reported that some symptoms were prolonged.
- Risk factors for persistence of symptoms: high blood pressure, obesity, mental health conditions.

Studies of long term health effects Severe Acute Respiratory Syndrome (SARS) infections from 2003 suggested [1] [3]:

- There was persistent and significant impairment of exercise capacity and health status in survivors of SARS over 24 months.
- Health workers who had SARS experienced even more adverse impact.
- 40% of people recovering from SARS still had chronic fatigue symptoms 3.5 years after being diagnosed.

COVID-19 can result in prolonged illness and persistent symptoms in young adults and persons with no underlying medical conditions who were not hospitalized. COVID-19 may increase the risk of long-term health problems [1]:

- Heart
 - Damage to heart muscle, heart failure
- Lungs
 - Damage to lung tissue and restrictive lung failure
- Brain and the nervous system
 - Loss of sense of smell (anosmia)
 - Consequences of thrombo-embolic events such as pulmonary embolism, heart attack, stroke
 - Cognitive impairment (e.g. memory and concentration)
- Mental health
 - Anxiety, depression, post-traumatic stress disorder and sleep disturbance
- Musculoskeletal and others
 - Pain in joint and muscles
 - Fatigue

The virus can damage the Lungs, Heart, Brain, and Kidneys. The most common signs and symptoms that linger over time include: Fatigue, Cough, Shortness of breath, Headache, Joint pain. Heart imaging tests taken months after recovery from COVID-19 show lasting damage to the heart muscle, even in people who experienced only mild COVID-19 symptoms. This may increase the risk of heart failure or other heart complications in the future. In the Lungs pneumonia often associated with COVID-19 can cause long term damage to the tiny air sacs

(alveoli) in the lungs. The resulting scar tissue can lead to long term breathing problems. In the Brain even in young people, COVID-19 can cause strokes, seizures and Guillain-Barre syndrome, a condition that causes temporary paralysis. COVID-19 may also increase the risk of developing Parkinson's disease and Alzheimer's disease. COVID-19 can weaken blood vessels, which contributes to potentially long term problems with the liver and kidneys. COVID-19 can make blood cells more likely to clump up and form clots. While large clots can cause heart attacks and strokes, much of the heart damage caused by COVID-19 is believed to come from very small clots that block tiny blood vessels (capillaries) in the heart muscle [4].

People who have severe symptoms of COVID-19 often have to be treated in a hospital's intensive care unit, with mechanical assistance such as ventilators to breathe. Simply surviving this experience can make a person more likely to later develop post-traumatic stress syndrome, depression and anxiety. Many who have recovered from SARS have gone on to develop chronic fatigue syndrome, a complex disorder characterized by extreme fatigue that worsens with physical or mental activity, but doesn't improve with rest. The same may be true for people who have had COVID-19 [4].

What is missing are the numbers and this is a very serious issue because we do not have a handle on the damage being cause by this disaster without the long term health effects numbers.

Table 21 - COVID-19 Long Term Health Effects

| Damage | 1 yr SARS-1 | 2 yr SARS-1 | Permanent SARS-1 | 1 yr COVID-19 | 1 yr COVID-19 | Permanent COVID-19 |
|--------------------------------|--------------------|--------------------|-------------------------|----------------------|----------------------|---------------------------|
| Lungs | ? | ? | ? | ? | ? | ? |
| Heart | | | | | | |
| Brain | | | | | | |
| Kidneys | | | | | | |
| Musculoskeletal | | | | | | |
| Other Physical | | | | | | |
| Post-traumatic stress syndrome | | | | | | |
| Depression | | | | | | |
| Anxiety | | | | | | |

This is yet another indication of the failures of the systems that everyone assumed were in place. However, they are either not in place or have been made ineffective [5].

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[2] Symptom Duration and Risk Factors for Delayed Return to Usual Health Among Outpatients with COVID-19 in a Multistate Health Care Systems Network - United States, Morbidity and Mortality Weekly Report MMWR/July 31, 2020/Vol. 69/No. 30993 US Department of Health and Human Services/Centers for Disease Control and Prevention Symptom, March–June 2020. webpage <https://www.cdc.gov/mmwr/volumes/69/wr/pdfs/mm6930e1-H.pdf>, October 2020. [Symptom Duration and Risk Factors for Delayed Return to Usual Health Among Outpatients with COVID-19 in a Multistate Health Care Systems Network - United States](#) . [PDF](#) . [local](#)

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[5] See section [Government Failure](#).

Indoor Outdoor Ventilation

The ventilation discussion includes both indoor and outdoor ventilation. A key finding is that an outdoor venue can behave like a poor indoor venue under certain conditions.

HVAC Systems

One of the major differences between the 1918 Flu Pandemic and the COVID-19 Pandemic of 2020 is the design of our buildings. The heating ventilation and cooling systems (HVAC) in use today did not exist in 1918. This begs the question, what can be done from an engineering perspective to reduce the level of airborne viruses in all buildings especially public space buildings.

This analysis suggests that the indoor ventilation rates in terms of Air Updates Per Hour (AUC) must be increased: [\[spreadsheet\]](#)

1. 20 - 030 AUC this is based on empirical data from ground transportation systems.
2. 50 - 100 AUC this is based various systems engineering paper analysis in this report.
3. 120 AUC this is based on a brute force engineering approach for a small bar and restaurant circa 1960's and 1970's.

4. As the AUC is increased the risk of infection is reduced, 20-30 AUC will lead to a 1% probability risk of infection rate, 120 AUC the risk approaches 0%.

Consumer and small public building recommendations:

1. Turn on the HVAC system fan and run it 24/7.
2. Replace all filters with the highest level ratings to capture as much virus and possible.
3. For small public buildings replace / cleans filters every week until the pandemic subsides.
4. Contact the HVAC maintenance company and have them document the current Air Update Changes per hours (AUC). Verify this by checking the model number / serial number where the size of the fan(s) is encoded and can be determined from the manufacturer. The size is in terms of cubic feet per hour. Dividing this number into the clubhouse cubic feet will provide the AUC.
5. Typically for most houses and small buildings the AUC is 1 to 4. It needs to be 20 to 30 AUC. Have the HVAC contractor provide recommendations.
6. If there is a long duct in the HVAC system, install UV-C lights in that portion of the HVAC system. The virus must spend about 3-6 seconds in the UV-C light path. That is why a long duct is needed. Follow the maintenance schedule but replace it before the maintenance time.
7. Restaurant kitchens use UV-C ceiling lights. Buy a light for each room in the public building.
8. There has been some movement on FAR-UV 222 lights. These lights would replace and or augment the current lights in the clubhouse. They are available from multiple companies. The issue with FAR-UV 222 light is that we really don't know if they have long term health effects. We know that UV-C damages skin and eyes but because of the longer wave length of the FAR-UV 222 light, it does not penetrate certain barriers on the skin and eyes. There is 1 company that may assume liability if they are installed.

This analysis states that the government should have immediately started a test and evaluation program using the national labs to develop specifications for modifications to all HVAC systems for all types of spaces [1]. Proposed legislation text is offered in the analysis [2].

References:

[1] See section [Ventilation Test and Evaluation](#)

[2] See section [Proposed Legislation](#)

HVAC Background

A literature search reveals the following documents of interest. The titles of the documents reveal some of the key issues.

- Chemical/Biological/Radiation (CBR) Safety of the Building Envelope [1]
- Simplifying the assessment of building vulnerability to chemical, biological and radiological releases [2]
- Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings [3]
- Protecting Buildings against Airborne Contamination [4]
- Chemical/Biological/Radiological Incident Handbook [5]

- Guidance for Filtration and Air Cleaning Systems to Protect Building Environments from Airborne Chemical, Biological, or Radiological Attacks [6] [7]
- Protecting Building Occupants from Exposure to Biological Threats [8]
- Building Retrofits for Increased Protection Against Airborne Chemical and Biological Releases[9]
- Biological Inactivation Efficiency by HVAC In-Duct Ultraviolet Light Systems [10]

References:

- [1] Chemical/Biological/Radiation (CBR) Safety of the Building Envelope, Rob Bolin, PE, Syska Hennessy Group, Whole Building Design Guide, January 2017. webpage <https://www.wbdg.org/resources/chemicalbiologicalradiation-cbr-safety-building-envelope>, April 2020. [Whole Building Design Grade](#) (.org)
- [2] Simplifying the assessment of building vulnerability to chemical, biological and radiological releases, U.S. Department of Energy Office of Scientific and Technical Information, LBNL-56780, January 2005. webpage <https://www.osti.gov/servlets/purl/929080>, April 2020. [LBNL-56780](#)
- [3] BIPS 06 / FEMA 426 Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings, U.S. Department of Homeland Security (DHS), October 2011. webpage <https://www.wbdg.org/ffc/dhs/criteria/bips-06>, April 2020. [IPS 06 / FEMA 426 Reference Manual](#)
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- [7] Guidance for Filtration and Air-Cleaning Systems to Protect Building Environments from Airborne Chemical, Biological, or Radiological Attacks, CDC, April 2003. webpage <https://www.cdc.gov/niosh/docs/2003-136/pdfs/2003-136.pdf>, April 2020. [Guidance for filtration and Air-Cleaning Systems to Protect Building Environments from Airborne Chemical, Biological, or Radiological Attacks](#) (CDC)
- [8] Protecting Building Occupants from Exposure to Biological Threats, Johns Hopkins University. webpage https://www.centerforhealthsecurity.org/resources/interactives/protecting_building_occupants/faq.html, April 2020. [Protecting Building Occupants from Exposure to Biological Threats](#)

[9] Building Retrofits for Increased Protection Against Airborne Chemical and Biological Releases, NIST, NISTIR 7379, March 2007. webpage https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=861035, April 2020. [NISTIR 7379 Building Retrofits for Increased Protection Against Airborne Chemical and Biological Releases](#)

[10] Biological Inactivation Efficiency by HVAC In-Duct Ultraviolet Light Systems, U.S. Environmental Protection Agency, American Ultraviolet Corporation ACP-24/HO-4, EPA 600/R-06/054, May 2006. webpage https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=459522, April 2020. [Biological Inactivation Efficiency By HVAC In-Duct Ultraviolet Light Systems](#) . [local](#)

Building Retrofit Technologies Including UV

A number of technologies have the potential to increase building protection against chembio agent releases. Most of these are in the particle filtration and gaseous air cleaning categories. Other technologies for building protection include systems for use in mail rooms, and other spaces that may be more vulnerable to agent releases, to capture and remove the agents before they are able to migrate to other portions of the building. [1]

Enhanced particle filtration

Particle filtration is currently employed in most commercial and institutional buildings, primarily to limit dirt buildup on cooling coils and other wetted surfaces in order to reduce the potential for microbial growth and to maintain good heat transfer between the air and the coil surfaces. However, typical levels of filtration are not always very effective in removing particles of the sizes associated with many biological agents, i.e., on the order of 1 μm . Nevertheless, dramatic increases in removal rates can still be achieved through enhanced filtration without the use of very high levels of efficiency (NIOSH 2003). Particle removal efficiencies are fairly well established based on the use of ASHRAE Standard 52.2 (ASHRAE 1999), which provides a rating method referred to as Minimum Efficiency Reporting Value (MERV). The implementation of enhanced filtration involves a number of important issues. First, the particle size of interest must be considered. Biological agents vary in size, but the bacteria and spores of most interest are generally on the order of 1 μm to 10 μm . In addition, the installation of more efficient filters will generally result in an increase in the pressure drop across the filter. Depending on the increase in filter efficiency and the type of filter installed, the increase in pressure drop may or may not be particularly large. In some cases, the air handling equipment will need to be modified due to the increased pressure drop. [1]

Sorption based gaseous air cleaning

Sorption based gaseous air cleaning is currently employed in a number of applications to control odorous, corrosive or otherwise undesirable gases generated within or outside of buildings. A variety of sorbents are employed including activated carbon, alumina and sorbents impregnated with compounds to enhance their ability to remove specific contaminants (NIOSH 2003, ASHRAE 2003). These sorbents have varying degrees of removal effectiveness depending on the particular sorbent-contaminant combination, and they capture contaminants through either physical adsorption or chemisorption. Some sorbents employing the former mechanism can be regenerated through heating or other processes. Adsorbents using a chemisorption process generally rely on catalytic (continuously self-regenerating) reactions that chemically decompose

the threat gases into less toxic or non-toxic gases. The effectiveness of sorbent-based air cleaners also depends on temperature, humidity, the concentrations of the contaminant of interest as well as other contaminants, and the residence time of the airstream in the air cleaning unit. Gaseous air cleaning devices are not typically employed in commercial and institutional buildings but are seeing increasing use in a number of applications. There are no standard test methods for determining the contaminant removal efficiency of gaseous air cleaning equipment for use in selecting and sizing these systems. Manufacturers have performance data and experience that can be useful, but efforts to develop the equivalent of a MERV rating for gaseous air cleaning are still being pursued.

In general, gaseous air cleaning systems are associated with a more significant pressure drop than particle filtration devices and require more space than typical filtration equipment. These increased pressure drops can in turn affect system airflow rates and may require significant system modifications. These devices must be changed at intervals that depend on their capacity, the concentrations to which they are exposed, and the degree of temperature and humidity control in the system. [1]

Ultraviolet germicidal irradiation (UVGI)

UVGI systems have been used for many years to kill airborne infectious agents in healthcare facilities and other venues, primarily to control the transmission of tuberculosis. These devices use ultraviolet irradiation in the 250 nm to 260 nm wavelength range and are generally installed in the upper portions of a room with shielding to protect the occupants or in ductwork where such shielding is not required. This application is distinct from the use of UVGI to kill biological contamination on exposed cooling coils resulting from dirt accumulation and condensation.

The effectiveness of these devices is primarily a function of device geometry, intensity of the light source, microbial resistance and residence time of the agents of concern. Inactivation or “kill” rates can be predicted with a fair level of reliability based on these parameters (VanOsdell and Foarde 2002). However, there is no standard test method for determining the effectiveness of these devices and they are not generally supplied with the performance data to determine kill rates. These devices are associated with electrical energy consumption and require some level of maintenance to keep them operating effectively. EPA Test Results: [2]

Photocatalytic oxidation air cleaning (PCO)

PCO is an air cleaning approach in which titanium dioxide (TiO₂) acts as a photocatalyst when irradiated by UV light, removing organic chemicals including both chemical and biological agents. If the photocatalytic reaction is 100 % complete, the byproducts include water and carbon dioxide, but complete conversion is difficult to achieve in practice. Various PCO devices are available as either portable, stand-alone units or in-duct devices. However, the lack of test methods for gas or biological removal limits the availability of performance data.

PCO systems generally have low pressure drops in comparison to particle filters and sorption based gaseous air cleaning. However, questions exist as to the useful life of the catalysts in practice and the production of undesirable byproducts associated with incomplete photochemical reactions. [1]

Work area treatment

A variety of devices are available for capturing and removing particulates from work areas, e.g. mail opening stations. These devices are essentially air capture hoods combined with high-efficiency filtration systems. Some of these devices also incorporate anti-microbial elements, gaseous air cleaning components and UVGI. The performance of these devices is generally expressed as a filter efficiency at a specific particle size and an airflow rate. Units with anti-microbial or gaseous air cleaning capabilities are impacted by the lack of standard test methods noted earlier. Another important parameter is the contaminant capture effectiveness, but this is not generally covered in the product specifications. [1]

References:

[1] Building Retrofits for Increased Protection Against Airborne Chemical and Biological Releases, NIST, NISTIR 7379, March 2007. webpage https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=861035, April 2020. [NISTIR 7379 Building Retrofits for Increased Protection Against Airborne Chemical and Biological Releases](#)

[2] Biological Inactivation Efficiency by HVAC In-Duct Ultraviolet Light Systems, U.S. Environmental Protection Agency, American Ultraviolet Corporation ACP-24/HO-4, EPA 600/R-06/054, May 2006. webpage https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=459522, April 2020. [Biological Inactivation Efficiency By HVAC In-Duct Ultraviolet Light Systems](#) (EPA 600/R-06/054) [local](#)

Ultraviolet Germicidal Irradiation (UVGI) - Open Air

This section addresses the use of Ultraviolet radiation in the open air rather than within an HVAC system or other enclosed system meant to disinfect the air or a surface. There are two broad categories to consider. The first is UV-C Ceiling Level lights and the second is FAR UV 222 full room lights. The UV-C application has a long history dating back into 1943. The FAR UV-222 full room lights are new technology with few applications.

This is the analysis. See sections for Design Solutions [UV-C Ventilation Design Solutions](#) . [FAR UV-222 Design Solutions](#). See section for [UV Infrastructure Cost Estimates](#).

UV-C Ceiling Level Lights

A 6 year study in 1943 performed in Philadelphia on the effects of the use of UV-C ceiling level lights concluded that the use of UV-C lights lowered infection levels. The study begins with: the prevalence of respiratory infection during the season of indoor congregation suggests a natural relationship between ventilation and communicable disease and concludes that the level of infection was much lower in the irradiated classroom compared to the unirradiated classroom despite the fact that there were more susceptibles in the irradiated classroom than the unirradiated classroom [1]. UV-C light when placed at the ceiling level is a ventilation approach. As the air is mixed through convection or via mechanical mechanisms and finds its way to the ceiling it is subjected to the UV-C light and bacteria or virus are destroyed. [2] [9]

This is the analysis. See section for Design Solutions [UV-C Ventilation Design Solutions](#). See section for [UV Infrastructure Cost Estimates](#).

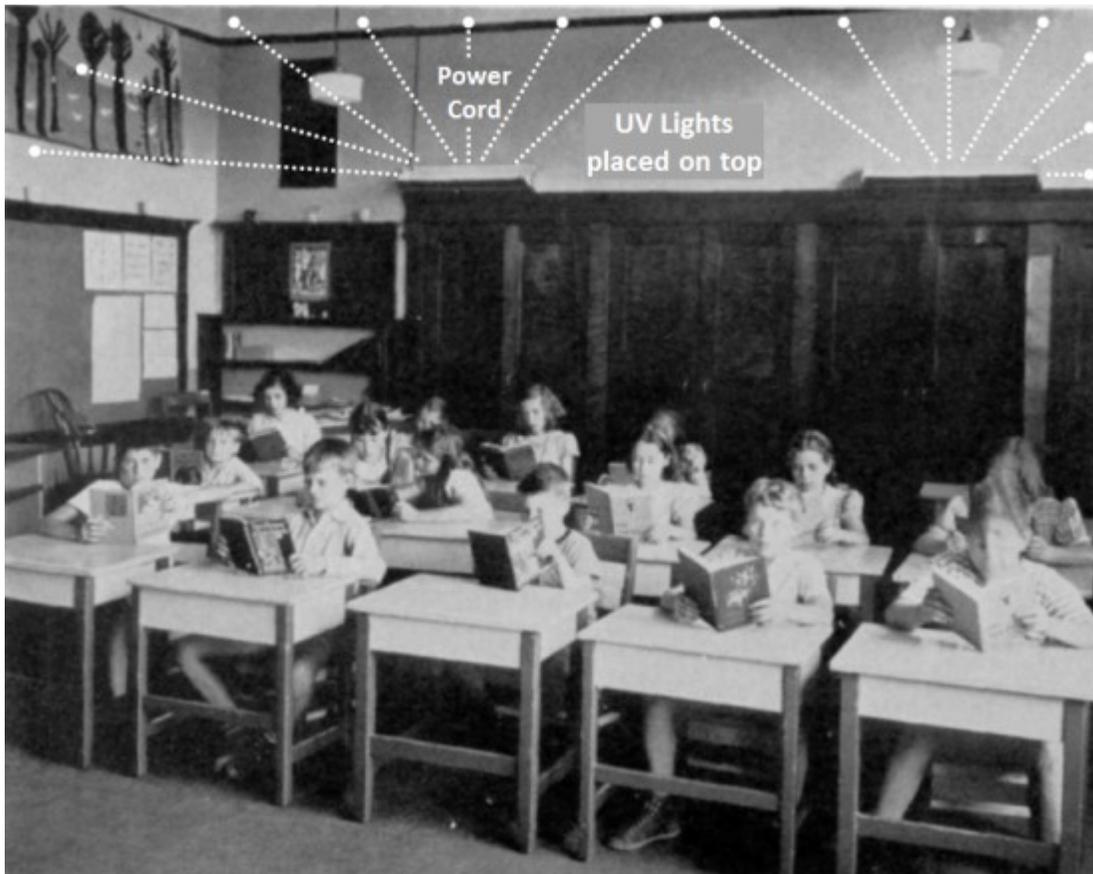


Figure 9 - Swarthmore Public School Classroom circa 1937 - 1943

According to CDC guidelines there is upwards of 90 percent effectiveness when applying UV-C lights and they effectively boost the air changes per hour where there can be 17 additional air changes per hour. During a study in a simulated healthcare room aerosolized *M. parafortuitum* was used in decay-method experiments that were conducted at mechanical ventilation rates of 0, 3, and 6 ACH, with a mixing fan to ensure a well-mixed room. The upper-room UVGI system (216 W) provided (42 ± 19) iW/cm² in the irradiated zone as measured by chemical actinometry. Inactivation rates (eACH) provided by the UVGI system were 17.5 ± 1.8 at 0 ACH, 20.0 ± 2.4 at 3 ACH, and 23.1 ± 0.78 at 6 ACH. [4] Note for this analysis eACH = AUC = ACH.

These are interesting numbers but they have no meaning. What matters is the percent of virus destroyed and the destruction rate. Without instantaneous 100% virus destruction we need to rely on test data. Regardless, the ceiling level UV-C systems need to be properly managed to ensure hot air is not trapped at the ceiling level, the air must circulate and yet allow sufficient time for the UV-C to destroy the virus. [2] [4]

UV-C radiation has been shown to destroy the outer protein coating of the SARS-Coronavirus [5] [7] [10]. The outer protein coating destruction leads to the inactivation of the virus. Although different from the current SARS-CoV-2 virus, it is a promising result. UV-C radiation also may be effective in inactivating the SARS-CoV-2 virus, which is the virus that causes the

Coronavirus Disease 2019 (COVID-19) [5]. The effectiveness of UV-C lamps for inactivating the SARS-CoV-2 virus is based on the wavelength, exposure time, and radiation level. [8]

There are UVGI lamps that have been in use for over 80 years. [3] They are proven technology. The primary issue is that they have moved from the general consumer industrial base to the commercial industrial base with applications primarily at the industrial level in very narrow settings. This unfortunately has translated into relatively high cost driven by supply and demand where the demand numbers are low but an extreme necessity. For example, a hospital or meat packing plant will pay the high cost because it is needed. A school will not pay for these lamps because of the high cost. Every dollar counts in a school. The idea that this is a florescent light fixture available at the local hardware store for \$29.95 requires an external agent to make that happen. These lamps were readily available at the consumer level in the 1960's and the previous generation knew of and understood their value. They were used everywhere in public spaces, restrooms, kitchens and even some home setting. As good health increased in the US during the 60's and 70's and the concept of infection and pandemics became an obsolete antiquated idea these lamps fell away from the consciousness of the population.

Low-pressure mercury lamp: This is the most common lamp used to produce UVC radiation. It is a low-pressure mercury lamp and more that 90% of the emission is at the 254 nm wavelength. Other specific narrow wavelengths are also available. There are other lamps that emit a broad range of UV wavelengths and also emit visible and infrared radiation. This is proven technology in use for decades.

Excimer lamp or Far-UVC lamp or FAR-UV 222: This is a new lamp being investigated to determine if humans can be directly exposed to this wavelength without any adverse health effects. This lamp produces a UV peak emission of approximately 222 nm. The concept is that the wavelength does affect the eyes or skin but will destroy the virus.

Pulsed xenon lamps: These lamps emit a short pulse of broad spectrum light (including UV, visible, and infrared) but have been filtered to emit mainly UV-C radiation. They are occasionally used in hospital settings to treat environmental surfaces in operating rooms or other spaces. They are normally used when no humans are occupying the space. This is proven technology in use for decades.

Light-emitting diodes (LEDs): Typically LEDs emit a very narrow wavelength band of radiation. Currently available UV LEDs have peak wavelengths at 214 nm, 265 nm, and 273 nm, and others. The small surface area and narrow beam width of LEDs may make them less effective for germicidal applications.

History

The germicidal effects of solar radiation was first identified in 1877 by Downes and Blunt who associated it the with actinic rays of the spectrum. The first large scale use of a UVGI system was for water purification in France in 1909 / 1910, when Marseilles authorities invited vendors of water purification equipment to participate in competitive tests. In 1936 UVGI was used to reduce postoperative infections. In 1937 UVGI was used in a school to reduce the incidence of measles, a highly contagious virus, the results were published in 1942 [9]. In the late 1950s and early 1960s a series of animal experiments showed that intense UVGI in air ducts kills or inactivates virulent *M. tuberculosis* in droplet nuclei. In addition to being used to control

airborne viruses and microorganisms, UVGI systems have been used in wastewater treatment facilities, air handling unit cooling coils and filter assemblies, pharmaceuticals, biohazard control, medical equipment, and food. [4]

In healthcare facilities, three types of UVGI systems are used:

1. Duct irradiation
2. Room air recirculation units
3. Upper room irradiation

In duct irradiation systems, one or more UVGI lamps are positioned within a duct to irradiate air being exhausted from a room or area through the duct. In room air recirculation units containing ultraviolet (UV) lamps, a fan draws room air into the unit near lamps to disinfect the air before it is recirculated back into the room. These units may be either portable or permanently mounted. In upper room UVGI systems, UV lamps are installed into fixtures suspended from a ceiling or mounted on a wall. The UV lamps are positioned so that air in the upper part of the room is irradiated. The intent is to maximize the levels of UV radiation in the upper part of the room and to minimize the level in the lower part of the room where occupants are located. These systems depend on good air mixing to transport the air (and thereby the microorganisms) to the upper portion of the room. [4]

UV Radiation

UV radiation is a form of electromagnetic radiation with a wavelength between the blue region of the visible spectrum and the X-ray region. For convenient classification, the International Electrotechnical Commission [CIE 1987] has divided the wavelengths between 100 nm and 400 nm into three wavelength bands:

- UV-A (315 nm to 400 nm, long wavelengths)
- UV-B (280 nm to 315 nm, midrange wavelengths)
- UV-C (100 nm to 280 nm, short wavelengths)

These spectral band designations are used to define approximate spectral regions and are shorthand notations that may vary between sources. Ozone in the atmosphere reacts with UV radiation below 290 nm and prevents UV-C radiation from reaching the earth's surface. UV-C radiation may be produced by a number of artificial sources (e.g. arc lamps, metal halide lamps). Germicidal lamps used in upper-room UVGI systems consist of low-pressure mercury vapor enclosed in special UV transmitting glass tubes. Approximately 95% of the energy from these lamps is radiated at 253.7 nm in the UV-C range [4].

The following table identifies other UV applications [11]

Table 22 - UV Applications

| Wavelength (nm) | UV Applications |
|-----------------|---------------------------------|
| 13.5 | Extreme Ultraviolet Lithography |

| Wavelength (nm) | UV Applications |
|------------------------|--|
| 30-200 | Photoionization, ultraviolet photoelectron spectroscopy |
| 230-365 | UV-ID, label tracking, barcodes |
| 230-400 | Optical sensors, various instrumentation |
| 240-280 | Disinfection, decontamination of surfaces and water (DNA absorption has a peak at 265 nm) |
| 254 | UV-C Low-pressure mercury lamp |
| 200-400 | Forensic analysis, drug detection |
| 270-360 | Protein analysis, DNA sequencing, drug discovery |
| 280-400 | Medical imaging of cells |
| 300-320 | Light therapy in medicine |
| 300-365 | Curing of polymers and printer inks |
| 300-400 | Solid state lighting |
| 350-370 | Bug zappers (flies are most attracted to light at 365 nm) |

Cellular Effects and Health Issues

UVGI damages living cells by directly or indirectly affecting the molecular structure of nucleic acids such as deoxyribonucleic acid (DNA). Other studies have indicated that UVGI may also affect cytoplasmic and membrane structures. The photobiological reaction (e.g. the formation of covalent bonds between adjacent thymine bases in DNA) that may occur when a photon of UVGI (at 254 nm) strikes a cell translates into cellular or genetic damage that may lead to cell death or inability to successfully replicate. UVGI provides a significant germicidal effect since many biological polymers absorb energy in this bandwidth. [4]

UVGI is absorbed by the outer surfaces of the eyes and skin. Short-term overexposure may result in photokeratitis (inflammation of the cornea) and/or keratoconjunctivitis (inflammation of the conjunctiva). Keratoconjunctivitis may be debilitating for several days but is reversible. Because these effects usually manifest themselves in 6 to 12 hours after exposure, their relationship to UVGI exposure may be overlooked. Symptoms may include an abrupt sensation of sand in the eyes, tearing, and eye pain that may be severe. Skin overexposure is similar to sunburn but does not result in tanning. Several instances of healthcare workers overexposed to UVGI have been reported. Five workers in a hospital emergency room were reported to have developed dermatosis or photokeratitis after exposure to high UVGI levels from a germicidal lamp. An

investigation of the incident determined that a UV lamp was unshielded. Additional reports of overexposure to UVGI from unshielded lamps have been reported in a hospital in Botswana and a morgue in the United States. [4]

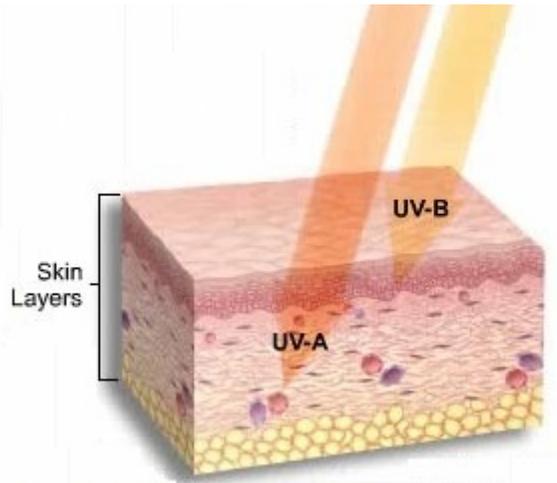


Figure 10 - Skin UV Damage

UV-A and UV-B rays can damage skin [6]
 Sunburn is a sign of short-term overexposure [6]
 UV-C does not penetrate as far

UV-C radiation has been shown to destroy the outer protein coating of the SARS-Coronavirus and the outer protein coating destruction leads to the inactivation of the virus. In 1947 during the Measles virus classroom study the UV levels were: average ultra-violet light intensity of 10 to 20 milliwatts per sq. ft. throughout the upper air; and 0.2 to 0.5 milliwatts per sq. ft. (or microwatts per sq. cm.) at face level of standing pupils [5] [9]. These numbers can be used as a reference for other analysis typically presented in microwatts per square centimeter:

- Note: 1 sq. ft. = 929.03 sq. cm.
- 10 to 20 milliwatts per sq. ft. ~ 10 to 20 microwatts per sq. cm.
- 0.2 to 0.5 milliwatts per sq. ft. ~ .2 to .5 microwatts per sq. cm.

The following table shows the disinfection time at 30,000 uW/cm² or 30mJ/cm² for bacteria, viruses, fungi and protozoa such as Cryptosporidium, Giardia, SARS, H5N 1 within one second. [11]

Table 23 - UV Exposure Infection Destruction Time

| Disinfection time in seconds at 30,000 uW/cm ² or 30mJ/cm ² | | | |
|---|-----------------|------------------|-----------------|
| Infection Source | 100% kill (Sec) | Infection Source | 100% kill (Sec) |
| Bacteria | | | |
| Anthraxes | 0.30 | Tuberculosis | 0.41 |

| Disinfection time in seconds at 30,000 uW/cm2 or 30mJ/cm2 | | | |
|---|-----------------|-------------------------|-----------------|
| Infection Source | 100% kill (Sec) | Infection Source | 100% kill (Sec) |
| Diphtheria | 0.25 | Vibrio Cholera | 0.64 |
| Clostridium Botulism | 0.80 | Pseudo monas Bacteria | 0.37 |
| Tetanus | 0.33 | Salmonella | 0.51 |
| Dysentery Bacillus | 0.15 | Fever Bacteria | 0.41 |
| Colibacillus | 0.36 | Bacillus Typhi murium | 0.53 |
| Hook-side Pylon Bacillus | 0.20 | Shigella | 0.28 |
| Legion Ella | 0.20 | Staphylococcus | 1.23 |
| Micro co | 0.4-1.53 | Streptococcus | 0.45 |
| Virus | | | |
| Adenovirus | 0.10 | Influenza Virus | 0.23 |
| Phagocyte Cell Virus | 0.20 | Polio Virus | 0.80 |
| Coxsackie Virus | 0.08 | Rota Virus | 0.52 |
| ECHO Virus | 0.73 | Tobacco Mosaic Virus | 16.00 |
| ECHO Virus 1 | 0.75 | Hepatitis B Virus | 0.73 |
| Mold Spores | | | |
| Aspergillums Niger | 6.67 | Soft Spores | 0.33 |
| Aspergillums | 0.73-8.80 | Penicillium | 2.93-0.87 |
| Dung Fungi | 8.00 | Penicillium Chrysogenum | 2.00-3.33 |
| Mucor | 0.23-4.67 | Other Fungi Penicillium | 0.87 |
| Water Algae | | | |
| Blue-green algae | 10-40 | Paramecium | 7.30 |
| Chlorella | 0.93 | Green Algae | 1.22 |
| Line Ovum | 3.40 | Protozoan | 4-6.7 |
| Fish Disease | | | |

| Disinfection time in seconds at 30,000 uW/cm ² or 30mJ/cm ² | | | |
|---|-----------------|--------------------------------|-----------------|
| Infection Source | 100% kill (Sec) | Infection Source | 100% kill (Sec) |
| Pang I Disuse | 1.6 | Infectious Pancreatic Necrosis | 4 |
| Leukodennia | 2.67 | Hemorrhagic | 1.6 |

The following analysis shows how long the virus needs to be exposed with lower power levels. It assumes 100% destruction and a linear time relationship. The original studies in 1937 - 1943 used power levels of 10-20 uW/cm² with an unknown AUC, however an assumption of 2 AUC is reasonable.

Table 24 - UV Infection Destruction Power Density and AUC

| 100% destroyed (sec) | uW/cm ² | AUC | kill (hours) | Comment |
|----------------------|--------------------|------|--------------|--------------------|
| 1 | 30000 | 3600 | 0.000277778 | |
| 60 | 500 | 60 | 0.016666667 | |
| 600 | 50 | 6 | 0.166666667 | |
| 900 | 33 | 4 | 0.25 | Design to criteria |
| 1800 | 17 | 2 | 0.5 | |
| 3600 | 8 | 1 | 1 | |

Guidelines Factors Influencing Effectiveness of Upper-Room UVGI Systems

The following is an extract from: Basic Upper-Room Ultraviolet Germicidal Irradiation Guidelines for Healthcare Settings, Department of Health and Human Services Centers for Disease Control and Prevention National Institute for Occupational Safety and Health, DHHS (NIOSH). [4]

Extract Start

Note: This guidance is based on the control of M. Tuberculosis. References to M. Tuberculosis have been replaced with the generic term Virus. This will affect the level of recommended UV exposure, however the levels in the extract remain unchanged. Additional studies identify the proper level of UV exposure needed to destroy various viruses.

1. UVGI Irradiance and Dose

Factors that must be considered when evaluating the ability of an upper-room UVGI system to kill or inactivate airborne microorganisms include the sensitivity of the microorganisms to UVGI and the dose of UVGI received by a microorganism or population of microorganisms. UVGI dose is the ultraviolet (UV) irradiance multiplied by the time of exposure and is usually expressed as micro watts per square centimeter (uW/cm²). A well-designed upper-room UVGI

system may be effective in killing or inactivating most airborne droplet nuclei containing mycobacteria if designed to provide an average UV fluence rate in the upper room in the range of 30 uW/cm² to 50 uW/cm² (for M. Tuberculosis), provided the other elements stipulated in these guidelines are met. In addition, the fixtures should be installed to provide as uniform a UVGI distribution in the upper room as possible. [4]

2. Upper-Room UVGI Systems and Mechanical Ventilation

As the mechanical ventilation rate in a room is increased, the total number of microorganisms removed from the room via this system is increased. However, when mechanical ventilation is increased in a room where an upper-room UVGI system has been deployed, the effectiveness of the UVGI system may be reduced because the residence time of the bacteria in the irradiated zone decreases. Under experimental laboratory conditions with mechanical ventilation rates up to six air changes per hour (ACH), the rate that microorganisms are killed or inactivated by UVGI systems appears to be additive with mechanical ventilation systems in well-mixed rooms. [4]

3. Air Mixing

Upper-room UVGI systems rely on air movement between the lower portion of the room where droplet nuclei are generated and the upper irradiated portion of the room. Once in the upper portion, droplet nuclei containing the Virus (original ref was M. Tuberculosis) may be exposed to a sufficient dose of UVGI to kill or inactivate them. When upper-room UVGI systems are installed, general ventilation systems should be designed to provide optimal airflow patterns within rooms and prevent air stagnation or short circuiting of air from the supply diffusers to the exhaust grills. Also, heating and cooling seasons should be considered and the system designed to provide for optimal convective air movement. Most rooms or areas with properly installed supply diffusers and exhaust grills should have adequate mixing. If areas of air stagnation are present, air mixing should be improved by adding a fan or repositioning the supply diffusers and/or exhaust grills. If there is any question about vertical air mixing between the lower and upper portions of the room due to environmental or other factors, a fan(s) should be used to continually mix the air. In a room without adequate air mixing under experimental laboratory conditions, the UVGI system effectiveness increased from 12% to 89% when a mixing fan was used. [4]

4. Humidity

A number of studies have indicated that the effectiveness of upper-room UVGI systems decreases as humidity increases. The reason for the decrease in UVGI effectiveness is not clearly understood. However, the effect needs to be considered in the general context of upper-room UVGI systems. For optimal efficiency, relative humidity (RH) should be controlled to 60% or less if upper room UVGI systems are installed. This is consistent with American Institute of Architects (AIA) and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommendations that the RH affecting patient care areas in hospitals and outpatient facilities range from 30% RH to 60% RH. If high humidity conditions are normal, it may be necessary to install a system with greater than normal upper-room irradiance levels.

5. Temperature

Recommendations developed by ASHRAE and AIA stipulate that the design temperature for most areas affecting patient care in hospitals and outpatient facilities range from 68F to 75F (20C to 24C). This temperature range is consistent with the optimal use of low pressure mercury lamps that are used in upper-room UVGI systems. [4]

Extract End

Practical Guidelines for Installation of Upper-Room UVGI Systems

The following is an extract from: Basic Upper-Room Ultraviolet Germicidal Irradiation Guidelines for Healthcare Settings, Department of Health and Human Services Centers for Disease Control and Prevention National Institute for Occupational Safety and Health, DHHS (NIOSH). [4]

Extract Start

Note: This guidance is based on the control of M. Tuberculosis. References to M. Tuberculosis have been replaced with the generic term Virus. This will affect the level of recommended UV exposure, however the levels in the extract remain unchanged. Additional studies identify the proper level of UV exposure needed to destroy various viruses.

1. UV Lamps

The most common way to generate germicidal UV radiation in lamps used in well-designed upper-room UVGI systems is to pass an electrical charge through low-pressure mercury vapor that has been enclosed in selected glass tubes that transmit only certain UV wavelengths. Care must be used in selecting the correct UVGI lamp for use in upper room UVGI systems. Typically, the optimal wavelength for UV germicidal radiation is 254 nanometers (nm) in the UV-C range. UV lamps are made for a variety of purposes that may have a negligible consequence in killing airborne microorganisms. Some UV lamps (such as those used for tanning) radiate energy in the UV-A and/or UV-B range and over extended periods may have adverse health consequences for exposed persons. Other UV lamps are designed to emit radiation at 184.9 nm and produce ozone, which is hazardous to humans even at low concentrations. Low-pressure mercury lamps should be rated for low or no ozone generation. Since all lamps must eventually be discarded, each lamp should contain only a relatively small quantity of mercury (i.e., 5 mg or less). [4]

2. UVGI Fixtures

In upper-room UV irradiation, fixtures containing UVGI lamps are suspended from the ceiling or installed on walls. The base of the lamp is shielded to direct the radiation upward and outward to create an intense zone of UVGI in the upper air while minimizing the level of UVGI in the lower (occupied) portion of the room or area. The height of the room must be considered to design an effective system. Only well-designed fixtures as noted in this document should be used. [4]

3. System Installation

Several rules of thumb for installation of the fixtures for upper-room UVGI systems have been developed over the last 50 to 60 years. In the CDC/NIOSH-funded study as indicated above, a

well-designed upper-room UVGI system may be effective in killing or inactivating airborne Virus (original ref was M. tuberculosis) if designed to provide an average UV fluence rate in the upper irradiated zone in the range of 30 uW/cm² to 50 uW/cm² provided the other elements stipulated in these guidelines are met. Based on this, two additional rules of thumb (guidelines) are provided in the document for installing UVGI systems. To simplify the installation process, the new guidelines are based on the required UV lamp wattage for the system. Considering all parameters, the installation of UVGI fixtures in rooms with approximately 2.4 m (8 ft) ceilings that provide (1) a UV-C irradiance of 1.87 W/m² (0.17 W/ft²) or (2) a UV-C power distribution of 6 W/m³ (0.18 W/ft³) in the upper UVGI zone should be effective in killing or inactivating airborne the virus (original ref was mycobacteria). A professional who is knowledgeable in upper-room UVGI systems and system installation should be consulted before procurement and installation of the system. The number of persons properly trained in the design of upper-room UVGI systems is currently limited. Persons who may be consulted include engineers, industrial hygienists, and radiation/ health physicists. A mechanism to provide training certification for system designers should be developed. [4]

4. Installation and Maintenance Considerations

Once the number and types of UVGI fixtures appropriate for the room or area have been determined, the fixtures need to be appropriately installed. Installation guidelines are provided in the document as well as problem areas that have been encountered during CDC/ NIOSH evaluations. Only qualified service technicians who have received training on the installation and placement of UVGI lamp fixtures should install the systems. Discussions are provided in the document on the required maintenance for the UVGI fixtures, UV lamps, and personal protective equipment (PPE) necessary during maintenance. Methods for UVGI measurements in the lower (occupied) level of a room or area and the upper irradiated area are discussed. [4]

Additional research needs for determining the most effective upper-room UVGI systems are provided in the document. These include UVGI measurements, air mixing, the effect of low humidity, microbial sensitivity, and testing and validating upper-room UVGI systems. Also, research needs to be done on the ability of UVGI systems to kill or inactivate microorganisms in (1) different size respirable droplet nuclei and (2) droplet nuclei coated with actual or simulated sputum. [4]

Extract End

See section for Design Solutions [UV-C Ventilation Design Solutions](#). See section for [UV Infrastructure Cost Estimates](#).

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FAR UV-222 Full Illumination

FAR UV-222 also known as FAR UVC is new technology and may be a promising approach for continuous safe decontamination in public spaces. Its wavelength is such that it will destroy viruses but not damage the skin and eyes thus potentially avoiding the damage caused by UV-C

direct light exposure [1] [2]. For the skin light at the 222 wavelength is absorbed by the Stratum corneum. This is the dead skin layer. For the eyes light at the 222 wavelength is absorbed in the outer surface of the cornea and is much less likely to cause cataracts. [A] [B] [C] There is an old study from 2014 suggesting that there may be issues associated with this technology. [D]

This is the Design section. For the Analysis see [FAR UV-222 Full Illumination](#). See section for [UV Infrastructure Cost Estimates](#).

The technology developed by Columbia University's Center for Radiological Research uses lamps that emit continuous low doses of a particular wavelength of ultraviolet light known as far-UVC. It kills viruses and bacteria without harming human skin, eyes and other tissues. So it can be used directly in a public space for continuous decontamination without harm to occupants. Research shows far-UVC effective in eradicating two types of airborne seasonal coronaviruses. It is effective in inactivating the airborne H1N1 influenza virus and drug-resistant bacteria. The researchers are now testing the light against the SARS-CoV-2 virus. Multiple long-term studies on animals and humans have confirmed that exposure to far-UVC does not cause damage to the skin or eyes. [4]



Photo: Columbia University For Radiological Research [4]

Figure 11 - FAR UV-222 Lights Installed

When researchers develop a vaccine against the COVID-19 virus, it will not protect against the next novel virus. This new technology if used in occupied public places has the potential to check future epidemics and pandemics. It eradicates airborne viruses minutes after they are breathed, coughed or sneezed into the air. It has the potential to prevent the global spread of the virus that causes influenza, measles, and now COVID-19. This approach takes a different tactic in the war against infection. Traditional approaches focus on fighting the infection once it has entered body. This approach has the potential to prevent the spread of viruses before they enter the body. The technology uses existing light fixtures and can be quickly deployed in hospitals, schools, shelters, airports, airplanes, offices, stores, and any other public and private space. [4]

A system that uses UV-C light (around 254 nm) kills viruses and bacteria. Hospitals and laboratories use germicidal UV-C light to sterilize unoccupied rooms and equipment. However UV-C light cannot be used in the presence of people because it causes health problems with the skin and eyes. It needs to be managed such as placing it within HVAC ducts or using ceiling level installations. Ceiling level applications will only clean the air, not the surfaces, and will only work when there is a proper installation and management of the lights. [4]

A system that uses Far-UVC light has a very short wavelength (from 205 to 230 nm) and cannot reach or damage living human cells. Yet these wavelengths can still penetrate and kill viruses and bacteria floating in the air or on surfaces. Its advantage is that it can illuminate an entire space, including surfaces, and its installation and maintenance are simple. Far-UVC lamps are now in production. [4]

One of the technical issues with FAR UV-222 is a physics challenge where power density drops off with the square of the distance. A device that provides sufficient uW/CM² within the distant regions of a room will have a very high uW/CM² near the light. This is a design challenge. It suggests multiple low power lights rather than one or two large power lights.

The following table identifies other UV applications.

Table 25 - FAR UV-222 and Other UV Applications

| Wavelength (nm) | UV Applications |
|------------------------|---|
| 13.5 | Extreme Ultraviolet Lithography |
| 30-200 | Photoionization, ultraviolet photoelectron spectroscopy |
| 205-230 | Far-UVC |
| 222 | Far UV-222 |
| 230-365 | UV-ID, label tracking, barcodes |
| 230-400 | Optical sensors, various instrumentation |
| 240-280 | Disinfection, decontamination of surfaces and water (DNA absorption has a peak at 265 nm) |
| 200-400 | Forensic analysis, drug detection |
| 270-360 | Protein analysis, DNA sequencing, drug discovery |
| 280-400 | Medical imaging of cells |
| 300-320 | Light therapy in medicine |

| Wavelength (nm) | UV Applications |
|------------------------|---|
| 300-365 | Curing of polymers and printer inks |
| 300-400 | Solid state lighting |
| 350-370 | Bug zappers (flies are most attracted to light at 365 nm) |

For the following discussion the following unit conversions are provided:

- 1 watt = 1 Joule/sec
- 1 W = 1 J/s
- 1 uW = 1 uJ/sec

The current dose limit guideline for 222 nm light from the International Commission on Non-Ionizing Radiation Protection (ICNIRP) is 23 mJ/cm² per 8-hour exposure [5]. This is an intensity of ~3 mJ/cm²/hour or 3uW/cm² in a 1 hour period. In the 1937 - 1946 study of UV-C the students were exposed to 0.2 uW/cm² to 0.5 uW/cm² and the decontamination zone at the ceiling level was 10 uW/cm² to 20 uW/cm². The power density is less than the ceiling level system, however the advantage is that all of the volume in the space is exposed to a higher UV power density. Also air mixing and air management becomes irrelevant and will not negatively impact the system. If we assume a 10 foot ceiling with a 1 foot irradiation zone we see that covers about 10% of the volume. This translates broadly to 1-2 uW/cm² across the entire volume with the UV-C approach. This simple relationship suggests that the FAR UV-222 level of 3uW/cm² should be equivalent to a UV-C based system unless the UV-C based system increases the power density at the ceiling level, manages the lower UV-C exposure via careful reflective structure, and manages the air exchange. Previous studies have suggested that a UV-C system could offer an AUC of up to 17 per hour [6].

FAR-UVC is being studied at Columbia University and they have disclosed some of the data. The following table shows the virus inactivation in a test chamber where the virus was exposed for 20 minutes. [5]

Table 26 - FAR UV-222 Virus & Inactivation Percent

| Virus & Inactivation % | 90% mJ/cm² per 20 min | 99% mJ/cm² per 20 min | 99.9% mJ/cm² per 20 min |
|-----------------------------------|---|---|---|
| HCov-229E | 0.56 | 1.10 | 1.70 |
| HCov-OC43 | 0.39 | 0.78 | 1.20 |
| Influenza A (H1N1) | 1.30 | 2.60 | 1.80 |

- 1 watt = 1 Joule/sec
- 1 W = 1 J/s
- 1 uW = 1 uJ/sec
- 1mJ = 1,000 uJ

The units need to be converted to uW/cm² so that we have a common performance number to compare with other systems and analysis. For example, the recommended exposure intensity is ~ 3mJ/hr/cm². This is 0.833 uJ/cm²/sec = uW. The following table shows that 90% of HCov-229E or HCov-OC43 is inactivated in 20 minutes and is within safe limits for an 8 hour exposure.

Table 27 - FAR UV-222 Virus Inactivation Power Density

| Virus & Inactivation % | 90% mJ/cm ² per 20 min | 99% mJ/cm ² per 20 min | 99.9% mJ/cm ² per 20 min | 90% uJ/cm ² per 20 min | 99% uJ/cm ² per 20 min | 99.9% uJ/cm ² per 20 min | 90% uJ/cm ² /sec uW/cm ² | 99% uJ/cm ² /sec uW/cm ² | 99.9% uJ/cm ² /sec uW/cm ² |
|------------------------|-----------------------------------|-----------------------------------|-------------------------------------|-----------------------------------|-----------------------------------|-------------------------------------|--|--|--|
| HCov-229E | 0.56 | 1.10 | 1.70 | 560 | 1100 | 1700 | 0.47 | 0.92 | 1.42 |
| HCov-OC43 | 0.39 | 0.78 | 1.20 | 390 | 780 | 1200 | 0.33 | 0.65 | 1.00 |
| Influenza A (H1N1) | 1.30 | 2.60 | 1.80 | 1300 | 2600 | 1800 | 1.08 | 2.17 | 1.50 |

Given that FAR-UVC or FAR UV-222 does not penetrate the skin or eye cornea, it is unclear what the recommended exposure intensity of ~ 3mJ/hr/cm² means in terms of future applications. The following are selected extracts from the Columbia University research on FAR-UVC [5]:

Extract Start

Beta results for the HCoV-OC43 coronavirus, continuous far-UVC exposure at this intensity would result in 90% viral inactivation in approximately 8 minutes, 95% viral inactivation in approximately 11 minutes, 99% inactivation in approximately 16 minutes and 99.9% inactivation in approximately 25 minutes. Low doses of far-UVC, 1.7 and 1.2 mJ/cm², can inactivate 99.9% of aerosolized alpha and beta coronavirus. The beta coronavirus results indicate that continuous far-UVC exposure in public locations at the currently recommended exposure limit (3 mJ/cm²/hour) would result in 99.9% viral inactivation in ~25 minutes. As all human coronaviruses have similar genomic size, a key determinant of radiation sensitivity, it is realistic to expect that far-UVC will show comparable inactivation efficiency against other human coronaviruses, including SAR-CoV-2.

Extract End

There are real world projects being implemented based on this technology. It is not theoretical. The following are examples of real world projects implementing FAR-UVC or FAR UV-222. It is not an endorsement of the technology or the companies involved. It is provided for reference and further research. The research is going live and perhaps is similar to the very first UV-C study that was started in 1937.

🚩 September 9, 2020 (Margate City, NJ) - 9600 Condominium, a premier, award-winning New Jersey Shore living destination, today announced that it will become the first Garden State facility to install Far-UVC 222nm light technology to help protect its staff, residents and guests against the spread of harmful viruses and pathogens. Developed by Melbourne, Fla. based Healthe, Inc., three state-of-the-art sanitization products will be installed at key touch and travel points throughout 9600 Condominium’s facility, including the building’s lobby, gym and

bathrooms. This state-of-the art sanitization technology was developed by Melbourne, Fla. based Healthe, Inc. [3]

▼ September 30, 2020 (New York, NY) - Australian-inspired coffee and hospitality brand Bluestone Lane announced today that it will become the first nationwide café chain to install Far-UVC 222 light technology to increase protections for locals and employees against the spread of harmful pathogens and viruses like COVID-19. Bluestone Lane is first deploying Healthe's suite of light solutions in its "Collective Café" (55 Greenwich Ave.) and "Bowery Café" (19 Kenmare Street), with plans for a nationwide rollout. [3]

▼ October 13, 2020 (Kohler, WI) - The Blind Horse Restaurant & Winery is the first restaurant in the United States to install Far-UVC 222 light technology to provide real-time mitigation of harmful pathogens and viruses. State-of-the-art sanitization solutions, developed by Melbourne, Fla. based Healthe, Inc., will be installed at key locations throughout the restaurant in mid-October. Far-UVC 222 light technology provides an additional layer of critical protection for staff and guests—along with the other safety initiatives already in place throughout the property. [3]

▼ October 22, 2020 (Summit, NJ) - Boll & Branch (the "Company"), the world's leading designer and retailer of sustainable home goods, is setting a new standard for the future of retail space safety by becoming the first retail store to install Far-UVC 222 light technology (Healthe Space™). This cutting-edge sanitization solution will increase protections for customers and employees against the spread of harmful pathogens and viruses. Boll & Branch has installed Far-UVC downlights in its newly opened retail locations in Greenwich, CT (169 Greenwich Ave) and Boca Raton, FL (Town Center at Boca Raton, 6000 Glades Road, Space 1034). This state-of-the art sanitization technology was developed by Melbourne, Fla. based Healthe, Inc. [3]

This is the analysis. See section for Design Solutions [FAR UV-222 Design Solutions](#). See section for [UV Infrastructure Cost Estimates](#).

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Air Flow Rates And Natural Ventilation

This analysis was started because of the observations made while examining the infection and death rates in certain countries [1]. The key observations are:

- Building architectures based on open ventilation may be a factor (Egypt)
- Heating Ventilation and Cooling systems in older buildings may be a factor (Russia)

The topics in this section are:

- Air Update Rates CDC and Other Guidelines

- World Health Organization Natural Ventilation
- What if Analysis
- Sneeze Analysis Model
- Virus Load Air Exchanges Needed Model
- Event Based Air Exchanges Needed Model
- Probability of Exposure Air Exchanges Needed Model
- CDC Airborne Contaminant Removal Model
- Full Picture Static Model
- Natural and Mechanical Ventilation Designs
- Observations

Air Update Rates CDC and Other Guidelines

There is a large body of guidelines recommending different building and room air flow rates from different organizations. Air flow is specified using the following units:

- AUC = Air Updates / Hour - Air Update Change
- ACH = Air Changes / Hour - Air Change Rates
- Changes = Updates (Note: fresh air exchange is identified separately such as Air Exchange Rates)
- Min/Chg - Minutes / Change
- l/s = Liters / Second
- cfm = Cubic Feet / Minute

It is easy to convert to the different units. In some cases the room size is needed to make the conversions. As the different guidelines are accessed, the air update rates are significantly different. Note that the amount of fresh air is irrelevant to this issue. Any virus contaminated air must be cleaned before being expelled to the outside. Since it must be clean, it can be recycled and mixed with fresh air as part of the existing design to minimize the effects of gas and other contaminants in the building air.

The CDC air update rates for hospitals appear to be significantly lower than for other settings. However the CDC does not provide upper limits suggesting that each hospital can decide on the upper AUC limits. Also hospitals are designed to ensure staff are upwind of infected patients and the staff know and understand how to use personal protection equipment. Outside of a hospital setting people do not understand the importance of being upwind from an infected person and do not understand how to use personal protect equipment. Further outside of a hospital setting people are not able to control their locations relative to air movement and access different levels of personal protection equipment. For example an infected person sneezes 6 feet away from a uninfected person and does not protect the sneeze and it just goes everywhere.

The following is a sampling of air flow rates compiled from multiple sources [2], [3], [4], [5], [6], [7]. [[spreadsheet](#)]

Table 28 - AUC Rates Sampling (Various Standards)

| Area | AUC min | AUC max | Source | Area | AUC min | AUC max | Source |
|------|---------|---------|--------|------|---------|---------|--------|
|------|---------|---------|--------|------|---------|---------|--------|

| Area | AUC min | AUC max | Source | Area | AUC min | AUC max | Source |
|----------------------|---------|---------|------------|-----------------------|---------|---------|----------------|
| Hospital Trauma room | 15 | - | CDC | Malls | 6 | 10 | EPA |
| Hospital rooms | 6 | 10 | EPA | Office | 8 | 30 | Greencheck |
| Restaurants | 8 | 12 | EPA | Engine Room | 20 | 60 | Greencheck |
| Restaurants | 8 | 20 | NCI | Kitchen | 12 | 60 | Greencheck |
| Restaurants | 15 | 20 | wiki | Kitchen | 7 | 8 | NCI |
| Bar | 15 | 30 | Greencheck | Kitchen | 14 | 18 | NCI |
| Bar | 15 | 20 | NCI | Kitchens (commercial) | 15 | 30 | EPA |
| Bar | 15 | 20 | wiki | Retail | 6 | 10 | NCI, wiki, EPA |
| School Classroom | 4 | 12 | EPA | Laboratory | 12 | 30 | Greencheck |
| Classroom (Art) | 16 | 20 | EPA | Laboratory | 6 | 12 | wiki |

The following table shows the lowest and highest ACH values from different guidelines. The range is significant and the guidelines vary significantly. A key issue is how were these values determined. Are they based on some engineering analysis, scientific findings, operational test findings from focus groups or other approaches. Now there is a need to determine the AUC or ACH because of the COVID-19 disaster. Is there an AUC or ACH that can be used to mitigate the effects of the virus inside buildings?

Table 29 - ACH Rates Min and Max (Various Standards)

| ACH Min | ACH Max | Avg | Source [REF: spreadsheet] |
|---------|---------|-----|--|
| 3 | 60 | 11 | Greencheck |
| 3 | 20 | 9 | NCI |
| 4 | 30 | 8 | Fan App |
| 2 | 50 | 11 | EPA |
| 4 | 60 | 9 | Eng Tool Box |

| ACH Min | ACH Max | Avg | Source [REF: spreadsheet] |
|---------|---------|-----|--|
| 3 | 30 | 8 | wiki |
| 2 to 15 | NA | 8 | CDC |

References:

[1] See section [Death Rates By Country](#)

[2] [American Society of Heating and Air-Conditioning Engineers \(ASHAE\)](#), webpage <https://www.ashrae.org>, May 2020.

[3] [Greencheck](#), webpage <https://www.greenheck.com>, May 2020.

[4] [Chartered Institution of Building Service Engineers](#), webpage <https://www.cibse.org>, May 2020.

[5] [National Comfort Institute](#), <https://www.nationalcomfortinstitute.com>, webpage, May 2020.

[6] Appendix B. Air Guidelines for Environmental Infection Control in Health-Care Facilities (2003). webpage <https://www.cdc.gov/infectioncontrol/guidelines/environmental/appendix/air.html>, May 2020. [Appendix B. Air Guidelines for Environmental Infection Control in Health-Care Facilities \(2003\)](#)

[7] Air Guidelines for Environmental Infection Control in Health-Care Facilities (2003) Updated July 2019. webpage <https://www.cdc.gov/infectioncontrol/pdf/guidelines/environmental-guidelines-P.pdf>, May 2020. [Air Guidelines for Environmental Infection Control in Health-Care Facilities \(2003\)](#) . [Library](#)

World Health Organization Natural Ventilation

In 2009 The World Health Organization (WHO) released a document offering guidelines for building ventilation for infection control [1]. A team of engineers, architects, infection-control experts and microbiologists was assembled to provide a design and operation guide for hospital planners, engineers, architects and infection control personnel. There was a review of literature on ventilation and disease transmission and effective natural ventilation solutions for infection control. There are very few studies on natural ventilation for infection control in hospitals. The WHO guidelines for Natural Ventilation for Infection Control in Health-Care Settings should be reviewed by everyone addressing HVAC modifications to deal with the COVID-19 disaster.

Note: Natural ventilation is found in buildings without modern air conditioning systems. Mechanical ventilation is found in buildings with Heating Ventilation and Cooling (HVAC) systems. Natural ventilation is found in outdoor settings.

The higher the ventilation rate, the more rapid the decay of virus droplet nuclei in the room air. According to the Wells-Riley equation, the probability of infection via droplet nuclei is inversely related to the ventilation rate. The parameters used in the Wells-Riley equation include ventilation rate, generation of droplet nuclei from the source (quanta/minute) and duration of exposure.

$$P = D/S = 1 - \exp (- (Ipqt/Q))$$

P = probability of infection for susceptibles

D = number of disease cases

S = number of susceptibles

I = number of infectors

p = breathing rate per person (m³/s)

q = quantum generation rate by an infected person (quanta/s)

t = total exposure time (s)

Q = outdoor air supply rate (m³/s)

quanta = virus

Based on this model, in situations of high virus production the estimated probability of infection with 15 minutes of exposure in a room with 12 ACH would be below 5%. However, this hospital scenario is not realistic while engaging in life such as going to school, working in an office, eating at a restaurant, shopping in a big box store, going to a beach or a park with a gentle wind, congregating outside with no wind, walking outside, and other scenarios. More realistic scenarios are developed further in this analysis that represent various living conditions [2].

Some key ACH numbers found in the WHO natural ventilation guidelines are:

Table 30 - ACH rates WHO Natural Ventilation

| Openings | ACH | Ventilation rate (l/s) |
|--|-----|------------------------|
| Open window (100%) + open door | 37 | 1300 |
| Open window (50%) + open door | 28 | 975 |
| Open window (100%) + closed door | 4.2 | 150 |
| Assumptions: <ul style="list-style-type: none"> wind speed of 1 m/s ward of size 7 m (length) × 6 m (width) × 3 m (height) window of 1.5 × 2 m² door of 1 m² × 2 m² (smallest opening). | • | |
| Note: infection is more rapid and frequent in a ventilation lower than 2 ACH | | |

Ventilation reduces the concentration of airborne virus by removing or diluting airborne droplet nuclei. A higher ventilation rate provides a higher dilution of the virus and reduces the risk of airborne infections in a shared physical space. According to this WHO report **The maximum ventilation rate above which there is no infection risk is unknown**. Ventilation rate is driven by the need to reduce energy consumption because of costs. However, this analysis has attempted to address this critically missing information and numbers are provided further in this text.

When ACH is used to measure ventilation performance, the volume of the enclosed room is an important parameter. For a given ACH, a room with a larger volume can provide a larger airflow rate (m³/h or l/s) than a room with a smaller volume. For natural ventilation the WHO recommends the following minimum hourly average ventilation rates:

- 160 l/s/patient (hourly average ventilation rate) for airborne precaution rooms (with a minimum of 80 l/s/patient) (note that this only applies to new health-care facilities and major renovations)
- 60 l/s/patient for general wards and outpatient departments
- 2.5 l/s/m³ for corridors and other transient spaces without a fixed number of patients

The CDC disclosed both the Droplet Evaporation curves from Wells (1934) and the Wells-Riley equation (1978) as part of their study on natural ventilation for infection control in health-care settings [1]. There is insufficient data to recommend a minimum ventilation rate for infection control against droplet nuclei. **It is known that infection among clinical workers is more rapid and frequent in an average ventilation lower than 2 ACH**. Once again, this analysis has

attempted to address this critically missing information and numbers are provided further in this text.

Between 1934 and 1978 we went from a natural ventilation society to an enclosed air conditioned society with massive Heating Ventilation and Cooling (HVAC) Systems. Further, with the energy crisis in the 1970's all fresh air systems were converted to recycled air to save on energy costs. The question that needs to be answered is what happens in a work setting during the COVID-19 pandemic and what engineering needs to be performed to modify physical spaces to reduce the risk of virus infection.

References:

[1] WHO Publication/Guidelines Natural Ventilation for Infection Control in Health-Care Settings, World Health Organization (WHO), 2009. webpage https://www.ncbi.nlm.nih.gov/books/NBK143284/pdf/Bookshelf_NBK143284.pdf, May 2020. [Natural Ventilation for Infection Control in Health-Care Settings, WHO, 2009](#) . [local](#)

[2] See section [Wells Riley Probability of Infection](#).

What if Analysis

The following analysis is called a what if analysis [1], [2]. It was started before the WHO guidelines were reviewed and it is being updated after the WHO guidelines were reviewed.

It follows a path of least resistance to surface related information and the nature of the problem. It is based on various worst case scenarios, relationships, correlations and other elements to try and understand the problem. It is a disclosure of the nonlinear thinking paths taken when trying to solve a problem. The analysis may lead nowhere and it may just sit until the systems team revisits it and is able to move forward with the analysis and resulting system architecture changes.

The case studies, models, and certain country infection rates suggest that the infection rate is less outdoors than indoors. The question is what can be done to modify indoor environments to match more closely outdoor environments. In the late 1970's building HVAC systems were modified to reduce the amount of fresh air intake to reduce energy use. This is now an accepted norm. It is unclear if the old standards for fresh air exchange would be sufficient to mitigate the spread of bacterial, virus, or fungal agents.

There are many standards that exist for air exchange rates per hour and they are a function of the room use and the number of occupants. The ideal situation might be to just open all the windows and have massive cross flow of outside air as found in buildings in Egypt. However, that is not practical for all existing building architectures. The only alternative is to increase the HVAC systems air flow rates to exchange more air. This challenge exists not only for buildings but also public transportation systems. The ground based public transportation systems have been analyzed in this text. [3]

There are two engineering approaches that can be used. The first is old school brute force engineering. The second is new school engineering based on mathematics and modeling. In brute force engineering the solution is over engineered and it is intuitively obvious that it will work

from a functional and performance perspective. In a mathematics and modeling based approach it is not intuitively obvious that the solution will work. Instead the numbers in the model suggest that the solution will work. This approach is used when it is not possible to brute force a solution because of cost or other issues including the ability to implement a viable solution.

The question is what the air flow rate should be to duplicate an outdoor environment in the indoor (building and transportation) settings.

An over engineered solution would be 1 cu-ft / sec per-person in a directed air flow setting. This is approximately equal to an outdoor wind speed of 1 mile per hour or a person walking and taking 1 step per second. The probability of any cross contamination in such an over engineered system is very low. The problem is that this translates into 60 cu-ft / min per-person in a building. Though possible, it is far beyond the current design guidelines for current buildings. For example, Hospital (Patient Rooms) are ventilated at 25 cu-ft per min. This scenario also translates to a personal air change rate of 1 per second or an AUC = 3600. That is beyond the limits of existing HVAC systems. Air exchanges in a room range from 1 to 30 per hour with the norm at 1 to 4 per hour. These are the various maximum AUC rates. [[spreadsheet ACH](#)]

Table 31 - AUC Maximum rates

| Source | AUC | References |
|------------------------------|------|-------------------------|
| Various Standards | 60 | [4], [5], [6], [7], [8] |
| CDC Hospital | 15 | [4] |
| WHO Open Window | 37 | [8] |
| Outside Walking at 1 mph | 3600 | this analysis |
| Outside Sitting 1 mph breeze | 3600 | this analysis |

Unfortunately, unless the building design is from the pre-air conditioning era it is unlikely that any HVAC systems will be modified to support a 1 mph breeze or an AUC of 3600. Further analysis is needed until someone can offer a technical solution to the massive artificial air flow rates needed to match outside conditions.

All the buildings would have to be modified with new massive air flow rates. It becomes problematic if the person is in a large room and the air is not directed over the person. This suggests the room air needs to be exchanged once per second. That is not possible. The solution needs to include directed air so that it is possible to implement the solution. The scenario is - The air gets sucked up at the rate of 1 cu-ft / sec per-person, enters the HVAC system, is subjected to massive UV-C and filtering, then is either fully exhausted to the outside environment or recycled back into the building with some percentage of fresh air and subjected to heating or cooling as needed.

Airplanes - Brute Force

It is relatively easy to retrofit an airplane cabin with floor or under seat vents and have massive airflow from the top vents to the floor because the plane is flying hundreds of miles per hour.

The challenge is to provide massive air flow while the airplane is on the ground. Even with the ground challenge the solution is relatively easy and low cost because of the small space.

Computer Labs - Brute Force

Many computer labs are still fitted with false floors and chillers used to cool old mainframe computers. The tiles in these floors came in 2 styles, vented and unvented. The vented tiles can be moved to appropriate locations where people gather and walk to direct the massive airflow up and away. Everyone that works in these settings knows about the massive airflow coming from the vented tiles and either cover them with cardboard material or stay away from the floor vents. This is a simpler solution that can be implemented immediately in many computer labs or other false floor settings that use pressurized floor cooling systems.

Old Building Architectures - Engineered Solution

These are old buildings that were built before air conditioning. They have strategic placement of windows, very high ceilings, and maybe even ductwork for massive exhaust fans. These buildings can be opened up and new exhaust fans can be used to provide massive fresh air flow ranging for 1 to 5 miles per hour. The challenge is during the cold winter months. In this case these buildings will need changes to the heating systems to implement massive air flow, UV-C in the ducts, and filters. However, these buildings tend to be smaller and it will be less difficult to implement these massive air flow heating systems.

Case History

In the 1960's my family purchased a bar and restaurant in Philadelphia, PA. It was a small establishment consisting of 5 brownstones that were modified in the early 1900s to be a bar and restaurant. It had three Fedders window air conditioners, the largest that were available at the time. It also had two exhaust fans. One in front in the Bar area and one in back in the kitchen area open to an eating area. This was during a time when people smoked heavily. In this type of business customers arrived in droves at unexpected times. The air conditioners in the summer ran constantly and they would clean the air of cigarette smoke most of the time. However during sudden bursts of crowds the smoke would get so thick it would be difficult to see people in the establishment. The exhaust fans were manually controlled and they would be off during this sudden surge which might happen over 15 minutes - 75 people arrive - they are all smoking - no one can break away to turn on the exhaust fans. Eventually the exhaust fans would be turned on and within 30 seconds all the smoke would be cleared Yes they were loud and yes there was massive air movement. This is an example of brute force engineering. The AUC was easily 120.

New Building Architectures - Engineered Solution

These buildings tend to be large and are not designed to bring in the outside air when the temperature is moderate. They are designed to have conditioned air 100% of the time. This will require serious engineering to even get a working solution that will provide the needed air flow. There is no room for over engineering like in the case of the Old Buildings because of the cost of purchasing and operating the HVAC systems.

After this initial analysis, other analysis approaches were performed and the AUC rate can be less than this brute force approach.

References:

[1] Systems Practices As Common Sense, Walter Sobkiw, ISBN: 978-0983253082, first edition 2011, ISBN: 978-0983253051, second edition 2020. [REF 1](#)

[2] Systems Engineering Design Renaissance, Walter Sobkiw, ISBN: 978-0983253075, 2014. [REF 2](#)

[3] See section [Public Transportation](#).

[4] Air Guidelines for Environmental Infection Control in Health-Care Facilities (2003) Updated July 2019. webpage <https://www.cdc.gov/infectioncontrol/pdf/guidelines/environmental-guidelines-P.pdf>, May 2020. [Air Guidelines for Environmental Infection Control in Health-Care Facilities \(2003\)](#) . [Library](#)

[5] Human Engineering, MIL-STD-1472F, Department of Defense, 23 August 1999, MIL-STD-1472D, 14 March 1989. [MIL-STD-1472F](#) . [MIL-STD-1472D](#) . [local](#)

[6] The Airliner Cabin Environment and the Health of Passengers and Crew, National Academy of Sciences, 2002. DTFA0100P100P10285, U.S. Department of Transportation. webpage <https://pubmed.ncbi.nlm.nih.gov/25032286>, May 2020. [Library](#)

[7] Strategies to Protect the Health of Deployed U.S. Forces: Force Protection and Decontamination Michael A. Wartell, Michael T. Kleinman, Beverly M. Huey, and Laura M. Duffy, Editors, Commission on Engineering and Technical Systems, National Research Council, ISBN: 0-309-66390-3, 262 pages, 6 x 9, (1999). [NIH - Strategies to Protect the Health of Deployed U.S. Forces: Force Protection and Decontamination](#) . [local](#)

[8] WHO Publication/Guidelines Natural Ventilation for Infection Control in Health-Care Settings, World Health Organization (WHO), 2009. webpage https://www.ncbi.nlm.nih.gov/books/NBK143284/pdf/Bookshelf_NBK143284.pdf, May 2020. [Natural Ventilation for Infection Control in Health-Care Settings, WHO, 2009](#) . [local](#)

Models

Various models were developed to try and understand the air update rates needed to mitigate the risks of infection inside a building [1] [2]. [[spreadsheet](#) Droplet Dispersion]

References:

[1] For references to the various numbers in the models see section [Virus Transmission](#).

[2] Additional models are developed in other sections.

Sneeze Analysis Model

When a contaminated person sneezes, they expel 200 million droplets and some percentage of those droplets contain the virus. Currently the models and analysis suggest that the droplets eventually fall to the floor. The question is how long the droplets are airborne. One analysis that can be performed is to determine the room size needed if the droplets were uniformly distributed where the virus load reaches the 1000 count threshold. This suggests that a person would inhale 1000 viruses with a single breath. If the room has a 12-foot ceiling the room dimensions are 59 feet X 59 feet. Further the sneeze is traveling at 50-200 miles per hour. The question then becomes how fast the air needs to be exchanged to protect a person from the infected sneeze. [[spreadsheet Droplet Dispersion](#)]

Table 32 - Sneeze Analysis

| Droplet Density Analysis | Male | Female | Assumptions & Comments |
|---|--------------------|--------------------|---|
| Total lung capacity (Liters) | 6 | 4.2 | Assumption |
| Total lung capacity (cu in) | 366.12 | 256.284 | |
| Total lung capacity (cu ft) | 0.211875 | 0.1483125 | |
| Infected Sneeze (droplets) | 200,000,000 | 200,000,000 | Assumption |
| Infection Level (droplets) | 1,000 | 1,000 | Assumption |
| Infected Sneeze/cu ft (droplets) | 42,375,000 | 29,662,500 | |
| Volume needed for infection level (cu ft) | 42,375 | 29,663 | Uniform droplet dispersion |
| Room Ceiling Level (ft) | 12 | 12 | Assumption |
| Room size needed (ft X ft) | 59 | 50 | |
| Square feet | 3600 | 2500 | This less than a grocery store, or big box store This is similar to a retail store or restaurant |

The equation is:

$$C1 * V1 = C2 * V2$$

C1 = infection event (breathing, cough, sneeze)

V1 = lung capacity volume

C2 = infection level (dose needed)

V2 = physical space volume

An interesting analysis but it does not yield any insights that might help in the design of an updated HVAC system in a building. However it forced a new set of perspectives and analysis as follows.

Virus Load Air Exchanges Needed Model

The next analysis performed is given a virus load what should the air exchange be to mitigate infection risk. The analysis started with breathing, it continued with coughing, and finally with sneezing.

Table 33 - Virus Load Air Exchanges Needed

| Analysis 2 - Virus Load Based Air Exchanges Needed | Any Person | Assumptions & Comments |
|---|-------------------|-----------------------------------|
| Infected Single Breath (virus load) | 20 | Assumption |
| Breaths / Second | 1 | Assumption |
| Infected Droplets / Hour | 72,000 | |
| Infection Level (droplets) | 1,000 | Assumption |
| Seconds Needed to Reach Virus Load | 50 | |
| Required Air Exchanges (per hour) | 72 | Possible but very high |
| <hr/> | | |
| Cough (droplets) | 3,000 | Assumption |
| Infection percentage | 0.8 | Assumption |
| Virus Load | 2,400 | |
| Coughs / Event | 3 | Assumption |
| Cough Events / Hour | 6 | Assumption |
| Total Coughs / Hour | 18 | |
| Infected Droplets / Hour | 43,200 | |
| Infection Level (droplets) | 1,000 | Assumption |
| Required Air Exchanges / Hour | 43 | Possible but still high |

| Analysis 2 - Virus Load Based Air Exchanges Needed | Any Person | Assumptions & Comments |
|---|-------------------|-----------------------------------|
| Sneeze (droplets) | 200,000,000 | Assumption |
| Infection percentage | 0.8 | Assumption |
| Virus Load | 160,000,000 | |
| Sneeze / Event | 1 | Assumption |
| Sneeze Events / Hour | 1 | Assumption |
| Total Sneeze / Hour | 1 | |
| Infected Droplets / Hour | 160,000,000 | |
| Infection Level (droplets) | 1,000 | Assumption |
| Required Air Exchanges / Hour | 160,000 | Not possible |

$$\text{AUC} = \text{Idh} / \text{IL} = \text{Isb} * \text{Bs} * 3600 / \text{IL}$$

Isb = Infected Single Breath (virus load) = assumption

Bs = Breaths / Second = assumption

Idh = Infected Droplets / Hour = Isb * Bs * 3600

IL = Infection Level (droplets) = assumption

Svl = Seconds Needed to Reach Virus Load = IL / (Isb * Bs)

AUC = Required Air Exchanges (per hour) = Idh / IL

$$\text{AUC} = \text{Idh}/\text{IL} = \text{Ed} * \text{Ip} * \text{Epe} * \text{Eph} / \text{IL}$$

Ed = Event - Cough (droplets) = assumption

Ip = Infection percentage = assumption

VL = Virus Load = Ed * Ip

Epe = Event - Coughs / Event = assumption

Eph = Event - Cough Events / Hour = assumption

Eth = Event - Total Coughs / Hour = Epe * Eph

Idh = Infected Droplets / Hour = VL * Eth

IL = Infection Level (droplets) = assumption

AUC = Required Air Exchanges / Hour = Idh / IL

$$\text{AUC} = \text{Idh} / \text{IL} = \text{Ed} * \text{Ip} * \text{Epe} * \text{Eph} / \text{IL}$$

Ed = Event Sneeze (droplets) = assumption

Ip = Infection percentage = assumption

$VL = \text{Virus Load} = Ed * Ip$
 $Epe = \text{Event - Sneeze / Event} = \text{assumption}$
 $Eph = \text{Event - Sneeze Events / Hour} = \text{assumption}$
 $Eth = \text{Event - Total Sneeze / Hour} = Epe * Eph$
 $Idh = \text{Infected Droplets / Hour} = VL * Eth$
 $IL = \text{Infection Level (droplets)} = \text{assumption}$
 $AUC = \text{Required Air Exchanges / Hour} = Idh / IL$

It is very difficult to protect against a sneeze event with an AUC of 160,000. Breathing is cyclic and predictable. Coughing is usually controlled. Sneezing is usually an uncontrolled event. As a result people do not cover their sneeze and the droplets are fully released into the environment. This led to an analysis based on events.

Event Based Air Exchanges Needed Model

This led to an interesting result however it soon became obvious that there is an exposure time window where there is risk of infection.

Table 34 - Event Based Air Exchanges Needed

| Analysis 3 - Event Based Air Exchanges Needed | Any Person | Assumptions & Comments |
|--|-------------------|-----------------------------------|
| Coughs or Sneeze / Event | 3 | Assumption |
| Coughs or Sneeze Events / Hour | 6 | Assumption |
| Total Coughs or Sneeze / Hour | 18 | |
| Number of People | 3 | Assumption |
| Required Air Exchanges / Hour | 54 | Possible but still high |
| Potential Infection Exposure (min) | 6 | Time before air is exchanged |
| Probability of Infection | 0.1 | Decreases with air exchange |

$AUC = Eth * N$

$Epe = \text{Event - Sneeze / Event} = \text{assumption}$
 $Eph = \text{Event - Events / Hour} = \text{assumption}$
 $Eth = \text{Event - Total Sneeze / Hour} = Epe * Eph$
 $N = \text{Number of People} = \text{assumption}$
 $AUC = \text{Required Air Exchanges / Hour} = Eth * N$
 $Pie = \text{Potential Infection Exposure (min)} = 60 - AUC$
 $Pi = \text{Probability of Infection} = Pie / 60$

This led to an analysis based on probability of exposure.

Probability of Exposure Air Exchanges Needed Model

This led to an interesting result because it is clear that near a certain threshold the probability of infection drops significantly with a doubling of the air exchange rate.

Table 35 - Probability of Exposure Air Exchanges Needed

| Analysis 4 Probability of Exposure Air Exchanges Needed | Any Person | Assumptions & Comments | Observations |
|--|-------------------------|-----------------------------------|----------------------------|
| Breaths / Second | 60 | Assumption | |
| Breaths / Hour | 3600 | | |
| Breaths / Infection Threshold | 50 | | |
| Seconds / Infection Threshold | 50 | | |
| Infection Virus Load | 1000 | Assumption | |
| Virus Load / Breath | 20 | Assumption | |
| Scenarios | Exchanges / Hour | Probability of Infection | |
| 1 | 3600 | ~0 | No infection |
| 2 | 1800 | ~0 | No infection |
| 3 | 900 | ~0 | No infection |
| 4 | 450 | ~0 | No infection |
| 5 | 225 | ~0 | No infection |
| 6 | 113 | ~0 | No infection |
| 7 | 56 | 0.21875 | Significant infection risk |
| 8 | 28 | 0.609375 | Ventilation is pointless |
| 9 | 14 | 0.8046875 | Ventilation is pointless |
| 10 | 7 | 0.90234375 | Ventilation is pointless |

The CDC has a similar study.

CDC Airborne Contaminant Removal Model

The following is the CDC guideline: Table B.1. Air changes/hour (ACH) and time required for airborne-contaminant removal by efficiency *

Table 36 - CDC Airborne Contaminant Removal Model

| ACH | Time (mins.) removal: 99% efficiency | Time (mins.) removal: 99.9% efficiency | Comments |
|------------|---|---|---|
| 2 | 138 | 207 | |
| 4 | 69 | 104 | |
| 6+ | 46 | 69 | |
| 8 | 35 | 52 | |
| 10+ | 28 | 41 | frequently cited ACH for patient-care areas |
| 12+ | 23 | 35 | frequently cited ACH for patient-care areas |
| 15+ | 18 | 28 | frequently cited ACH for patient-care areas |
| 20 | 14 | 21 | |
| 50 | 6 | 8 | |

ACH Values were derived from the formula:

$$t_2 - t_1 = - [\ln (C_2 / C_1) / (Q / V)] \times 60, \text{ with } t_1 = 0$$

where:

- t1 = initial timepoint in minutes
- t2 = final timepoint in minutes
- C1 = initial concentration of contaminant
- C2 = final concentration of contaminant
- $C_2 / C_1 = 1 - (\text{removal efficiency} / 100)$
- Q = air flow rate in cubic feet/hour
- V = room volume in cubic feet
- $Q / V = \text{ACH}$

Values apply to an empty room with no aerosol-generating source. With a person present and generating aerosol, this table would not apply. Other equations are available that include a constant generating source. However, certain diseases (e.g., infectious tuberculosis) are not likely

to be aerosolized at a constant rate. The times given assume perfect mixing of the air within the space (i.e., mixing factor = 1). However, perfect mixing usually does not occur. Removal times will be longer in rooms or areas with imperfect mixing or air stagnation.

Full Picture Static Model

It took a while to get to this analysis. This is a static model and it is based on computer static timing and sizing analysis. I wanted to perform this analysis first, but my fear was that something would be missed from other perspectives. It appears that this analysis might be the most useful from a users perspective. It shows the required air update change per hour (AUC) and the point at which a person is exposed to the virus infection load.

Table 37 - Full Picture Static Model

| AUC / hour | Breaths/ Sec | Exposure Sec | Breaths/ Air Exchange | Exposure Min | Virus Load | Infection Load | Virus inhaled (1 hr) | Virus inhaled (2 hr) | Virus inhaled (3 hr) | Hours before Infected Load |
|------------|--------------|--------------|-----------------------|--------------|------------|----------------|----------------------|----------------------|----------------------|----------------------------|
| 3600 | 1 | 1 | 1 | 0.02 | 20 | 1000 | 20 | 40 | 60 | 50.00 |
| 1800 | 1 | 2 | 2 | 0.03 | 20 | 1000 | 40 | 80 | 120 | 25.00 |
| 900 | 1 | 4 | 4 | 0.07 | 20 | 1000 | 80 | 160 | 240 | 12.50 |
| 450 | 1 | 8 | 8 | 0.13 | 20 | 1000 | 160 | 320 | 480 | 6.25 |
| 225 | 1 | 16 | 16 | 0.27 | 20 | 1000 | 320 | 640 | 960 | 3.13 |
| 113 | 1 | 32 | 32 | 0.53 | 20 | 1000 | 640 | 1280 | 1920 | 1.56 |
| 56 | 1 | 64 | 64 | 1.07 | 20 | 1000 | 1280 | 2560 | 3840 | 0.78 |
| 28 | 1 | 128 | 128 | 2.13 | 20 | 1000 | 2560 | 5120 | 7680 | 0.39 |
| 14 | 1 | 256 | 256 | 4.27 | 20 | 1000 | 5120 | 10240 | 15360 | 0.20 |
| 7 | 1 | 512 | 512 | 8.53 | 20 | 1000 | 10240 | 20480 | 30720 | 0.10 |
| 4 | 1 | 900 | 900 | 15.00 | 20 | 1000 | 18000 | 36000 | 54000 | 0.06 |
| 2 | 1 | 1800 | 1800 | 30.00 | 20 | 1000 | 36000 | 72000 | 108000 | 0.03 |
| 1 | 1 | 3600 | 3600 | 60.00 | 20 | 1000 | 72000 | 144000 | 216000 | 0.01 |

TBIL = IL/(Bs * (3600/AUC) * VL)

TBIL = IL/Vi1

TBIL = IL/(Bae * VL)

TBIL = IL/(Bae * VL)

TBIL = IL/(Bs * Es * VL)

TBIL = IL/(Bs * (3600/AUC) * VL)

$AUC = AUC/Hour = Assumptions$
 $Bs = Breaths/Sec = Assumptions$
 $Es = Exposure/Sec = 3600/AUC$
 $Bae = Breaths/Air\ Exchange = Bs * Es$ (needed for when the Breaths/sec changes e.g. 0.5 or 2.0)
 $Em = Exposure\ Min = (Exposure/Sec)/60$ (to get a feel for exposure time)
 $VL = Virus\ load = Assumption$
 $IL = Infection\ load = Assumption$
 $Vi1 = Virus\ inhaled\ (1\ hr) = Bae * VL$ (any value above the Infection Load will lead to infection)
 $Vi2 = Virus\ inhaled\ (2\ hr) = Vi1 * 2$
 $Vi3 = Virus\ inhaled\ (3\ hr) = Vi2 * 3$
 $TBIL = hr\ before\ infected\ load = IL/Vi1$

The magic number appears to be between 50 and 100 air exchanges per hour. Another important consideration is the amount of time before the infection level is reached. Even though an air exchange rate of 113 may exist the infection level will still be reached in 1.56 hours. This is a significant finding because it suggests that the best mitigation is to leave any enclosed spaces as soon as possible. Further an enclosed space is not just a building but it is also a large crowd in a outdoor space with no ventilation into the crowd center.

Natural and Mechanical Ventilation Designs

A picture is worth a thousand words. Examining the design of hospital rooms and natural ventilation structures can provide insights into how to prepare different public spaces. It is all about air movement. Just because people are at an outdoor cafe it does not mean the air exchange is sufficient or in the directions that are needed to minimize the potential spread of disease.

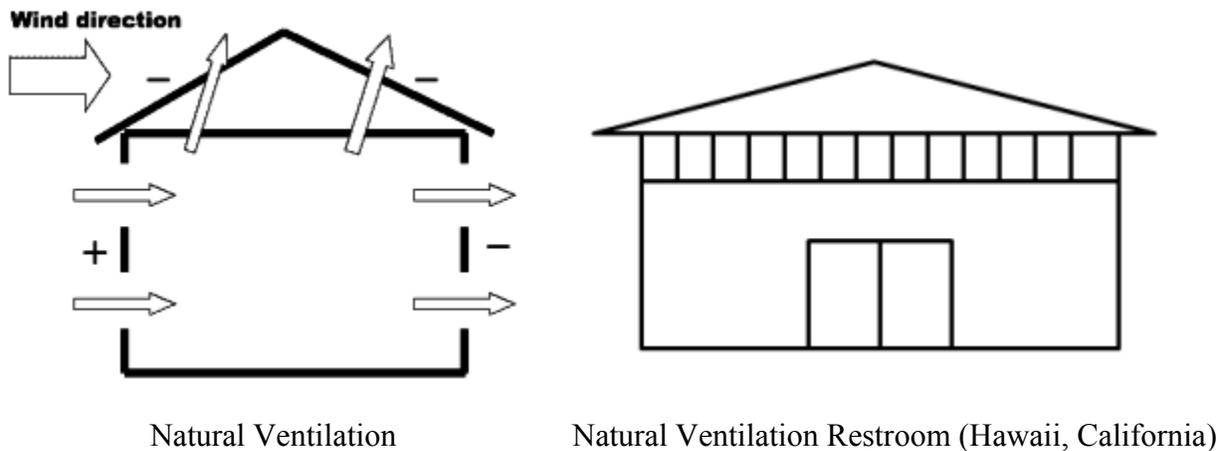
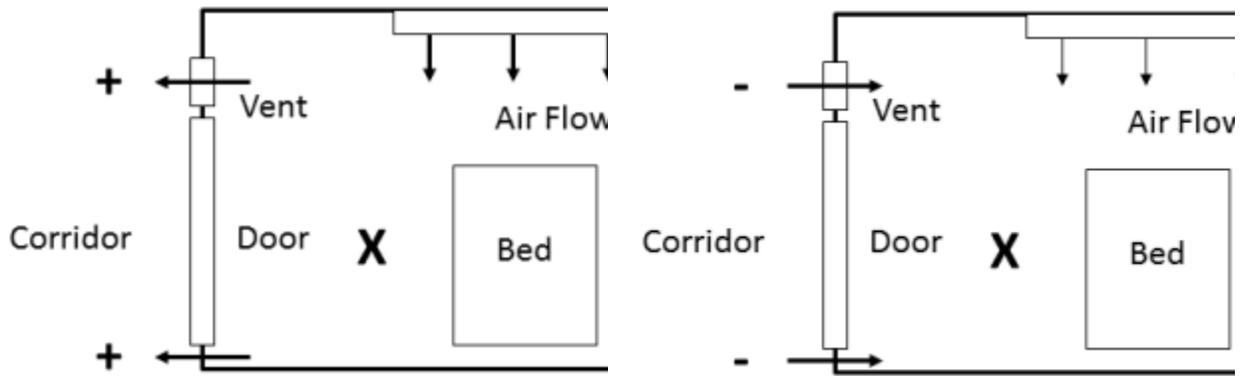


Figure 12 - Natural and Mechanical Ventilation Buildings

Careful placement of people and mechanical ventilation is needed and can only happen with a drawing or sketch of the outdoor venue. Simple ceiling fans, wall fans, exhaust fans in strategic locations will keep the outdoor air moving but it must not be trapped in circulating zones. After some thought and a simple paper design, a smoke test can be used to tune the final placement of the fans.



Hospital Room Positive Pressure

Hospital Room Negative Pressure

Figure 13 - Hospital Room Positive/Negative Pressure

Observations

We know that fresh air movement is key. We know that when we walk we move into a space of fresh air once per second. We also know that is approximately 1 mile per hour. This should be easy to duplicate with outdoor venues. It is problematic with modern office buildings. The modern office buildings will need serious HVAC upgrades. Some of the office buildings have outdoor spaces. People should be encouraged to spend time in these outdoor spaces.

Hospitals are designed to mitigate the spread of infection. Further the hospital staff uses different levels of professional protection equipment based on the circumstances. The issue is what can people do as they return back to life during a pandemic with a highly infectious disease. Some buildings are able to immediately take advantage of natural ventilation and bring the outside air indoors with relatively large AUC levels. Other buildings are closed and use HVAC systems that are designed for energy efficiency and not minimizing the spread of disease. It is these buildings that must be updated with massive new AUC levels. The analysis suggests that the:

AUC levels must be: **50 - 100 AUC** to minimize the spread of disease inside tight buildings with no external ventilation alternatives

This is very interesting because the case history of a small bar and restaurant in the 1960's and 1970's had a brute force engineering approach where the AUC was easily 120. [1]

With such a high AUC level it is obvious that any virus would be quickly diluted and then expelled from the environment. It would be nice if formal lab testing could be immediately initiated to determine if this recommended AUC level is sufficient or if it can be reduced.

References:

[1] See section [What if Analysis](#), Old Building Architectures - Engineered Solution.

Design Solutions

HVAC and Open Ventilation Design Solutions

This analysis has attempted to identify the AUC levels that must be achieved to mitigate virus infection. The next step is to determine if a design is possible and what are the issues associated with the design. A product search was initiated to locate large commercial fans for potential mechanically assisted natural ventilation in small buildings like a Home Owners Association Clubhouse. The following analysis was performed for a house using a whole house fan, a house using its current HVAC system and then a public clubhouse modified with commercial attic based ventilation fans.

The following analysis is for a house. It is provided to get a feel for the design considerations and possibility of very high AUC levels. [[spreadsheet](#) Design]

Table 38 - HVAC and Open Ventilation

| Whole House Fan System | | House HVAC System | |
|-----------------------------------|--------------|--------------------------|--------------|
| 30 inch whole house fan cu-ft/min | 5,700 | Home HVAC cu-ft/min | 1,600 |
| 30 inch whole house fan cu-ft/hr | 342,000 | Home HVAC cu-ft/hr | 96,000 |
| Ceiling | 10 | Same | Same |
| square feet | 2,400 | Same | Same |
| Space cu-ft | 24,000 | Same | Same |
| AUC | 14.25 | AUC | 4.00 |
| Minutes to change air | 4.21 | Minutes to change air | 15.00 |

The following analysis is for a public club house.

Table 39 - Small Building Design Example

| HOA Club House | Alternative 1 | Alternative 2 | Alternative 3 | Alternative 4 | Comments |
|-----------------------|---------------|---------------|---------------|---------------|----------|
| fan system cu-ft/min | 53,900 | 53,900 | 53,900 | 53,900 | Note 1 |
| Number of fans | 1 | 2 | 3 | 4 | Note 2 |
| cu-ft/min | 53,900 | 107,800 | 161,700 | 215,600 | |
| cu-ft/hr | 3,234,000 | 6,468,000 | 9,702,000 | 12,936,000 | |
| Ceiling | 10 | 10 | 10 | 10 | |
| square feet | 12,000 | 12,000 | 12,000 | 12,000 | |
| Space cu-ft | 120,000 | 120,000 | 120,000 | 120,000 | |
| AUC | 26.95 | 53.90 | 80.85 | 107.80 | Note 3 |
| Minutes to change air | 2.23 | 1.11 | 0.74 | 0.56 | |

Note 1: Direct Drive Wall Fan 48 inches. [Vendor](#).

Note 2: More smaller fans may be better. For example 1 per room.

Note 3. This systems engineering analysis suggests an AUC of 50-100 to minimize the risk of infection [Air Flow Rates And Natural Ventilation](#)

It appears that 2 to 3 commercial grade exhaust/attic fans can provide the suggested AUC levels in this analysis. That is 1 to 2 times the CDC recommended AUC levels from Table B.1. Air changes/hour (ACH) and time required for airborne-contaminant removal by efficiency or 1 to 2 times the recommended level for a commercial kitchen. The issue is that the open windows and doors will be bringing outside air into the building. This includes pollen. Also, depending on the window and door opening sizes the drafts may be significant while also creating dead air zones. This requires careful management of openings to ensure consistent and full air flow throughout the building. The exhaust/attic fan based solution is only viable when the temperatures are moderate.

Modifying the HVAC system to have AUC levels approaching the recommended levels may require additional duct work. One possibility is to use the attic/exhaust fans and HVAC system at the same time when temperatures are extreme. This is not a new operational setting. Many small bars and restaurants in the major cities operated in this mode throughout the 1960's and 1970's. They had to deal with massive cigarette smoke and provide for comfortable temperature and humidity conditions. As movement happened into the suburbs the new structures used centralized HVAC systems and so there was less of a dependence on exhaust fans to freshen the air and remove cigarette smoke from these settings. The final change happened when cigarette smoking was banned in many public spaces. So there was no longer a need to run the HVAC and exhaust fans at the same time. With the COVID-19 disaster, running the HVAC systems in parallel with the fans exhaust systems once again should be considered in the designs and used in operational settings.

This is a challenge that no one will touch with a 10 foot pole. There are great engineering companies that have attempted to go down this path but they stop short of claiming to have the

answer [1]. However these companies can be helped with a massive government sponsored Ventilation Test and Evaluation program.

The JASON group from MITRE performed analysis for restarting university research programs that were impact because of the inability to physically access workspaces because of the COVID-19 disaster. These are some of the findings. From the executive summary they suggest labs ensure at least 4 air changes per hour (ACH) and to increase the flow rate if the lab has more than a single occupant. Within the report more detail is provided - more than half the benefit is achieved at 4 ACH, which is on the lower end of typical commercial spaces; and 90% of the benefit is achieved at 15 ACH, which is on the high end of what one might be found in a laboratory space. Aerosols are an important means of transmission in laboratories and other enclosed spaces. In addition to wearing masks, minimizing double occupancy, and maintaining distance, buildings HVAC systems can play a role in mitigating transmission [2].

References:

[1] COVID-19 White Paper, Taylor Engineering, Updated: May 28, 2020. webpage <https://taylorengeers.com/taylor-engineering-covid-19-whitepaper>, July 2020. [COVID-19 White Paper](#) . [local](#)

[2] Managing the Risk from COVID-19 During a Return to On-Site University Research, JASON The MITRE Corporation, JSR-20-NS1, July 2, 2020. <https://fas.org/irp/agency/dod/jason/covid-19.pdf>, July 2020. [Managing the Risk from COVID-19 During a Return to On-Site University Research](#) . [local](#)

UV-C Ventilation Design Solutions

UV-C when placed at the ceiling level is a ventilation approach. As the air is mixed through convection or via mechanical mechanisms and finds its way to the ceiling it is subjected to the UV-C light and the virus is destroyed. This addition to a room can translate into 17, 20, 23 additional eAUC per hour for mechanical ventilation rates of 0, 3, and 6 ACH. The performance of these systems is base on the time the air spends at the ceiling levels and the power density of the UV design. [2] [4] Note that for this analysis $eAUC = ACH = AUC$.

This is the Design section. For the Analysis see section [UV-C Ceiling Level Lights](#). See section for [UV Infrastructure Cost Estimates](#).

There are no shrink wrapped products that allow the average consumer to buy and install a ceiling level UV-C solution without external support from professionals. Unique design needs to be performed to determine the maximum UV-C effectiveness that can be achieved for different room sizes and ceiling heights. Some of the considerations include the existing ventilation system. The ventilation must be tuned so that the virus is subjected to the ceiling level UV-C for a sufficient amount of time to destroy the virus and yet maximize the virus destruction rate (the UV-C based AUC). For rooms that use radiant heat in the winter this may require the introduction of fans. For rooms that use forced hot air systems this may require modifications of airflow from the vents. The same applies to air conditioned environments during the hot weather months [5] [6].

In spite of the lack of shrink wrapped products, UV-C ceiling level applications exist in hospitals, schools, homeless shelters, etc. The industrial base does need to be expanded to address the home market because of high cost and systems that may be too large for the typical home. The market is basically an industrial market. Design guidance is provided by the CDC and FDA.

- Basic Upper-Room Ultraviolet Germicidal Irradiation Guidelines for Healthcare Settings - CDC [4]
- UV Lights and Lamps: Ultraviolet-C Radiation, Disinfection, and Coronavirus - FDA [5]
- Ultraviolet (UV) Radiation - FDA [6]

The first proven design appeared in 1937 as part of a study performed in Philadelphia by W.F. Wells. He was an Associate Professor in Research in Air-borne Infection at the Laboratories for the Study of Air-borne Infection in the Department of Preventive Medicine and Public Health at University of Pennsylvania School of Medicine, Philadelphia, PA. The findings were presented in part before the Engineering Section of the American Public Health Association at the Seventy-first Annual Meeting at St. Louis, Mo., October 30, 1942. It was supported by a grant from the Commonwealth Fund to the University of Pennsylvania for the study of the mechanics of air-borne infection and control. The design was based on science and engineering using numbers to understand the system and its level of performance [1].



Figure 14 - Swarthmore Public School Classroom

The effectiveness of UVGI is typically expressed in terms of deactivation rate, which is a function of device geometry, intensity of the light source, resistance of the bioagent of interest,

and residence time of the agent in the field of irradiation. Inactivation or kill rates can be predicted based on these parameters. However, there is no standard test method for determining the effectiveness of these devices and they are not generally supplied with the performance data to determine kill rates. There is a proposed UVGI Rating Value (URV) from 8 to 15 that corresponds to an average light intensity expressed in units of mW/cm^2 [10]. Based on the exposure time and the susceptibility of a particular organism, the URV value can then be converted to a kill rate for that organism. However, the URV concept has not yet been adopted in an industry standard. At this point, UVGI systems are described in terms of the lamp specifications, including the light intensity expressed uW/m^2 . [11]

The design solution needs to be verified. This is accomplished using measurement equipment that measures the ceiling level UV concentration where the virus is expected to be destroyed and the lower room level UV concentration where people are expected to be present to ensure that safe levels are present. Ideally the measurements should be continuous 24/7 or when the space is open to the public. The power levels are a function of the power density. There are studies being performed to determine the power density needed to destroy this virus. There is data SAR-Cov-1 that can be used as a starting point.

Various product brochures are in the Library [[Lib/UV-Systems/Products](#)]. The potential vendors and organizations are shown below (there is no for or against endorsement).

Table 40 - UV Industry Vendors and Organizations

| Company / Organization | Links | Products & Markets | Comment |
|------------------------------------|--|--------------------------------|--|
| Lightbest Co, LTD * | https://www.light-best.com https://lightbest.en.alibaba.com | All products all markets | International manufacturing company |
| Coospider | https://coospider.com | Light Fixtures and bulbs | International manufacturing company |
| . | | | |
| Atlantic Ultraviolet Corporation * | https://www.buyultraviolet.com | All products all markets | Manufacturing company |
| EvergreenUV / Lumalier | https://www.lumalier.com | All products all markets | Manufacturing company |
| American Air and Water | https://www.americanairandwater.com | All products all markets | Manufacturing company |
| American Ultraviolet | https://www.americanultraviolet.com | All products all markets | Manufacturing company |
| Larson Electronics | https://www.larsonelectronics.com | UV-C & FAR UV- | Manufacturing company |

| Company / Organization | Links | Products & Markets | Comment |
|---------------------------------------|--|-------------------------------|---|
| | | 222 | |
| ProLampSales | https://www.prolampsales.com/collections/g13-base-uv-c-bulbs https://www.prolampsales.com/collections/uv-c-indirect-upper-air-sanitizers | UV-C Lights | Distributor |
| Phillips | https://www.lighting.philips.com/main/products/uv-disinfection | All products all markets | International manufacturing company |
| . | | | |
| International Ultraviolet Association | http://www.iuva.org | All products all markets | Professional organization |
| UVSolutions | https://uvsolutionsmag.com | All products all markets | The Official Publication of the International Ultraviolet Association |
| UV Solutions Buyers Guide | https://uvsolutionsmag.com/buyersguide/services/MAIN_COVID19 | All products all markets | The Official Publication of the International Ultraviolet Association |

* vendors use in conceptual design solution

Table 41 - Vendor Datasheet: Lightbest

| Model Number | Diameter (mm) | Length (Inch) | Arc Length (mm) | Power (W) | Current (mA) | voltage (V) | UV output at 1 meter (uw/cm2) | Watts | Rated Life (h) |
|--------------|---------------|---------------|-----------------|-----------|--------------|-------------|-------------------------------|-------|----------------|
| G10T5I | 15 | 14 | 277 | 17 | 425 | 51 | 54 | 5.7 | 9000 |
| G36T5I | 15 | 33 | 763 | 41 | 425 | 120 | 130 | 13 | 9000 |
| G48T5I | 15 | 45 | 1068 | 55 | 425 | 165 | 170 | 18 | 9000 |
| G64T5I | 15 | 61 | 1474 | 75 | 425 | 220 | 225 | 24 | 9000 |

Instant Start (Slimline) Germicidal Lamps-T5 SP_DE Instant start lamps-Ozone free

Table 42 – Vendor Datasheet: Atlantic Ultraviolet Corporation

| Model Number | Length (inches) | Watts |
|-------------------------|-----------------|-------|
| LIND24-EVO 40-0125B | 24 | 8.5 |
| LIND24-EVO-2PM 40-0126C | 24 | 17 |

The following table shows a potential design for a house. The solution is based on components that are assembled by the installer. This approach is the lowest cost approach. Until there is a commercial consumer market this is the only reasonable option because of cost. [[Spreadsheet UV Design](#)]

Table 43 - UV-C Whole House Design

| Whole House UV-C | Lamp Type | Number | Length Inches | Watts / Light |
|------------------|-----------|--------|---------------|---------------|
| Living room | G36T5I | 2 | 33 | 13 |
| Dining Room | G36T5I | 1 | 33 | 13 |
| Kitchen | G36T5I | 1 | 33 | 13 |
| Rec Room | G36T5I | 2 | 33 | 13 |
| Bedroom | G36T5I | 1 | 33 | 13 |
| Bedroom | G36T5I | 1 | 33 | 13 |
| Bedroom | G36T5I | 1 | 33 | 13 |
| Bedroom | G36T5I | 1 | 33 | 13 |
| Bathroom | G10T5I | 1 | 14 | 5.7 |
| Bathroom | G10T5I | 1 | 14 | 5.7 |
| Powder Room | G10T5I | 1 | 14 | 5.7 |

| Whole House UV-C | Lamp Type | Number | Length Inches | Watts / Light |
|-------------------------|------------------|---------------|----------------------|----------------------|
| UV Measurement Tool | - | 1 | - | - |

It is unclear if the house installation benefits outweigh the risk. For example homeowners and children tampering with the UV lights while they are on is a risk while the benefit is just limited to a small number of people in extreme close contact. However, if there is an infected person in the house there may be a benefit to the infected person where the free virus load in the air is significantly reduced allowing the body to fight off a diminished total virus load that includes external and internal body virus exposure.

The following table shows a potential design for a Home Owners Association (HOA) club house. It uses industrial products. This is currently a high cost approach. The analysis shows that this approach costs 15 times more than sourcing the individual components and assembling the components onsite. [\[Spreadsheet UV Design\]](#)

Table 44 - UV-C HOA Club House Design

| HOA Club House | # Units | Unit Type | Length Inches | Watts / Unit |
|-----------------------|----------------|-------------------------|----------------------|---------------------|
| Ballroom | 4 | LIND24-EVO-2PM 40-0126C | 24 | 17 |
| Library | 1 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Sitting Area | 1 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Conference Room | 1 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Office | 1 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Craft Room | 1 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Billiards Room | 1 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Game Room | 1 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Exercise Room | 2 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Indoor Pool | 2 | LIND24-EVO-2PM 40-0126C | 24 | 17 |
| Locker Room 1 | 2 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Locker Room 2 | 2 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Powder Room 1 | 2 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Powder Room 2 | 2 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Reception Area | 2 | LIND24-EVO 40-0125B | 24 | 8.5 |
| Hallway | 2 | LIND24-EVO 40-0125B | 24 | 8.5 |
| UV Measurement Tool | 1 | - | - | - |

In all cases the UV installation needs to be tested for UV levels where the infection is to be destroyed and for the worst case living levels. This is to ensure that maximum benefit is achieved

and there is minimal UV exposure to humans. Permissible Exposure Times (PET) can be calculated for various irradiance levels as follows:

$$\text{PET (seconds)} = \text{REL (6000 uJ/cm}^2 \text{ at 254 nm)} / \text{Measured irradiance level at 254 nm (uW/cm}^2\text{)}$$

where: At 254 nm, the CDC/NIOSH REL is 6 mJ/cm² (6000 uJ/cm²)

The following table shows the PET values for different scenarios. [4]

Table 45 - UV-C Permissible Exposure Times (PET)

| PET (Units given) | PET (Sec) | Effective Irradiance (uW/cm²) |
|------------------------------|----------------------|---|
| 8 h | 28,800 | 0.2 |
| 4 h | 14,400 | 0.4 |
| 2 h | 7,200 | 0.8 |
| 1 h | 3,600 | 1.7 |
| 30 min | 1,800 | 3.3 |
| 15 min | 900 | 6.7 |
| 10 min | 600 | 10 |
| 5 min | 300 | 20 |
| 1 min | 60 | 100 |
| 30 sec | 30 | 200 |
| 10 sec | 10 | 600 |
| 1 sec | 1 | 6,000 |
| 0.5 sec | 0.5 | 12,000 |
| 0.1 sec | 0.1 | 60,000 |

In the original 1937 - 1943 Air Disinfection in Day Schools study, the exposure was 0.2 to 0.5 milliwatts per sq. ft. (or microwatts per sq. cm.) at face level of standing pupils. Those taller than the students, such as adults would have been exposed to a higher level. To destroy the virus, the upper air level was 10 to 20 milliwatts per sq. ft (or microwatts per sq. cm.). [1] The CDC recommends 30 uW/cm² to 50 uW/cm² but the number as of November 2020 for the COVID-19 virus is unknown. We can only look at data from previous MERS and SARS outbreaks. [12]



Figure 15 - Public School UV Light Installation circa 2020

Case History

In the 1960's my family purchased a bar and restaurant in Philadelphia, PA. It was a small establishment consisting of 5 brownstones that were modified in the early 1900s to be a bar and restaurant. Around the perimeter of the main bar area at the ceiling level there were UV-C lights. They were controlled via a standalone switch behind the bar. The UV-C light tubes were mounted inside a stained wooden box that matched the rest of the bar trim and wood architecture. The box was approximately 12 inches deep, 12 inches high, and continuously spanned across all 4 walls. The trim was angled away toward the interior perhaps 15 degrees. The UV-C lights were mounted inside this structure. The perimeter box top was perhaps 18-24 inches below the ceiling allowing the UV-C to irradiate the ceiling. This was obviously a custom installation but it illustrates the point that existing architectural materials are used to house the electrical components.

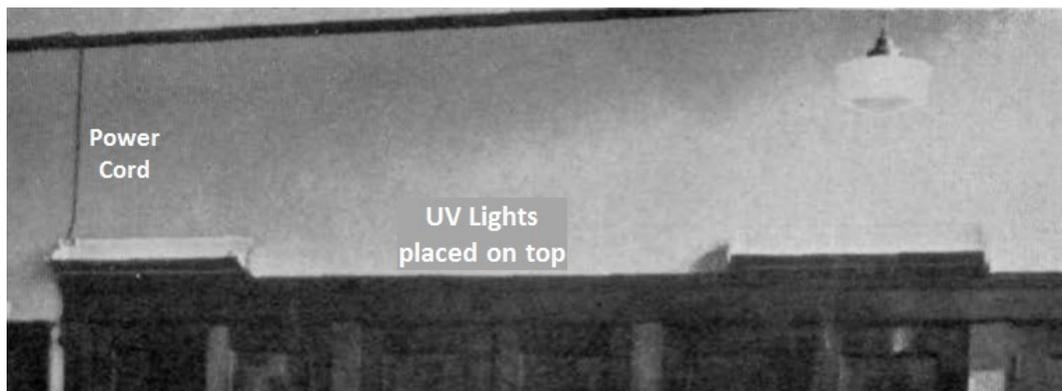


Figure 16 - Public School UV Light Installation circa 1937 - 1943

Author Comment: As far as UV risks - management and wavelength is very important. As of November 2020 we have dangerous products and products that do not work being sold to the public. In the previous century it was called snake oil and that is why the US established the FDA.

This is the Design section. For the Analysis see section [UV-C Ceiling Level Lights](#). See section for [UV Infrastructure Cost Estimates](#).

References:

[1] Air Disinfection in Day Schools, W.F. Wells Associate Professor in Research in Air-borne Infection, Laboratories for the Study of Air-borne Infection, the Department of Preventive Medicine and Public Health, University of Pennsylvania School of Medicine, Philadelphia, Pa. 1943. webpage <https://ajph.aphapublications.org/doi/pdf/10.2105/AJPH.33.12.1436>, November 2020. [Air Disinfection in Day Schools](#) . [local](#)

[2] [How Can Airborne Transmission of COVID-19 Indoors be Minimized?](#), May 01, 2020. <https://www.youtube.com/watch?v=jK6Cef5A8FQ>. [local transcript](#)

[3] The History of Ultraviolet Germicidal Irradiation for Air Disinfection, Public Health Reports/January–February 2010/Volume 125. webpage <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2789813> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2789813/pdf/phr125000015.pdf>, November 2020. [The History of Ultraviolet Germicidal Irradiation for Air Disinfection](#) . [PDF](#) . [local](#)

[4] Basic Upper-Room Ultraviolet Germicidal Irradiation Guidelines for Healthcare Settings, Department of Health and Human Services Centers for Disease Control and Prevention National Institute for Occupational Safety and Health, DHHS (NIOSH), Publication No. 2009-105 March 2009. webpage <https://www.cdc.gov/niosh/docs/2009-105/pdfs/2009-105.pdf>, November 2020. [Basic Upper-Room Ultraviolet Germicidal Irradiation Guidelines for Healthcare Settings](#) . [local](#)

[5] UV Lights and Lamps: Ultraviolet-C Radiation, Disinfection, and Coronavirus, US Food and Drug Administration - FDA, August 19, 2020. webpage <https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/uv-lights-and-lamps-ultraviolet-c-radiation-disinfection-and-coronavirus>, November 2020. [UV Lights and Lamps: Ultraviolet-C Radiation, Disinfection, and Coronavirus](#) . [local](#)

[6] Ultraviolet (UV) Radiation, US Food and Drug Administration - FDA, August 19, 2020. webpage <https://www.fda.gov/radiation-emitting-products/tanning/ultraviolet-uv-radiation>, November 2020. [Ultraviolet \(UV\) Radiation](#) . [local](#)

[7] Upper-Room-Disinfection, National Academies of Sciences, Engineering, and Medicine, September 17, 2020. webpage <https://www.nationalacademies.org/event/09-16-2020/docs/D00062573057472031C5B95374B5C068AE9324D53EC4>, November 2020. [Upper-Room-Disinfection](#) . [local](#)

[8] Upper-room ultraviolet air disinfection might help to reduce COVID-19 transmission in buildings: a feasibility study, PeerJ peerj.com, October 13, 2020. webpage

<https://peerj.com/articles/10196>, November 2020. [Upper-room ultraviolet air disinfection might help to reduce COVID-19 transmission in buildings: a feasibility study](#) . [local](#)

[9] Effect of Ultra-violet Irradiation of Classrooms on Spread of Measles in Large Rural Central Schools, New York State Department of Health, Albany, N.Y. webpage <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1623610/pdf/amjphnaton01116-0034.pdf>, November 2020. [Effect of Ultra-violet Irradiation of Classrooms on Spread of Measles in Large Rural Central Schools](#) . [local](#)

[10] Proposed Standards and Guidelines for UVGI Air Disinfection, The Indoor Environment Center Department of Architectural Engineering The Pennsylvania State University, August 20, 2007. [local](#)

[11] Building Retrofits for Increased Protection Against Airborne Chemical and Biological Releases, U.S. Environmental Protection Agency, EPA 600/R-06/157 NIST IR7379, February 2007. webpage <https://nepis.epa.gov/Exe/ZyPDF.cgi/P1005UD2.PDF?Dockkey=P1005UD2.PDF>, November 2020. [Building Retrofits for Increased Protection Against Airborne Chemical and Biological Releases](#) . [local](#)

[12] See section [UV-C Ceiling Level Lights](#).

FAR UV-222 Design Solutions

Unlike the UV-C approach, FAR UV-222 also known as FAR UVC may not need special engineering to perform a design. Guidance in terms of light selection and placement may be sufficient to ensure a safe and yet effective system. Existing UV-C companies also offer FAR UV-222 solutions and there appears to be one or more companies focusing on FAR UV-222 solutions.

This is the Design section. For the Analysis see [FAR UV-222 Full Illumination](#). See section for [UV Infrastructure Cost Estimates](#).

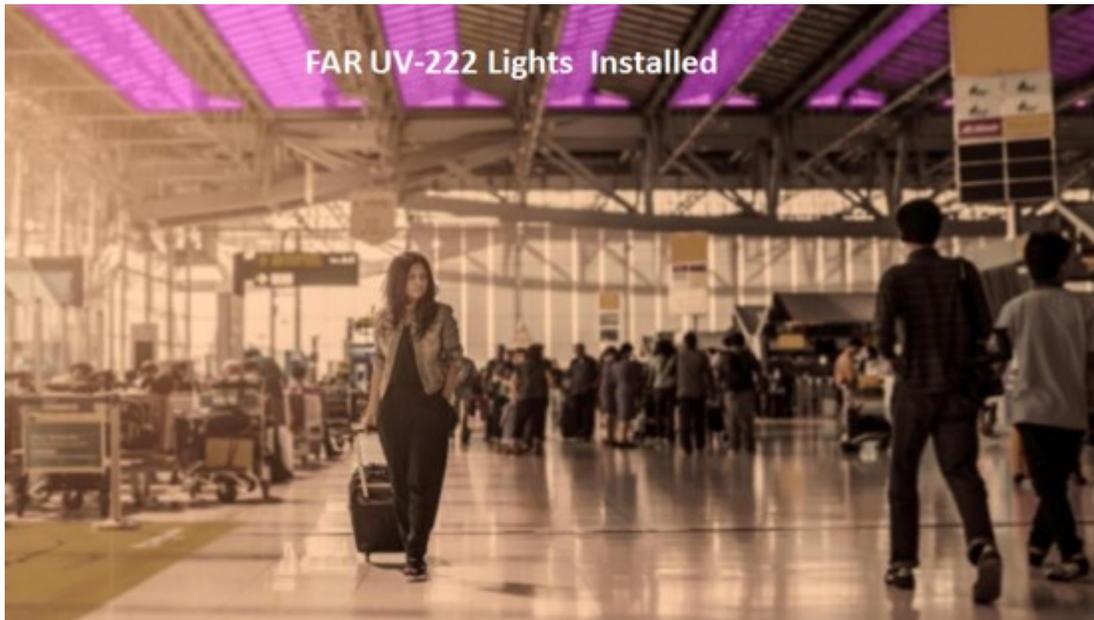


Photo: Columbia University For Radiological Research [1]

Figure 17 - FAR UV-222 Airport Application

The light is typically produced from Excimer lamps (excilamps). They are a special type of gas discharge lamps generating ultraviolet light. They can generate quasi-monochromatic UV light with particularly short wavelengths, are fairly efficient, and can have long lifetimes. Typical applications are printing, photolithography, UV curing of adhesives, surface cleaning and surface modification, ozone generation and sterilization.

Various product brochures are in the Library [[Lib/UV-Systems/Products](#)]. The potential vendors and organizations are shown below (there is no for or against endorsement).

Table 46 - FAR UV-222 Companies and Organizations

| Company / Organization | Links | Products & Markets | Comment |
|------------------------|---|---|-------------------------------------|
| Healthe | https://healthlighting.com | FAR UV-222 all markets | Provides total system installation |
| Ushio America | https://www.ushio.com | FAR UV-222 | International manufacturing company |
| Larson Electronics | https://www.larsonelectronics.com | 222 nm UVC Excimer Lamp Far-UV Recessed 8" Can | Distributor |

| Company / Organization | Links | Products & Markets | Comment |
|--|---|-----------------------|---|
| | | Light | |
| | | | |
| Columbia University Center for Radiological Research (CRR) | https://www.crr.columbia.edu | Research | Columbia University is performing FAR UV-222 research |
| | | | |
| RP Photonics Consulting GMBH | https://www.rp-photonics.com/bg/buy_excimer_lamps.html | Excimer lamps | Excimer Lamps buyers guide |
| International Ultraviolet Association | http://www.iuva.org | Traditional UV-C | Professional organization |
| UVSolutions | https://uvsolutionsmag.com | Traditional UV-C | The Official Publication of the International Ultraviolet Association |
| UV Solutions Buyers Guide | https://uvsolutionsmag.com/buyersguide/services/MAIN_COVID19 | Traditional UV-C | The Official Publication of the International Ultraviolet Association |

As of November 2020, there appears to be a great deal of confusion about UV light disinfection. There are many uncertified products with questionable effectiveness. Industry must step up to the challenges and nation state governments from around the world also must step up to begin proper regulation and certification of products. Otherwise critical technology and important companies will be lost in the noise of snake oil sales and products that do not work and can cause harm.

As of November 2020, there appears to be a great deal of confusion about UV light disinfection. There are many uncertified products with questionable effectiveness. Industry must step up to the challenges and nation state governments from around the world also must step up to begin proper regulation and certification of products. Otherwise critical technology and important companies will be lost in the noise of snake oil sales and products that do not work and can cause harm.

One of the technical issues with FAR UV-222 is a physics challenge where power density drops off with the square of the distance. A device that provides sufficient uW/CM² within the distant

regions of a room will have a very high uW/CM2 near the light. This is a design challenge. It suggests multiple low power lights rather than one or two large power lights.

The following table shows a potential design for a house. Because of the high cost the suggestion is to use a portable moveable fixture and move the fixture into the space occupied by people.

[\[Spreadsheet UV Design\]](#)

Table 47 - UV-222 House Design

| Whole House UV-C | Lamp Type | Number | Watts / Light | Comment |
|-------------------------|--|---------------|----------------------|-------------------------------|
| Living room | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 1 | 10 | Portable moveable fixture |
| Dining Room | | | | Use portable moveable fixture |
| Kitchen | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 1 | 10 | Portable moveable fixture |
| Rec Room | | | | Use portable moveable fixture |
| Bedroom | | | | Use portable moveable fixture |
| Bedroom | | | | Use portable moveable fixture |
| Bedroom | | | | Use portable moveable fixture |
| Bedroom | | | | Use portable moveable fixture |
| Bathroom | | | | Use portable moveable fixture |
| Bathroom | | | | Use portable moveable fixture |
| Powder Room | None | 0 | 0 | Not covered |
| UV Measurement Tool | - | 1 | - | - |

It is unclear if the house installation benefits outweigh the risk. For example homeowners and children tampering with the UV-222 lights while they are on is a risk while the benefit is just limited to a small number of people in extreme close contact. However, if there is an infected person in the house there may be a benefit to the infected person where the free virus load in the air is significantly reduced allowing the body to fight off a diminished total virus load that includes external and internal body virus exposure.

The following table shows a potential design for a Home Owners Association (HOA) club house. The analysis shows that this UV-222 approach costs approximately the same as the UV-C approach. [[Spreadsheet](#) UV Design]

Table 48 - UV-222 HOA Club House Design

| HOA Club House | # Units | Unit Type | Watts / Unit |
|-----------------------|----------------|--|---------------------|
| Ballroom | 4 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Library | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Sitting Area | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Conference Room | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Office | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Craft Room | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Billiards Room | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Game Room | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Exercise Room | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Indoor Pool | 2 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Locker Room 1 | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Locker Room 2 | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Powder Room 1 | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Powder Room 2 | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Reception Area | 1 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |
| Hallway | 2 | IND-CDL-RD-8-FUVC-MP-1L-V1 Far-UV Sanitation Light | 10 |

| HOA Club House | # Units | Unit Type | Watts / Unit |
|---------------------|---------|-----------|--------------|
| UV Measurement Tool | 1 | - | |

In all cases the UV-222 installation needs to be tested for UV-222 levels where the infection is to be destroyed and for the worst case living levels. This is to ensure that maximum benefit is achieved and there is minimal UV exposure to humans. This is new technology and the system performance numbers are still being studied. [2]

Author Comment: As far as UV risks - management and wavelength is very important. As of November 2020 we have dangerous products and products that do not work being sold to the public. In the previous century it was called snake oil and that is why the US established the FDA.

This is the Design section. For the Analysis see [FAR UV-222 Full Illumination](#). See section for [UV Infrastructure Cost Estimates](#).

References:

[1] Could a New Ultraviolet Technology Fight the Spread of Coronavirus, Columbia University, June 30, 2020. webpage <https://news.columbia.edu/ultraviolet-technology-virus-covid-19-UV-light>, November 2020. [Could a New Ultraviolet Technology Fight the Spread of Coronavirus](#)

[2] See section [FAR UV-222 Full Illumination](#).

UV Infrastructure Cost Estimates

The following is a cost estimate to roll out UV into the entire US infrastructure. It does not consider that there are already UV systems in operation in hospitals, some homeless shelters, some work settings like meat packing plants, some restaurant kitchens, and elite facilities. The production ramp up is considered only a small challenge because UV-C lights are basically florescent lights without internal coating to produce the desired visible light. [[Spreadsheet UV Design](#)]

Table 49 - UV Infrastructure Cost Estimates

| UV Space | sq-ft [1] | Cost/sq-ft | Cost | Comment |
|-------------------------|---------------|------------|------------------|---|
| Schools | 1,698,000,000 | \$1.76 | \$2,996,470,588 | Public and private |
| Commercial Office Space | 4,000,000,000 | \$1.76 | \$7,058,823,529 | Manhattan skyscrapers to lawyer's office |
| Retail | 9,500,000,000 | \$1.76 | \$16,764,705,882 | Indoor & strip malls, big box retailers, grocery stores, restaurants, shopping center |

| | | | | |
|---------------------|----------------|--------|------------------|------------------------------------|
| | | | | space |
| Industrial property | 13,000,000,000 | \$1.76 | \$22,941,176,471 | Manufacture, distribute, warehouse |

The cost per sq-ft is derived from using an average cost of \$1,588 in a 900 sq-ft school classroom. The cost of the components to make a UV-C light fixture is approximately 10-20 percent the cost of current fixtures. If these devices were to become ubiquitous it is anticipated that the costs would significantly drop. There are also operational and maintenance costs which are considered to be negligible at this time. The roll out strategy should follow some type of priority such as:

1. Airports
2. Other Transportation Centers
3. Schools
4. Retail especially bars, restaurants, and small retail spaces
5. Office spaces and industrial property

The benefit from this investment is provided in Section [Current and Future Virus Eradication Findings](#).

The analysis showing the history and effectiveness of UV is in Section [Ultraviolet Germicidal Irradiation \(UVGI\) - Open Air](#).

References:

[1] Commercial Real Estate and the Economy, The Balance, February 28, 2019. webpage <https://www.thebalance.com/what-is-commercial-real-estate-3305914>, November 2020. [Commercial Real Estate and the Economy](#)

Ventilation Test and Evaluation

It is possible to establish a test and evaluation strategy to determine if the proposed analysis and resulting design can mitigate the risk of virus infection. The approach is to use smoke generators to simulate the volumes of air that contain the virus and track the path and dispersion characteristics of the smoke. Alternatives include various gases and gas detectors.

We know that a male exhales 6 liters of air because that is the typical lung capacity. The 6 liters of puffing smoke from one or more emitters can be tracked visually using cameras and a time stamp on the images. We also know that the virus load in the 6 liters of smoke can range from 20 (single breath) to some factor of 200,000,000 (sneeze). As the smoke is dispersed the volume is increase and it can be measured. This measurement will provide an estimate of the dispersed virus load. The next step is to determine the real world scenarios. The final step is to perform the tests, gather the data, and reduce the data to potential results. These results can then be provided as specifications for all ventilation modifications.

The scenarios are based on physical space, number of emitters with different infection loads (breathing, coughing, sneezing), and different air exchange rates (2 to 100 or more if needed). The physical spaces are:

- Classroom
- School Cafeteria
- Cubical in a Cube Farm
- Single Multi Person Office
- Restaurant Large Room, Multiple Small Rooms
- Movie Theater
- Outdoor Venues (e.g. restaurants) Under a Tent, Umbrellas, Open Air
- At the Beach, Park, Lake under various wind conditions
- Public Community Center
- Library
- Rehabilitation Facilities
- Assisted Living Facilities
- Airport Security Check
- Public Demonstrations
- Airplane Passenger Cabin
- Cruise Ship
- Public Transportation (bus, train, subway, taxi)
- Generic Spaces 1-n to be defined as more is learned

Test different ideas:

- Testing HVAC air change rates using increments such as 2, 4, 8, 10, 16, 32, 50, 100 (to determine when virus is fully mitigated based on various time exposures)
- Testing natural ventilation with and without exhaust fans
- Testing indoor exhaust fans with and without existing HVAC systems running in background
- Testing negative pressure vents below airplane seat front areas to determine effectiveness of airflow control
- Testing personal space negative pressure vents at workstations (low cost PVC tube constructions)
- Testing modifications to fixed consoles in command and control centers (ATC) to provide personal space negative pressure
- Testing personal space negative pressure tubes (PVC) in public settings (**classrooms**, airport security check, restaurant tables, outdoor venues)
- Testing negative pressure walkways, standing pads, floors especially in areas like TSA checks and healthcare examination rooms
- Other ideas

The following diagrams are offered to suggest the various test scenarios and different test ideas.

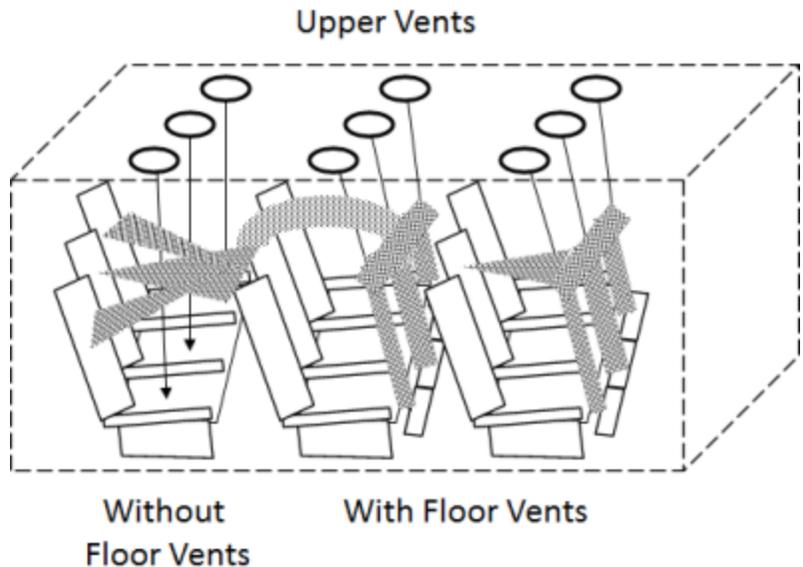


Figure 18 - Airplane Passenger Compartment

Airplanes have positive pressure vents above each passenger. There are also other positive and negative pressure vents. The test involves mapping the current air circulation to understand potential infection paths. It is anticipated that there are multiple infection paths and one approach is to install negative pressure vents at the floor of each seat position or under the chair and study the changed airflow paths. At some air flow level and placement of negative pressure vents the paths can be modified to mitigate exposure to the virus.

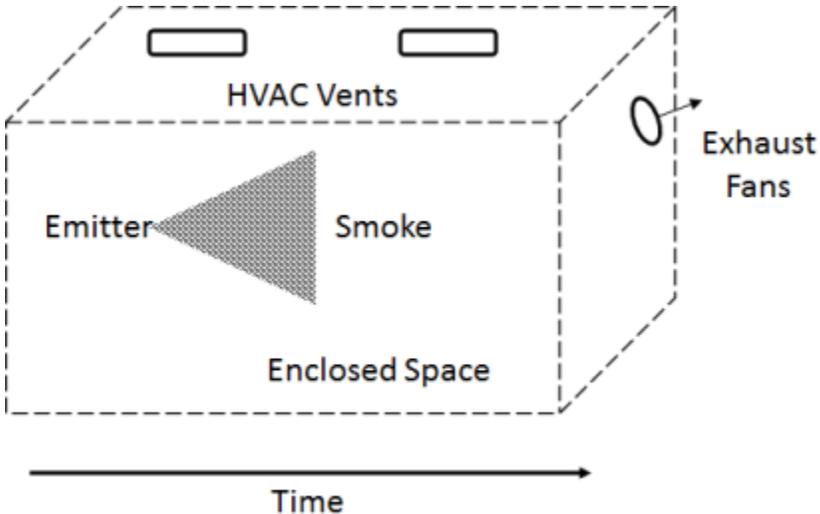


Figure 19 - Enclosed Space

Enclosed spaces have a room size, existing ventilation, and a maximum person capacity. This test involves changing the airflow rates, percentage of infected people, and number of people in the enclosed spaced. This systems engineering analysis suggests that the AUC needs to be 50 to 100, but as with all models and analysis reasonable testing needs to be performed. It is possible

the rate can be lower or it needs to be higher. We will not understand the situation until testing is performed.

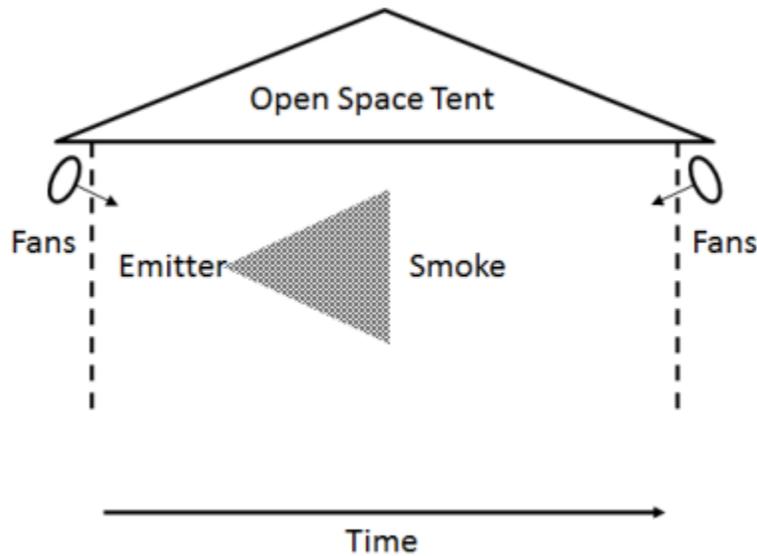


Figure 20 - Outdoor Space Tent

Many have suggested that outdoor venues can be held because the setting is outside. There is a big difference walking outside exchanging the air 3600 times per hour and sitting in an open space surrounded by people when there is no air movement. Testing needs to be performed to understand various outdoor venues. Simple placement of a few fans will significantly change the air exchange rate in the open space.

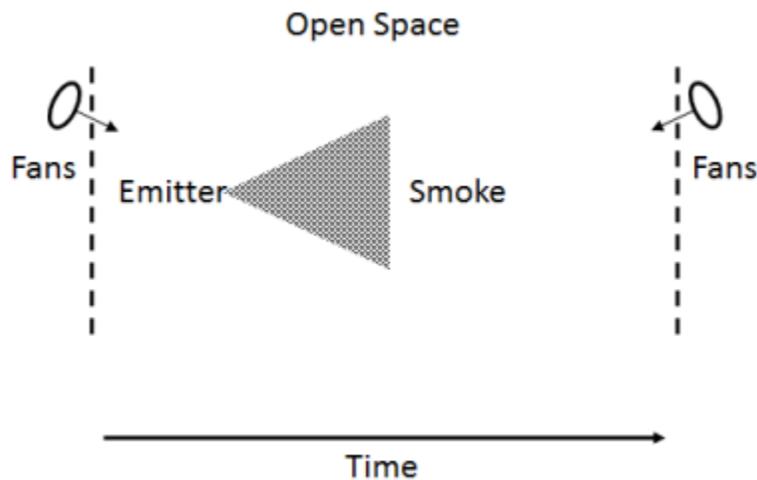


Figure 21 - Outdoor Open Space

Students at a desk and people at work are personal space situations similar to what is found on an airplane. It is expected that many buildings will not be able to increase the air update rates. One approach is to introduce personal negative pressure vents.

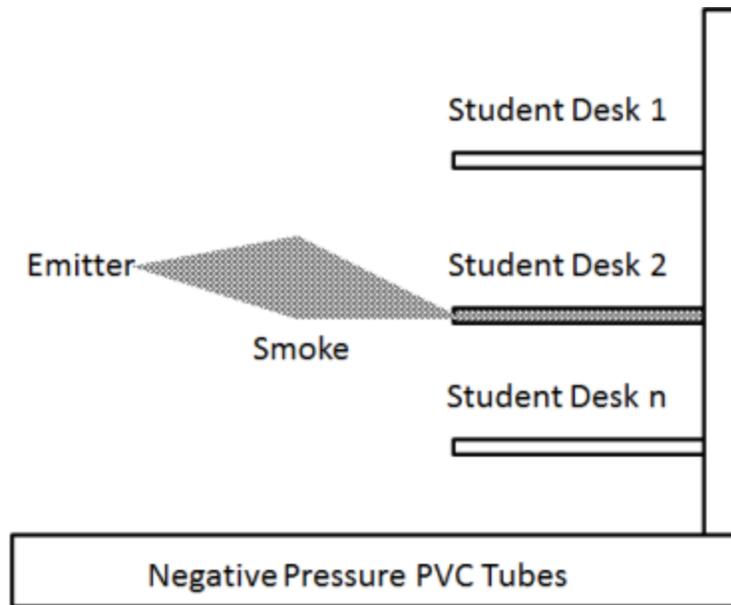


Figure 22 - Student Desk Negative Pressure Vents

Negative pressure is established at the student desk or workstation and it is routed via low cost tubing to a fan, UV-C lights, filter, and then released back into the environment. In a centralized system the release can be near the negative pressure vents of the existing HVAC system and exhaust fans. In a decentralized system the release can be into the floor or into the ceiling.

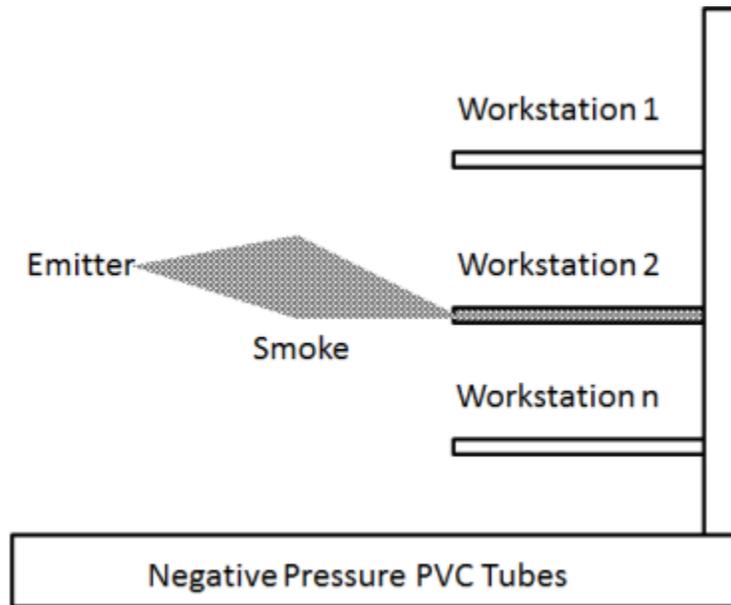


Figure 23 - Workstation Negative Pressure Vents

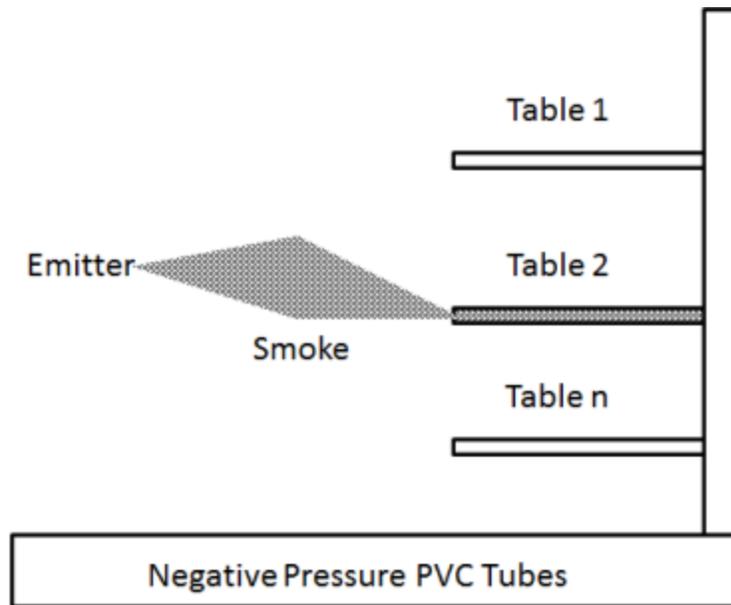


Figure 24 - Restaurant Table Negative Pressure Vents

People will gather to engage in life. In a restaurant situation tables and bars can be modified to introduce negative pressure vents.

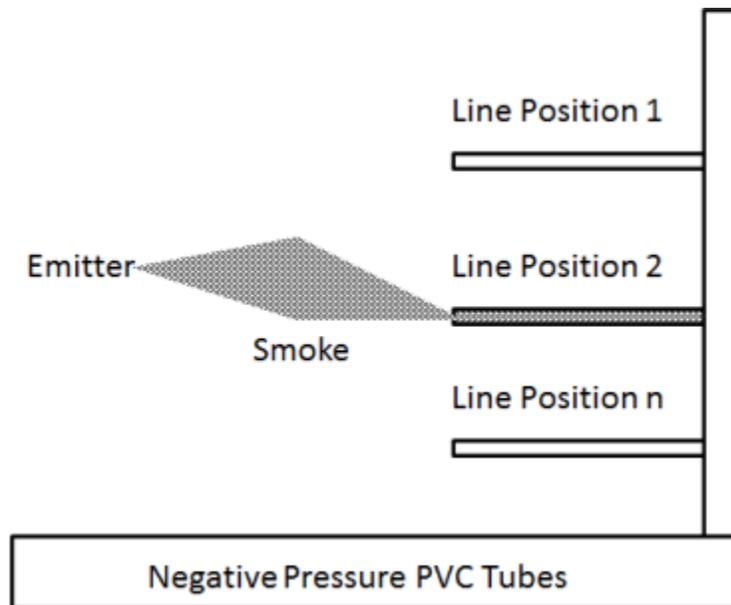


Figure 25 - Crowd Negative Pressure Vents

In crowd situations there are always crowd control border mechanisms using a pole and a soft cloth or hard barrier. They can be replaced or updated with negative pressure poles connected by flexible hoses that can also serve as a soft barrier or PVC tubes can be used for hard barrier settings.

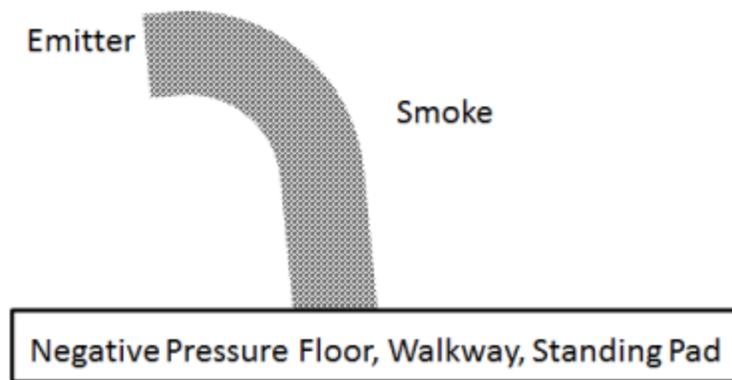


Figure 26 - Negative Pressure Floor, Walkway, Pad

Negative pressure walkways, standing pads, floors especially in areas like TSA checks and healthcare examination rooms can be added.

Initial Virus Mitigation Test and Evaluation Program

The following is a suggestion for starting an engineering based virus mitigation test and evaluation effort. It can be expanded to cover all the aspects described in this section plus all the suggestions that will come from such an effort.

- ▼ Airplane Passenger Compartment Testing. Determine the effectiveness of different air flow modifications in an airplane passenger compartment.
- ▼ Enclosed Space Testing. Determine the required HVAC airflow rates needed in buildings. Include HVAC the UV-C light levels and filter recommendations.
- ▼ Outdoor Space Tent Testing. Simple placement of a few fans will significantly change the air exchange rate.
- ▼ Outdoor Open Space Testing. Simple placement of a few fans will significantly change the air exchange rate.
- ▼ Negative Pressure Vents Testing. Students at a desk and people at work are personal space situations similar to what is found on an airplane. The same applies to restaurant tables and people waiting in a line with traditional physical walking boundaries.
- ▼ National Lab Testing. The FAA Technical Center performed similar tests related to fire mitigation in the late 1970's. They have the facilities and capability to immediately ramp up to perform the world class engineering testing needed to mitigate the spread of the virus.
- ▼ Other Engineering Testing. Ideas will come. Everyone should be encouraged to perform their own engineering tests and publish their results.

Where is Industry

Others have started to try to understand ventilation but the next step is needed where effective engineering is performed to solve the virus transmission problem within enclosed and semi

enclosed spaces. It is time to apply the massive US Federal Government resources needed to solve this massive problem of bring people safely back to life. A picture is worth a thousand words. Here are some pictures from various groups doing great work. They should be used as a starting point for this massive Ventilation Test and Evaluation program. How big is the program? Your guess is as good as mine. Let's start with \$1 billion dollars over the next 6 months engaging every national lab in the US. Redirect existing national lab resources immediately.

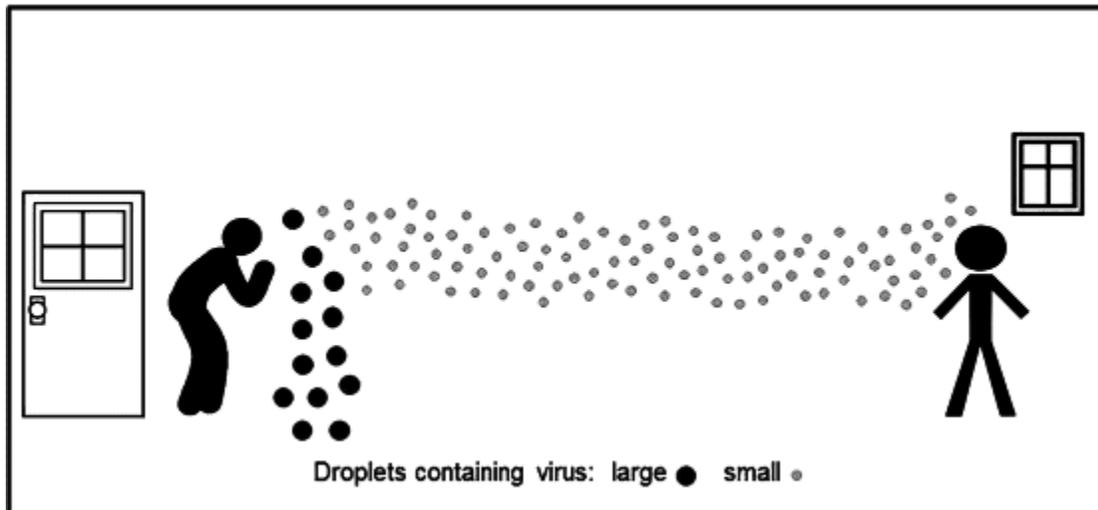


Figure 27 - Droplet and Aerosol Transmission

Larger droplets with viral content fall to the ground (droplet transmission), while smaller droplets travel long distances in the air (aerosol transmission) [1]

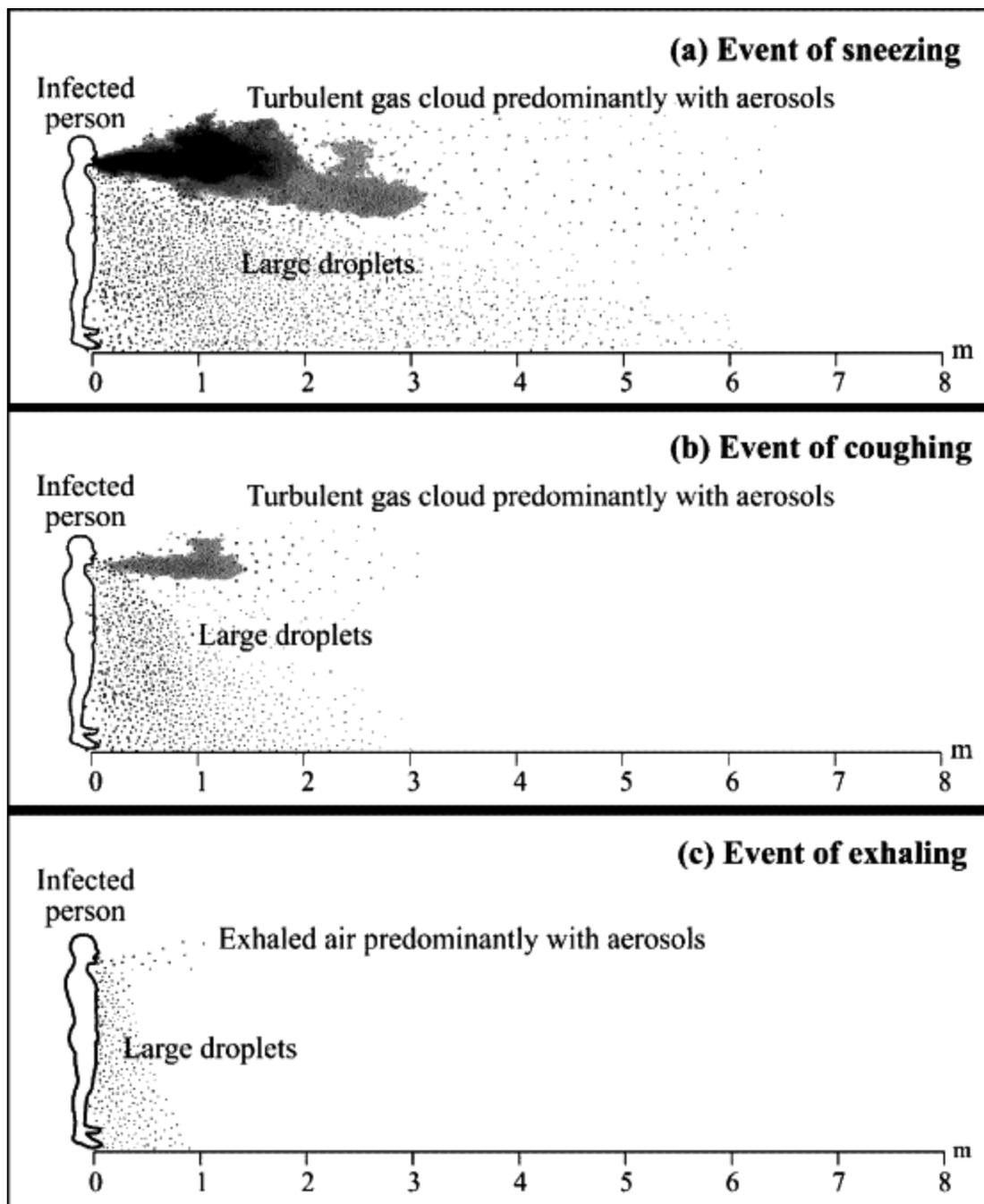


Figure 28 - Droplets and Aerosols Sneeze Cough and Exhale

Trajectories of droplets and aerosols from an infected patient (a) event of sneezing with droplets travelled for 6 m at a speed of 50 m/s within 0.12 s (b) event of coughing with droplets travelled for 2 m at a speed of 10 m/s within 0.2 s (c) event of exhaling with droplets travelled for 1 m at a speed of 1 m/s within 1 s. [2]

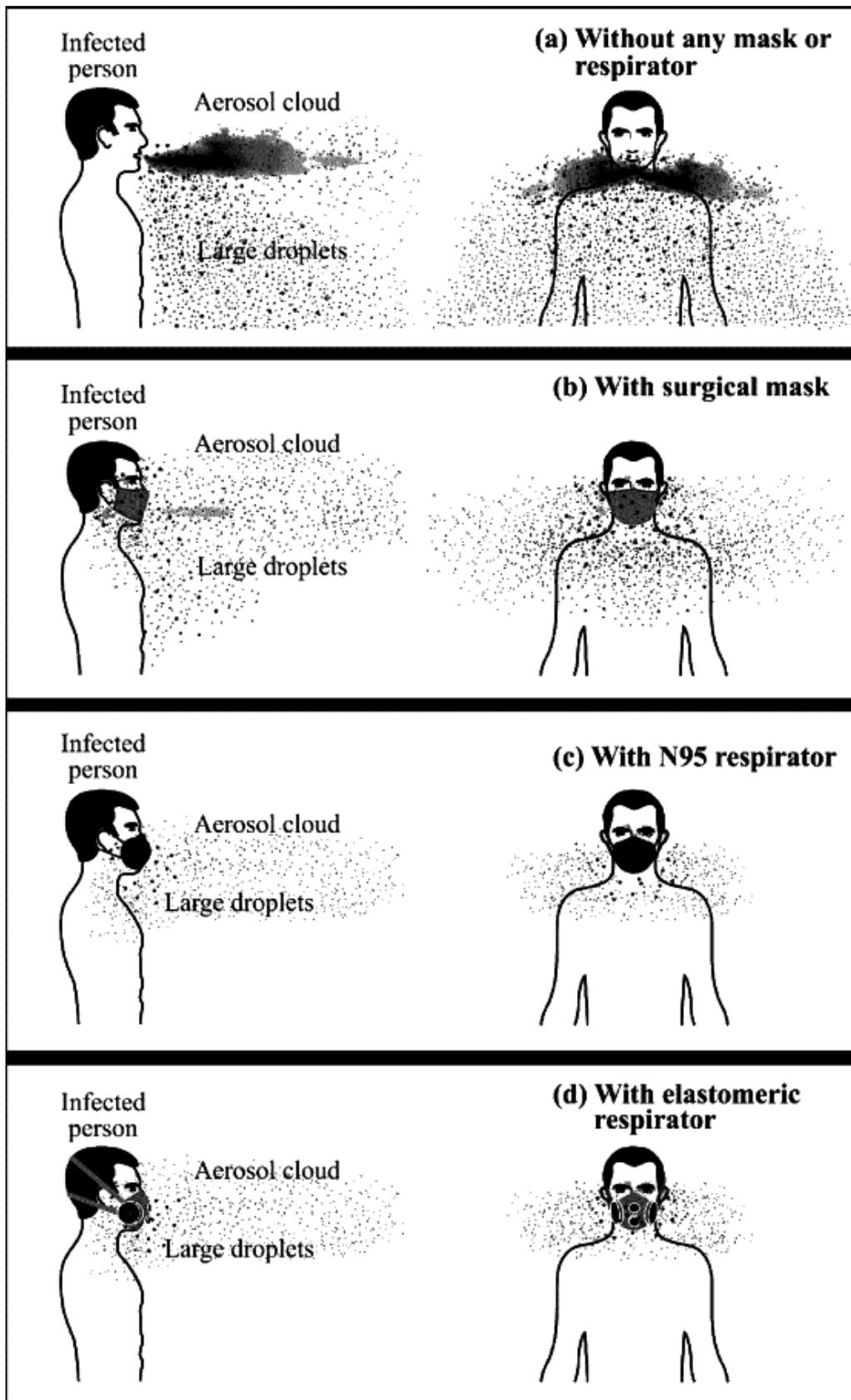


Figure 29 - Droplets and Aerosols Mask Mitigation

Trajectories of droplets and aerosols from an infected patient in the event of coughing with different masks and respirators worn (a) without any mask or respirator (b) with surgical mask (c) with N95 respirator (d) with reusable elastomeric respirator. [2]

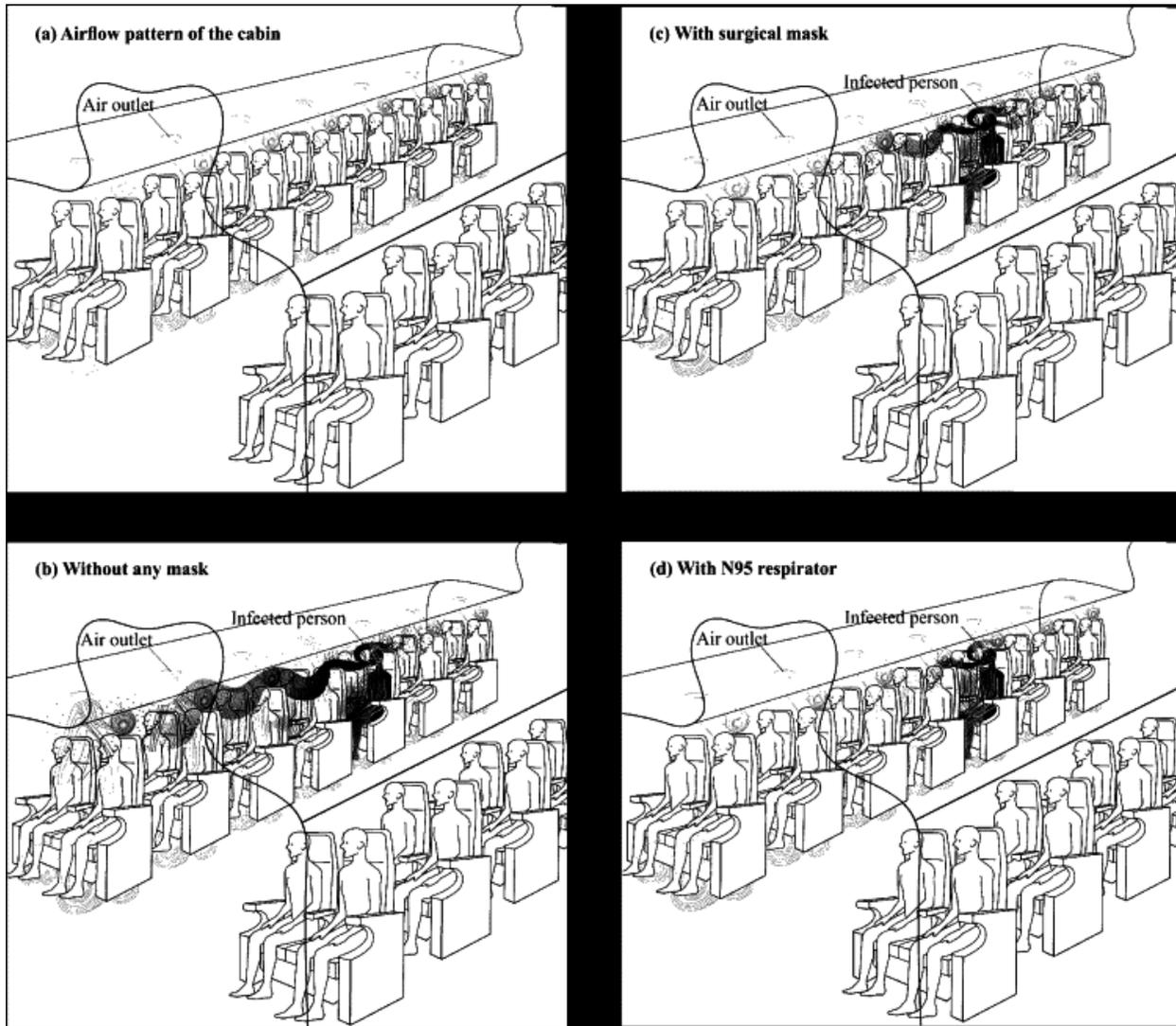


Figure 30 - Airflow Airplane Passenger Area Mask Mitigation

Trajectories of droplets and aerosols from an infected patient in the event of coughing in an aircraft (a) airflow pattern of the cabin without any cough-jet expiration (b) without any mask (c) with surgical mask (d) with N95 respirator. [2]

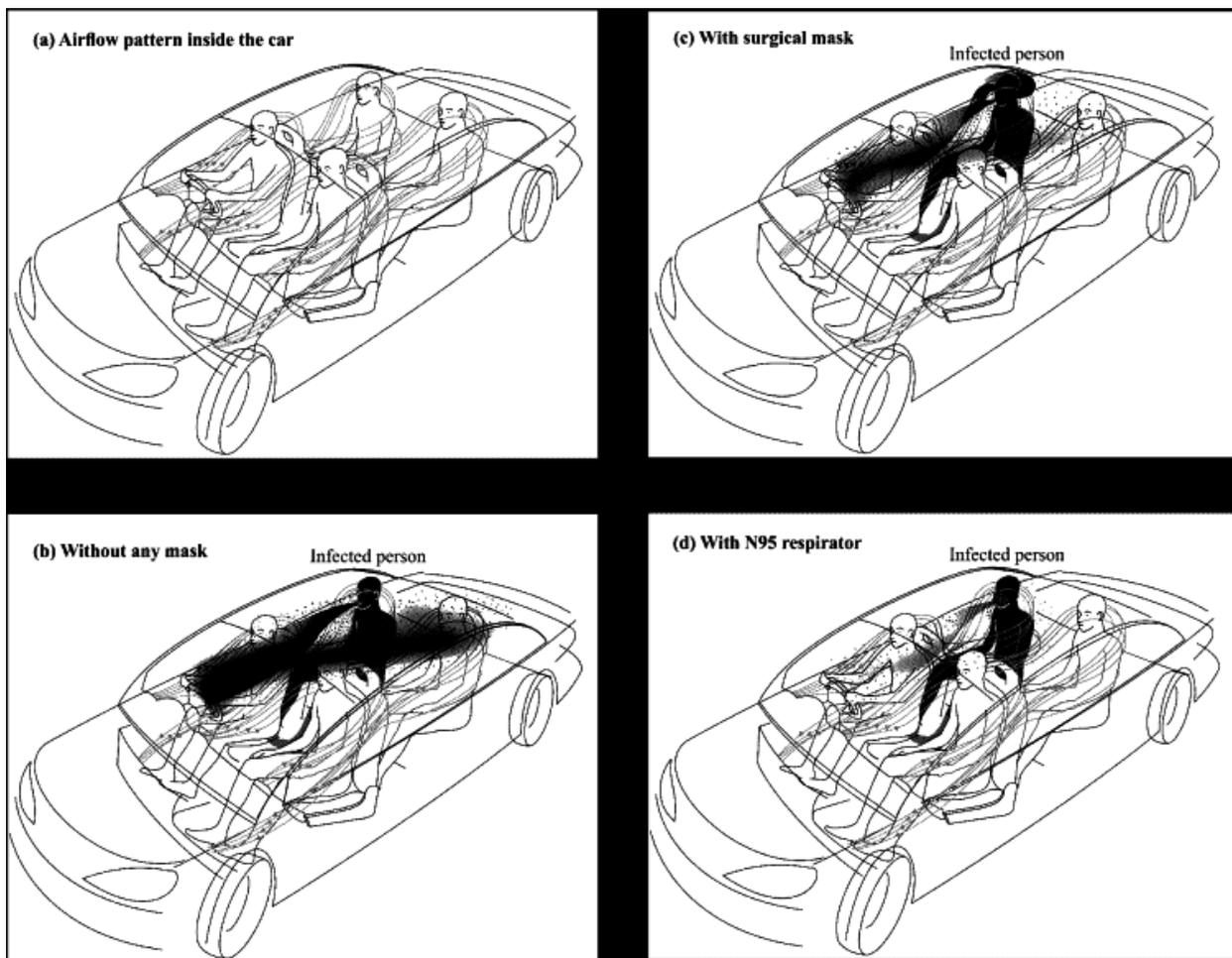


Figure 31 - Airflow Car Closed Windows Mask Mitigation

Trajectories of droplets and aerosols from an infected patient in the event of coughing in a car with air-conditioner switched on (a) airflow pattern inside the car without any cough-jet expiration (b) without any mask (c) with surgical mask (d) with N95 respirator. [2]

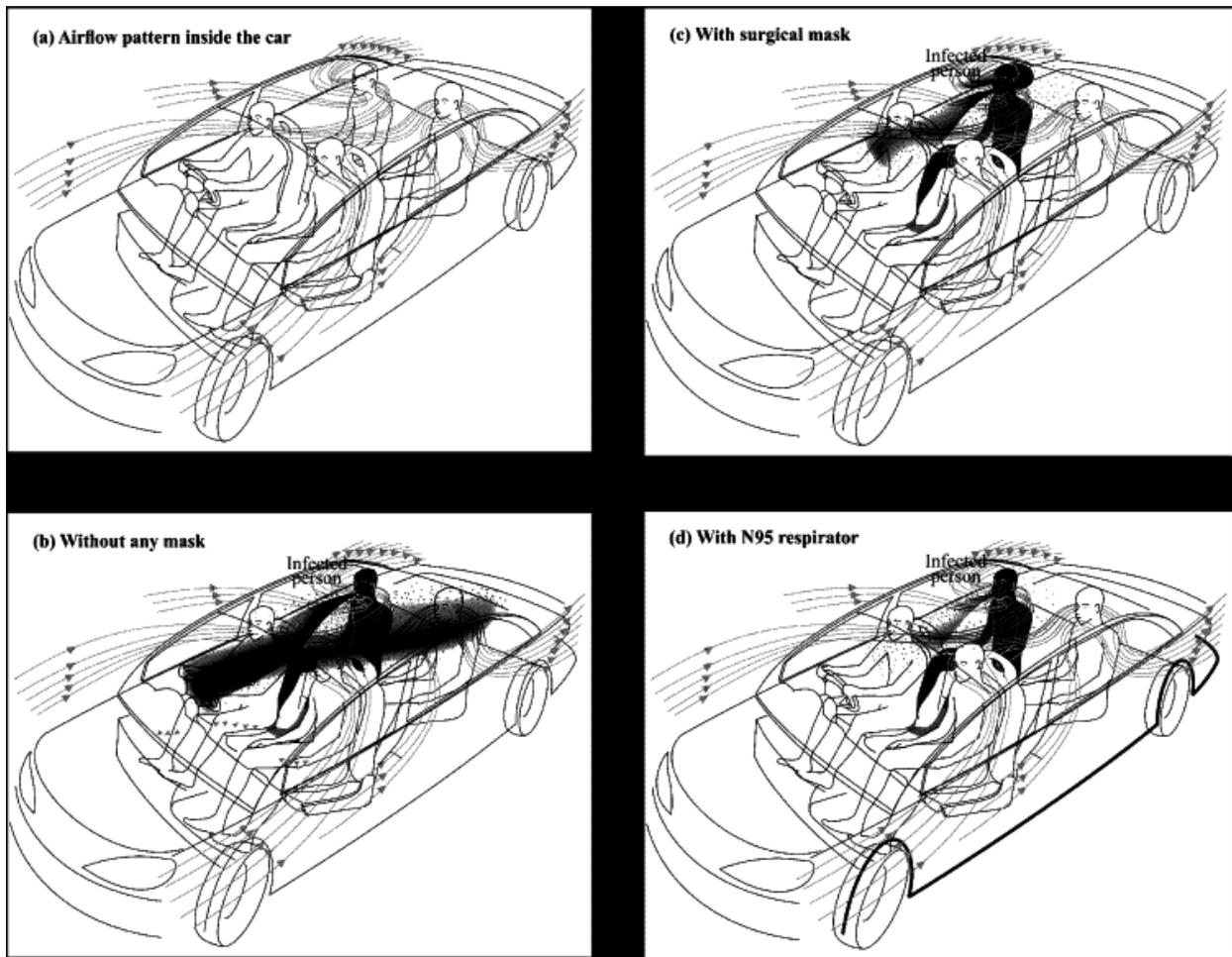


Figure 32 - Airflow Car Open Windows Mask Mitigation

Trajectories of droplets and aerosols from an infected patient in the event of coughing in a car with windows opened (a) airflow pattern inside the car without any cough-jet expiration (b) without any mask (c) with surgical mask (d) with N95 respirator. [2]

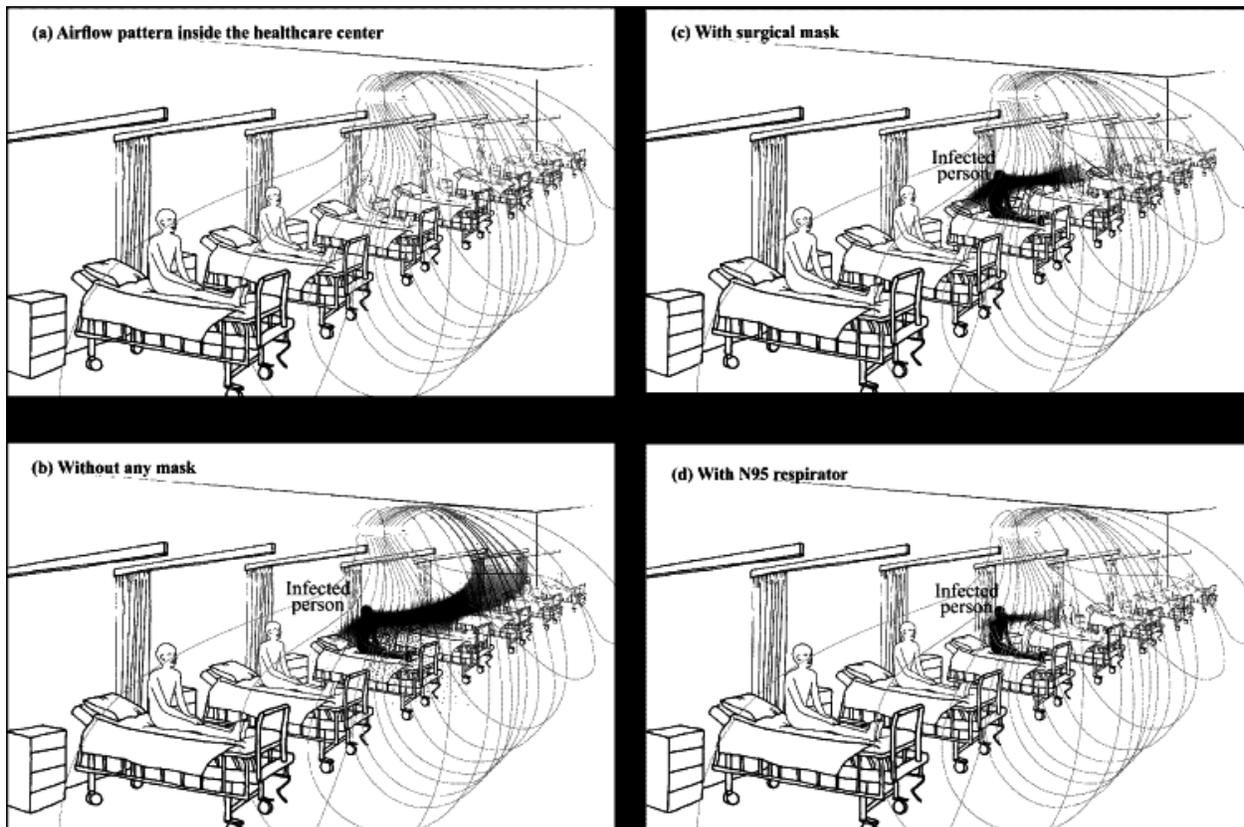


Figure 33 - Airflow Hospital Mask Mitigation

Trajectories of droplets and aerosols from an infected patient in the event of coughing in a healthcare center with ventilation provided by an air conditioner (a) airflow pattern inside the healthcare center without any cough-jet expiration (b) without any mask (c) with surgical mask (d) with N95 respirator. [2]

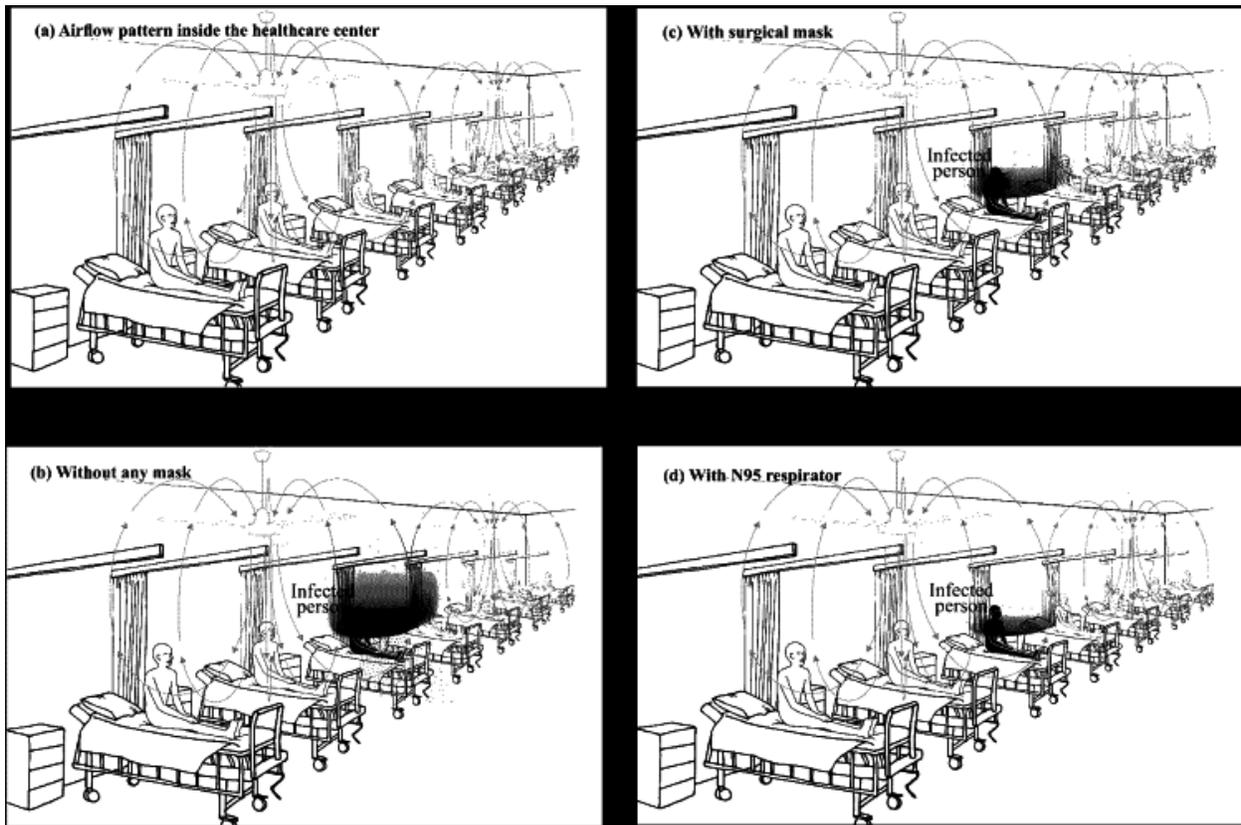


Figure 34 - Airflow Hospital Ceiling Fans Mask Mitigation

Trajectories of droplets and aerosols from an infected patient in the event of coughing in a healthcare center with ventilation provided by ceiling fans (a) airflow pattern inside the healthcare center without any cough-jet expiration (b) without any mask (c) with surgical mask (d) with N95 respirator. [2]

Sample Literature Search

Evaluating Virus Containment Efficiency Of Air-Handling Systems: Air-handling systems serving an infected space can transfer an infection agent through the ductwork. This article presents a mathematical model of virus-laden aerosol propagation through air-handling systems. It also recommends simple engineered measures that can improve the system's virus containment efficiency [3].

Makeshift Negative Pressure Patient Rooms In Response to COVID-19: Recommendations and Lessons Learned: You don't have much time to create negative pressure hospital patient rooms during a pandemic. You can create these rooms quickly using appliances such as portable HEPA exhaust fan units, along with guidance from relevant codes and standards and hospital requirements [4].

References:

[1] Airborne transmission of SARS-CoV-2: The world should face the reality, Lidia Morawskaa, Junji Caob, International Laboratory for Air Quality and Health (ILAQH), School of Earth of

Atmospheric Sciences, Queensland University of Technology, Brisbane, Queensland 4001, Australia, Key Lab of Aerosol Chemistry & Physics (KLACP), Chinese Academy of Sciences, Beijing, China, Environment International 139 (2020) 105730, June 2020, 105730. webpage <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7151430>, July 2020. [Airborne transmission of SARS-CoV-2: The world should face the reality](#) . [local](#)

[2] Transmission of COVID-19 virus by droplets and aerosols: A critical review on the unresolved dichotomy, Mahesh Jayaweeraa,, Hasini Pererab, Buddhika Gunawardanaa, Jagath Manatungea, Department of Civil Engineering, University of Moratuwa, Sri Lanka, Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Sri Lanka, Environmental Research 188 (2020) 109819, June 2020. webpage <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7293495>, June 2020. [Transmission of COVID-19 virus by droplets and aerosols: A critical review on the unresolved dichotomy](#) . [local](#)

[3] Evaluating Virus Containment Efficiency of Air-Handling Systems, ASHRAE Journal, vol. 62, no. 7, July 2020, Renat Manassypov, Ph.D., P.Eng., ASHRAE, July 2020.

[4] Makeshift Negative Pressure Patient Rooms In Response to COVID-19, ASHRAE Journal, vol. 62, no. 7, July 2020, Frank Shadpour, P.E.; Stefanie Johnson, ASHRAE, July 2020.

Real Time Monitoring of Air Flow Conditions

The ventilation test and evaluation program suggests that there may be approaches to perform real time monitoring of the airflow. This may be especially useful for outdoor venues where everyone assumes the airflow is safe. However we know that the air can stagnate in these settings without the use of fans especially on hot summer days. Simple elegant smoke emitters can provide immediate feedback to the staff who can turn on / off different fans as needed. This also can be effective indoors when the HVAC system is being tuned to the new needs to mitigate the risk of infection. It can also show if something has changed with the HVAC system.

Proposed Legislation

There needs to be multiple virus mitigation solution-base-programs legislation actions to allow for a reasonable return to life scenario. This is the first proposed legislation.

TITLE

COVID-19 Funding for Facility Ventilation Upgrade Recommendations and to Upgrade all Public Schools

DATE

July 3, 2020

BACKGROUND

The current system for containing the COVID-19 virus is based on wearing masks, practicing social distancing, quarantine of infected individuals, and waiting for a potential vaccine. During this time the country has been shutdown and only essential workers have been going to work.

Research is suggesting that the risk of virus infection is significantly higher within enclosed buildings than in outdoor settings. Further it appears that the virus has not been contained, it continues to spread.

The purpose of this legislation is to provide the funding to develop existing and new engineering based ventilation approaches and perform a ventilation test and evaluation effort using the best science and engineering available to determine what must be done to facilities to ensure that they are safe and the potential virus infection is fully mitigated. It is anticipated that the engineering solutions are off the shelf and the primary effort will be in ventilation test and evaluation so that government certified specifications can be developed and then offered to the industrial base for implementations. The government certification will ensure that the best science and engineering has been used and that all legal liability issues are fully addressed so that industry can provide the safe solutions.

Unfortunately it is anticipated that this engineering based effort to provide safe indoor and outside venues and environments will continue for multiple years until the virus is fully mitigated. Sadly, during this time people will get sick and die but without a cure there is no other alternative.

May our children and God forgive us for waiting so long to take this reasonable and appropriate action.

RESOURCES

1. All national labs shall be redirected to support an engineering based Ventilation Test and Evaluation effort.
2. The FAA William J. Hughes Technical Center in Atlantic City, NJ shall take the lead role in this massive Ventilation Test and Evaluation effort.

They are selected because of their role in ensuring the safety of airplane passenger compartments (they have performed similar studies in the past), they maintain hundreds of facilities across the country that must be free from virus infection risk, they are located in close proximity to the finest Universities in the world, they have an onsite airport that can accommodate military and civilian aircraft, they are located in an area with massive numbers of small businesses that also must have their needs addressed, they have the contracting expertise to roll out the massive amount of funding that is anticipated for this effort, and they have the physical space to build the anticipated structures that will be needed for proper testing and evaluation.

3. The FAA shall engage the MITRE corporation to help them establish and manage the Ventilation Test and Evaluation effort.
4. The CDC shall take on an equal and parallel role and use the engineering resources of the FAA Technical Center in Atlantic City to more fully understand how the virus spread can be mitigated using engineering approaches.

It is recognized that the CDC is primarily focused on disease control and that this has been viewed primarily from a healthcare perspective. Until now there was no need to examine our

infrastructure from a disease spread and mitigation perspective. This is a new development in the 21st century. This requires an engineering perspective.

RESULTS (Ventilation Test and Evaluation) AND TIME TABLE

1. Within 6 months the Ventilation Test and Evaluation effort shall provide recommendations for the minimum amount of air exchanges per hour based on multiple tests in multiple scenarios that represent all the reasonable anticipated living scenarios. This includes both indoor and outside venues and environments.
2. Within 6 months the Ventilation Test and Evaluation effort shall provide recommendations for the proper use of UV-C lights and filters based on multiple tests in multiple scenarios that represent all the reasonable anticipated living scenarios. This includes both indoor and outside venues and environments.
3. Within 6 months the Ventilation Test and Evaluation effort shall provide recommendations for various engineering based solutions that stop the spread of the virus based on multiple tests in multiple scenarios that represent all the reasonable anticipated living scenarios. This includes both indoor and outside venues and environments.
4. All the results shall be updated monthly and made available via a public access website so that the industrial base can implement these results as quickly as possible.
5. Within 1 year the Ventilation Test and Evaluation effort shall provide status on the success of the program based on industry acceptance, facilities upgraded, and estimates of potential lives saved.
6. After 1 year this program shall be assessed to determine the work that must be performed in the next year.

RESULTS (Materials) AND TIME TABLE

1. As we have focused on environmentally friendly materials we may have the unintended consequences of developing infrastructure that promotes the spread the virus, bacteria, and fungi within our physical structures.
2. Within 6 months an Infrastructure Materials and Disease Effects study shall be produced identifying how our infrastructure materials have changed in the past 50 years and if that change has resulted in the potential spread of disease.
3. Within 6 months an Infrastructure Materials and Disease Effects study shall identify environmentally friendly materials that also do not allow virus, bacteria, and fungi to survive.

The study shall search for various materials, propose new materials, and quantify the potential mitigation effects. For example copper, brass, and nickel are known to have these characteristics.

4. Within 6 months an Infrastructure Materials and Disease Effects study shall identify where virus mitigation materials should be immediately applied, applied in the midterm, and applied in the long term.

5. During the Infrastructure Materials and Disease Effects study, the findings and recommendations shall be subjected to a Materials Test and Evaluation effort to ensure that the study findings are valid.
6. Within 1 year the Infrastructure Materials and Disease Effects effort shall provide status on the success of the program based on industry acceptance, facilities upgraded, and estimates of potential lives saved.
7. After 1 year this program shall be assessed to determine the work that must be performed in the next year.

FUNDING

1. The initial funding for the Ventilation Test and Evaluation effort shall be a minimum of \$1 billion dollars.
2. In order to allow schools to safely open as soon as possible, a minimum of \$110 billion dollars shall be initially allocated to fund the upgrade of all public schools using the results of this effort. [spreadsheet Schools]
3. The funding shall be increased as needed to support any short falls in the Ventilation Test and Evaluation effort but not to exceed \$10 billion dollars with this legislation.
4. The funding shall be increased as needed to support any short falls in the upgrade of all public schools but not to exceed \$428 billion dollars with this legislation. [spreadsheet Schools]

CLOSING REMARKS

This is the worst disaster in modern history. There is something very wrong with our systems and they must be corrected. It is possible that our modern enclosed buildings and transportation systems might have led to this massive disaster. This program will help to determine if that is the case and it will then develop the solutions that are needed moving forward. As a result of this program we will have healthier facilities and this will lead to reduced healthcare costs in general. The initial \$1 billion dollar investment to perform massive Ventilation Test and Evaluation is irrelevant once compared with the massive costs already incurred from this disaster. Based on existing analysis we will need to upgrade our buildings. We should begin with our schools.

STUDENTS AND TEACHERS RETURNING BACK TO WORK

These are the stakeholder needs of the students and teachers. As these needs are reviewed it becomes very clear that this legislation is critical and must be passed or the consequences will be horrific.

Masks and social distancing is not possible. The infrastructure must be modified.

1. Wearing a mask with no break for 7 to 8 hours is not possible.
2. Children and teenagers wearing a mask at bus stops unlikely, in bus unlikely, in cafeteria not possible, during gym not possible, during classroom changes unlikely, in classroom will destroy learning experience

3. Children and teenagers social distancing at bus stops unlikely, in bus unlikely, in cafeteria not possible, during gym not possible, during classroom changes unlikely, in classroom not possible
3. Special needs children and teenagers wearing a mask and social distancing is not possible.
4. Bullies will place students in grave risk by engaging in dangerous behavior (spiting, coughing, etc).
5. When possible move all classroom activity outside. (the stakeholders now know some of the engineering analysis and want these solutions)
6. Open all the windows and doors and help natural ventilation with fans everywhere. (the stakeholders now know some of the engineering analysis and want these solutions)
7. HVAC Infrastructure must be modified to allow for massive air exchanges. (the stakeholders now know some of the engineering analysis and want these solutions)
8. Add UV-C ceiling lights and update HVAC systems with UV-C lights. (the stakeholders now know some of the engineering analysis and want these solutions)
9. All funding gaps must be addressed by the Federal Government as part of the COVID-19 disaster. Many states are not permitted to carry a deficit unlike the Federal Government. This means they are completely incapable of dealing with this massive disaster.

CAPABILITY

This legislation will establish a national level capability to answer key questions and certify safe systems such as:

1. I need to know the air update changes needed for a certified safe building, is it 5, 10, 15, 25, 50, or 100 AUC.
2. I have a negative pressure restaurant table and I want to have it tested and certified.
3. I want to augment student desks with negative pressure using low cost PVC, will this work.
4. I have people standing in long lines and I want to test negative pressure crowd control poles and barriers.
5. I have negative pressure office cubical separators and I want it tested to see if it will work.
6. I have a positive / negative pressure open face mask and I want to have it tested for virus containment.
7. I just put up a tent for an event and I need to know what must be done to make it safe.

The scenarios include: Classroom, School Cafeteria, Cubical in a Cube Farm, Single Multi Person Office, Restaurant Large Room, Multiple Small Rooms, Movie Theater, Outdoor Venues (e.g. restaurants) Under a Tent, Umbrellas, Open Air, At the Beach, Park, Lake under various wind conditions, Public Community Center, Library, Rehabilitation Facilities, Assisted Living Facilities, Airport Security Check, Public Demonstrations, Airplane Passenger Cabin, Cruise Ship, Public Transportation (bus, train, subway, taxi), Generic Spaces 1-n to be defined as more is learned.

Virus Transmission

This section needs to be reviewed with great care. No one should come away with the thoughts that COVID-19 is not contagious. We know that it is extremely contagious. We know that it will spread until there is a herd immunity or there is a cure. We also know that if we do not control the infection rate it will spread so quickly that all our systems will be massively overwhelmed - our civilization will collapse, period. However, that does not mean that we should not try to understand how this virus is spread. From a systems analysis perspective a reasonable starting point is to identify different scenarios and use data to gain insight into the virus mechanical transmission characteristics.

Infection and Body Response

1. Viruses are self-replicating.
2. The infection can start with a small number of viruses (dose).
3. When the dose reaches the respiratory tract, cells are infected and are re-programmed to produce many new viruses. The new viruses infect many more nearby cells.
4. Early in the infection, the Innate Immune System detects there is a virus infection and starts an innate immune response.
5. The Innate Immune System is a non-specific anti-viral response with interferon and cytokines, small proteins that have the side effect of causing fever, headaches, and muscle pain.
6. The Innate Immune System response slows down the replication and spread of the virus until the Acquired Immune Response with Antibodies begins.
7. The Antibodies clear the infection and establish the immune memory to allow for a faster response if infected again in the future.
8. The Antibody response causes the Innate Immune System to stop because the infection is being cleared.
9. If the Antibody response is delayed the virus replicates and spreads and this causes the Innate Immune System response to increase.
10. Without the antibodies to clear the infection the innate immune response will keep increasing as the virus replicates and spreads causing inflammation.
11. Inflammation causes damage of uninfected tissue. This is a cytokine storm and is seen with SARS and avian influenza H5N1. It is difficult to manage, requires intensive care, and has a high risk of death.
12. A massive dose will lead to a massive innate immune response to control the virus prior to the establishment of acquired immunity antibodies leading to significant inflammation and a cytokine storm. This scenario applies to clinical staff conducting procedures on patients who are not known to be infected.

Virus Transmission Mental Model

This model attempts to understand the virus behavior from different biological event scenarios. Each scenario has a potential virus load and distance traveled based on the droplets produced [1] [2]. The scenarios considered are:

- Cough
- Sneeze
- Infected Cough or Sneeze

- Single Breath
- Infected Single Breath
- Speaking
- Bathroom

Current data suggests that most people get infected in their own home. A household member gets the virus in the community and brings it into the physical house. In that structure there is sustained contact between household members. This close constant contact appears to be an element in the virus transmission characteristics. However, the virus is originating outside the house in the community.

A key question is what amount of virus exposure leads to infection. This can be viewed as a dosage amount. Infection dosage studies were performed on the MERS [3] and SARS [4] outbreaks. Based on these studies it is estimated that 1000 COVID-19 viral particles are needed for infection and illness. This begs the next question - does the virus dosage amount affect the severity of the resulting illness [5].

Table 50 - Infection Rate Mental Model Data

| Bio Event | Droplets | Virus Load (count) | Speed (miles/hour) | Distance (Feet) | Comment |
|--------------------------|-----------------|---------------------------|---------------------------|------------------------|--|
| Cough | 3,000 | none | 50 | 12 | Most droplets are large, and fall quickly (gravity), but many do stay in the air and can travel across a room in a few seconds. [6] |
| Sneeze | 30,000 | none | 200 | 18 | Most droplets are small and travel great distances (easily across a room). [6] [7] |
| Infected Cough or Sneeze | 200,000,000 | some % of 200 million | 50 - 200 | 12 | Dispersed into the environment. Cough and sneeze droplets have huge concentrations of viral material. [6] [7] |
| Single Breath | 50 - 5000 | none | Low | - | Most droplets are low velocity and quickly fall to the ground. There are even fewer droplets released through nose-breathing. Viral particles from the lower respiratory areas are not likely to be expelled because of small of the small force with a breath. [8] |
| Infected Single Breath | - | 20 17 - 1667 | Low | 6 | Respiratory droplets released from breathing have a low concentration of virus. Influenza can be used as a starting point until the COVID-19 studies are complete. A person infected with influenza releases about 3 - 20 virus RNA copies per minute of breathing. [9] COVID-19 patients exhale 1,000 to 100,000 virus particles per minute, with the highest rate seen during the early stages of COVID-19. [13] [14] |
| Speaking | - | 200 | Low | 6 | Increases the release of respiratory droplets about 10 times over breathing. [10] |
| Bathroom | - | High | - | - | Bathrooms have many high touch surfaces, door handles, faucets, stall doors. Fomite transfer risk in this environment is high. [11] We still do not know whether a person releases infectious material in feces or just fragmented virus, but we do know that toilet flushing does aerosolize |

| Bio Event | Droplets | Virus Load (count) | Speed (miles/hour) | Distance (Feet) | Comment |
|-----------|----------|--------------------|--------------------|-----------------|--|
| | | | | | <p>many droplets. Environmental biologists at the University of Stirling have warned that the potential spread of COVID-19 via sewage "must not be neglected" in the battle to protect human health [11].</p> <p>We know from studies in China that the virus is found in feces and raw sewage. From the report [12]:</p> <p><i>"2.4 Disposal of Fecal Matter and Sewage.</i></p> <p><i>(1) Before being discharged into the municipal drainage system, fecal matter and sewage must be disinfected by treating with chlorine-containing disinfectant (for the initial treatment, the active chlorine must be more than 40 mg/L). Make sure the disinfection time is at least 1.5 hours;</i></p> <p><i>(2) The concentration of total residual chlorine in the disinfected sewage should reach 10 mg/L."</i></p> <p>SARS-CoV-2 may have the potential to be transmitted through aerosols. Room ventilation, open space, sanitization of protective apparel, and proper use and disinfection of toilet areas can limit the concentration of SARS-CoV-2 RNA in aerosols. Future work should explore the infectivity of aerosolized virus [13].</p> |

A mental model can be developed using the MERS and SARS studies suggesting 1000 virus particles. The mental model can show how infection happens under different scenarios. In the model assume infection occurs with 1000 viral particles received in one breath or from one eye-rub. Alternatively assume 100 viral particles inhaled with each breath over 10 breaths, or 10 viral particles with 100 breaths. In the model each of these situations can lead to an infection. Now run the different scenarios.

There is a relationship between exposure to the virus and time: **Infection Prediction = Virus Load * Time** where virus load is associated with the number of droplets released by an infected person.

If an infected person coughs or sneezes 200,000,000 droplets go everywhere and most of the droplets have the virus. Some viruses hang in the air, some falls onto surfaces, most fall to the ground within a few hours unless there is some mechanical air movement and displacement.

Model Run Scenario 1 Cough or Sneeze in Room: If an infected person coughs or sneezes, some infected droplets can hang in the air for a few minutes filling every corner of a room. A 20 x 20 x 10 foot room is 4000 cubic feet. This results in 50,000 droplets per cubic foot. When someone enters the room, it's easy to see how it is possible to inhale 1,000 virus particles and become infected.

Model Run Scenario 2 Cough or Sneeze in Face: During a face-to-face a conversation, if an infected person sneezes or coughs, it's easy to see how it is possible to inhale 1,000 virus particles and become infected.

Model Run Scenario 3 Breathing: With general breathing 20 viruses per minute into a room would require 50 minutes to be exposed to 1000 viruses.

Model Run Scenario 4 Speaking: Assuming every virus is inhaled, it would take 5 minutes of speaking face-to-face to receive the required dose for infection.

Model Run Scenario 5 Bathroom: Treat public bathrooms with extra caution (surface and air).

Model Results

- ▼ The formula **Infection Prediction = Virus Load * Time** is the basis of contact tracing.
- ▼ Anyone that spends greater than 10 minutes with an infected person in a face-to-face setting is likely to get infected.
- ▼ Anyone that shares a space (office) with an infected person for an extended period is likely to get infected.
- ▼ It is critical for people who are symptomatic to stay home.
- ▼ Sneezes and coughs expel so much virus that they can infect a whole room of people.

The next step is to try and find case histories to see if this mental model is reasonable.

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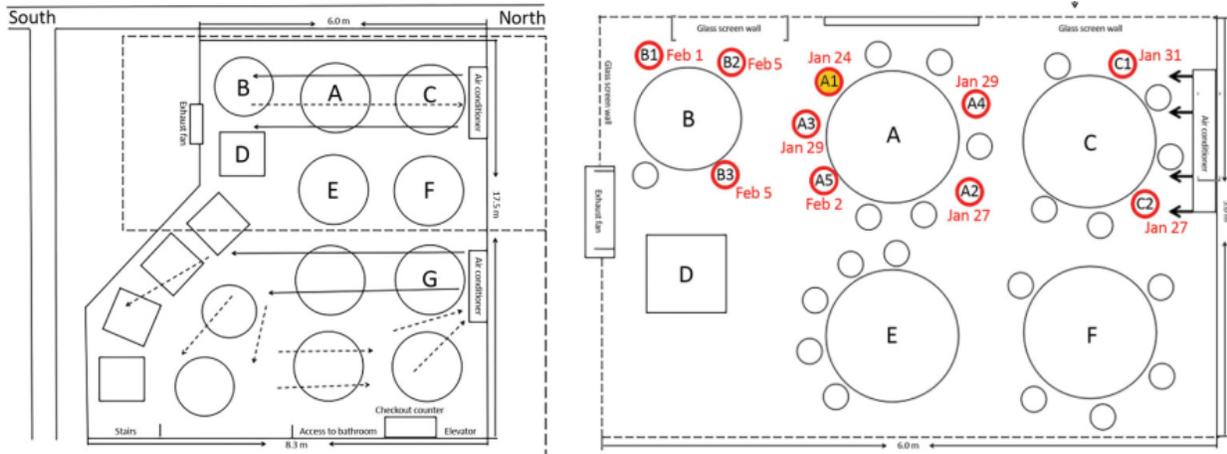
Virus Transmission Case Histories

Restaurants

From January 26 to February 10, 2020, an outbreak of 2019 COVID-19 affected 10 persons from 3 families (families A–C) who had eaten at the same air-conditioned restaurant in Guangzhou, China. One of the families just traveled from Wuhan, Hubei Province, China. [1]

The infected person (A1) sat at a table and had dinner with 9 people. During this meal, the asymptomatic carrier released low levels of virus into the air from breathing. Airflow from the restaurant's various airflow vents was from right to left. Approximately 50% of the people at the infected person's table became sick over the next 7 days. 75% of the people on the adjacent downwind table B became infected. And even 2 of the 7 people on the upwind table C were infected (turbulent airflow). No one at tables E or F became infected, they were out of the main airflow from the air conditioner on the right to the exhaust fan on the left of the room.

The only known source of exposure for the affected persons in families B and C was patient A1 at the restaurant. We determined that virus had been transmitted to more than 1 member of family B and more than 1 member of family C at the restaurant and that further infections in families B and C came from within-family transmission.



The Restaurant is air-conditioned, in a 5-floor building without windows. The third-floor dining area occupies 145 m²; each floor has its own air conditioner. The distance between each table is about 1 m. Families A and B were each seated for an overlapping period of 53 minutes and families A and C for an overlapping period of 73 minutes. The air outlet and the return air inlet for the central air conditioner were located above table C.

On January 24, a total of 91 persons (83 customers, 8 staff members) were in the restaurant. Of these, a total of 83 had eaten lunch at 15 tables. Among the 83 customers, 10 became ill with COVID-19; the other 73 were identified as close contacts and quarantined for 14 days. During that period, no symptoms developed, and throat swab samples from the contacts and 6 smear samples from the air conditioner (3 from the air outlet and 3 from the air inlet) were negative for severe acute respiratory syndrome COVID-19 by reverse transcription PCR.

From the examination of the potential routes of transmission, it was concluded that the most likely cause of this outbreak was droplet transmission. Although the index patient (patient A1) was asymptomatic during the lunch, presymptomatic transmission has been reported. Given the incubation periods for family B, the most likely scenario is that all 3 family B members were directly infected by patient A1. However, we cannot not exclude the possibility that patients B2 and B3 were infected by patient B1, the first family B member to become ill. For family C, a possible scenario is that both patients C1 and C2 were infected by patient A1; another scenario is that the patient C1 acquired the infection while caring for patient C2, beginning on January 27.

Virus transmission in this outbreak cannot be explained by droplet transmission alone. Larger respiratory droplets (>5 µm) remain in the air for only a short time and travel only short distances, generally <1 m. The distances between patient A1 and persons at other tables, especially those at table C, were all >1 m. However, strong airflow from the air conditioner could have propagated droplets from table C to table A, then to table B, and then back to table C.

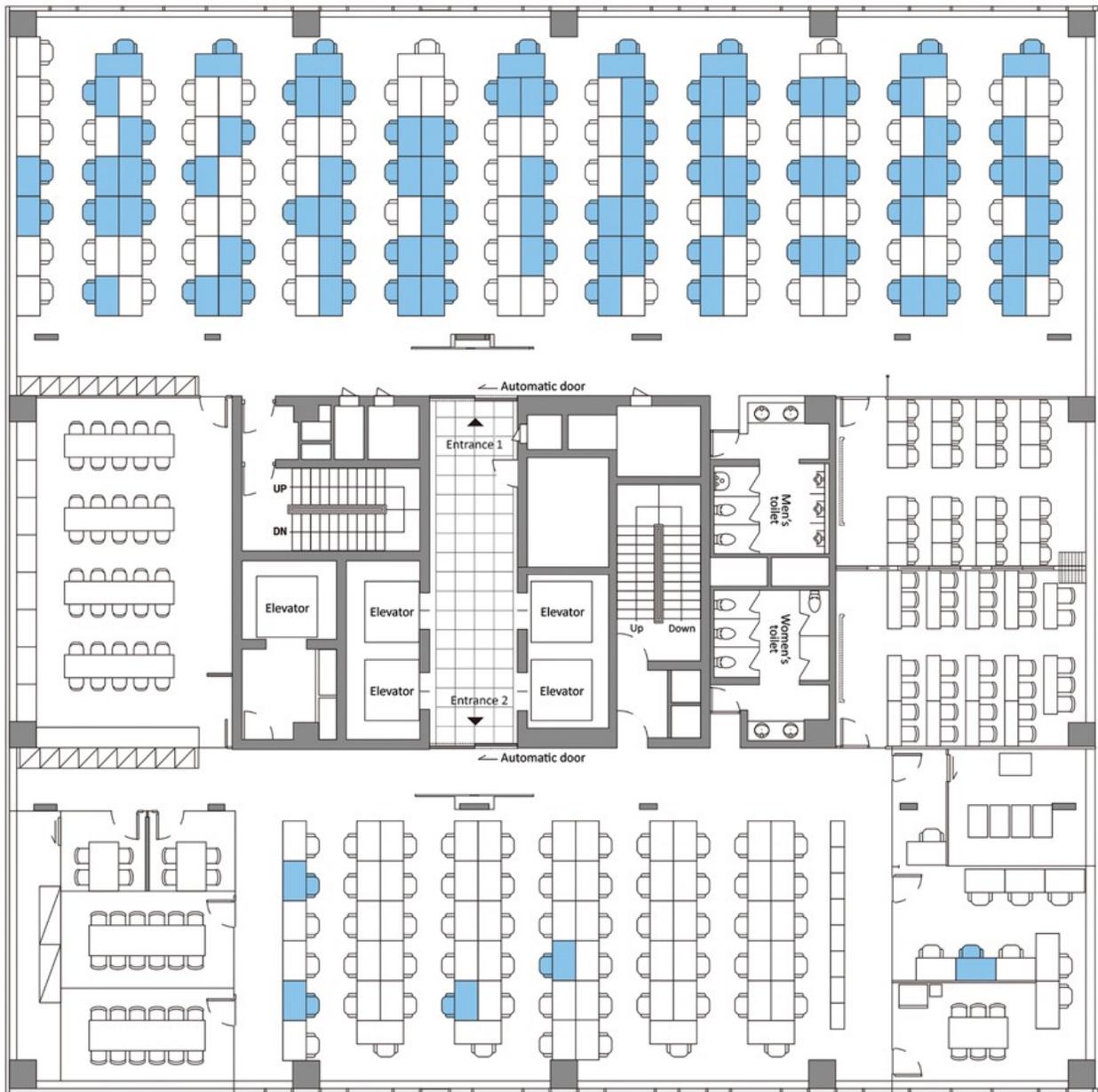
Virus-laden small (<5 µm) aerosolized droplets can remain in the air and travel long distances, >1 m. Potential aerosol transmission of severe acute respiratory syndrome and Middle East respiratory syndrome viruses has been reported. However, none of the staff or other diners in the

restaurant were infected. The smear samples from the air conditioner were all nucleotide negative. This finding is less consistent with aerosol transmission. However, aerosols would tend to follow the airflow, and the lower concentrations of aerosols at greater distances might have been insufficient to cause infection in other parts of the restaurant.

The conclusion is that this outbreak is caused by droplet transmission was prompted by air-conditioned ventilation. The key factor for infection was the direction of the airflow. Of note, patient B3 was afebrile and 1% of the patients in this outbreak were asymptomatic, providing a potential source of outbreaks among the public. To prevent spread of COVID-19 in restaurants, the recommendation was to strengthen temperature-monitoring surveillance, increasing the distance between tables, and improving ventilation.

Workplace

A single infected employee came to work on the 11th floor of a building with 216 employees. Over the period of a week, 94 people become infected (43.5%: the blue chairs), 92 of those 94 people became sick, and 2 remained asymptomatic. One side of the office is primarily infected, while there are very few people infected on the other side. While exact the number of people infected by respiratory droplets / respiratory exposure verse fomite transmission (door handles, shared water coolers, elevator buttons etc) is unknown. This suggests that being in an enclosed space, sharing the same air for a prolonged period increases the chances infection. Another 3 people on other floors of the building were infected, but the study was unable to trace the infection to the primary cluster on the 11th floor. Even though there were interaction between workers on different floors of the building in elevators and the lobby, the outbreak was mostly limited to a single floor. [2]



Choir

A choir Washington State decided to go ahead with rehearsal and dozens of members were infected with COVID-19 and two died. The people were aware of the virus and took steps to minimize transfer: they avoided handshakes and hugs, brought their own music to avoid sharing, and socially distanced themselves during practice. A single asymptomatic carrier infected most of the people in attendance. The choir sang for 2 1/2 hours, inside an enclosed church which was roughly the size of a volleyball court. [3]

Singing unlike talking significantly aerosolizes respiratory droplets. Deep breathing while singing facilitated the respiratory droplets getting deep into the lungs. Two and half hours of exposure time subjected people to enough virus over a long enough period of time for infection to take place. Over a period of 4 days, 45 of the 60 choir members developed symptoms, 2 died. The youngest infected was 31.

Indoor sports

A curling event in Canada with 72 attendees became a hotspot for COVID-19 transmission. Curling brings contestants and teammates in close contact in a cool indoor environment, with heavy breathing for an extended period. This tournament resulted in 24 of the 72 people becoming infected. [4]

Funeral / Birthday Party / Personal Care / Church

This report describes the cluster of 16 cases of confirmed or probable COVID-19, including three deaths, likely resulting from transmission of COVID-19 at two family gatherings (a funeral and a birthday party) and other activities. [5]

Funeral

In February 2020, a funeral was held for a decedent with a non-COVID-19, nonrespiratory cause of death. A close friend of the bereaved family (patient A1.1) attended the funeral. Patient A1.1 had recently traveled out of state and was experiencing mild respiratory symptoms. He was tested later as part of the epidemiologic investigation and received a diagnosis of confirmed COVID-19. The evening before the funeral, patient A1.1 shared a takeout meal, eaten from common serving dishes, with two family members of the decedent (patients B2.1 and B2.2) at their home. At the meal, which lasted approximately 3 hours, and the funeral, which lasted about 2 hours and involved a shared “potluck-style” meal, patient A1.1 also reported embracing family members of the decedent, including patients B2.1, B2.2, B2.3, and B3.1, to express condolences.

Patients B2.1 and B2.2 subsequently developed confirmed COVID-19 with onset of symptoms 2 and 4 days, respectively, after the funeral. Patient B2.3 developed probable COVID-19 with symptom onset 6 days after the funeral. Patient B2.1 was hospitalized, required endotracheal intubation and mechanical ventilation for acute respiratory failure, and died. Patients B2.2 and B2.3 were managed as outpatients, and both recovered.

Another family member who had close physical contact with patient A1.1 at the funeral (patient B3.1) visited patient B2.1 in the acute medical inpatient ward, embraced patient B2.1, and provided limited personal care, while wearing no personal protective equipment (PPE). Patient B3.1 developed signs and symptoms consistent with COVID-19, including a fever and cough after last visiting B2.1. Patient B3.1 had also attended the funeral but described more extensive exposure while visiting patient B2.1 in the hospital.

Birthday Party

Three days after the funeral, patient A1.1, who was still experiencing mild respiratory symptoms, attended a birthday party attended by nine other family members, hosted in the home of patient A2.1. Close contact between patient A1.1 and all other attendees occurred. Patient A1.1 embraced others and shared food at the 3-hour party. Seven party attendees subsequently developed COVID-19, including three with confirmed cases (patients A2.1, A2.2, and A2.3) and four with probable cases (patients A2.4, A2.5, A2.6, and A2.7). Two patients with confirmed COVID-19 (A2.1 and A2.2) were hospitalized. Both required endotracheal intubation and mechanical ventilation, and both died. One patient with a confirmed case (A2.3) experienced mild symptoms of cough and subjective low-grade fever, as did the four others who received

diagnoses of probable COVID-19. Two attendees did not develop symptoms within 14 days of the birthday party.

Personal Care

Two persons who provided personal care for patient A2.1 without using PPE, including one family member (patient A3.1) and a home care professional (patient C3.1), both developed probable COVID-19. It is likely that patient A3.1 subsequently transmitted COVID-19 to a household contact (patient A4.1), who did not attend the birthday party, but developed a new onset cough 3 days following unprotected, close contact with patient A3.1 while patient A3.1 was symptomatic.

Church

Three symptomatic birthday party attendees with probable COVID-19 (patients A2.5, A2.6, and A2.7) attended church 6 days after developing their first symptoms (investigation day 17). Another church attendee (patient D3.1, a health care professional) developed confirmed COVID-19 following close contact with patients A2.5, A2.6, and A2.7, including direct conversations, sitting within one row for 90 minutes, and passing the offering plate.

The patients described in this report ranged in age from 5 to 86 years. Three patients died (patients A2.1, B2.1 and A2.2).

Various Settings in China

This is a case study from China that identified various living venues and tracked the COVID-19 outbreaks. They concluded that all identified outbreaks of three or more cases occurred in an indoor environment, which confirms that sharing indoor space is a major COVID-19 infection risk. They identified only a single outbreak in an outdoor environment, which involved two cases. [6]

Meat Packing Plants

You would think that companies dealing with food would know how to deal with virus and bacterial contamination. Apparently, there are extremely stupid people in charge of these operations. It is also outrageous that the US Federal Government did not step in to secure the nation's food supply. This case study is not one of infection spread and control. Instead it is one of a collapsed system that has become completely incompetent and dangerous with severe grave consequences. The COVID-19 virus cannot be blamed for this mess. [7]

Nursing Homes

In Hawaii, an assisted living facility went into shelter in place mode on December 1, 2019 to deal with the COVID-19 outbreak based on news from around the world. They screen all visitors prior to entry and have instituted other policies and procedures. As of May 2020, there are no reported COVID-19 cases. [personal ref]

This contrasts with what is happening on the mainland in the US and around the world. [8]

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Case Studies Observations

Indoor spaces, with limited air exchange or recycled air and lots of people, are high risk settings:

- We know that 60 people in a volleyball court-sized room (choir) results in massive infections.
- Same situation with the restaurant and the call center.

- Social distancing guidelines don't hold in indoor spaces where you spend a lot of time
- People on the opposite side of a room were infected

Long time exposure to low density virus counts is high risk:

- In all these cases, people were exposed to the virus in the air for a prolonged period (hours)
- Even if they were 50 feet away (choir or call center)
- Even a low dose of the virus in the air reaching them
- The long time exposure was enough to cause infection and death
- The principle of viral exposure over an extended period of time was demonstrated by the case studies

Social distancing rules are to protect a person with brief exposures or outdoor exposures:

- In these situations there is not enough time to achieve the infectious viral load when you are standing 6 feet apart
- where wind and the infinite outdoor space for viral dilution reduces viral load
- The effects of sunlight UV on viral survival may minimize the risk to everyone when outside

When assessing the risk of infection (via respiration) at the grocery store or mall consider:

- The volume of the air space (very large)
- Number of people (restricted)
- How long people are spending in the store (workers - all day; customers - an hour)
- For store workers the work time they spend in the store significantly increases the infectious dose risk

The Federal Government is not working:

- The meat packing plants should have never been compromised
- Many of the COVID-19 studies are originating outside the US
- The government continues to fail miserably in this COVID-19 disaster

Personal Assessments:

- Examine the environment and make judgments
- How many people are here
- How much airflow is there
- How long will I be in this environment
- If in an open floorplan office, critically assess the risk (volume, people, and airflow)
- If in a job that requires face-to-face talking or even worse, yelling, assess the risk
- If sitting in a well ventilated space, with few people, the risk is low
- If outside, and walk past someone, it is the Dose and Time needed for infection, you would have to be in their airstream for 5+ minutes for a chance of infection
- While joggers may be releasing more virus due to deep breathing, remember the exposure time is also less due to their speed

Droplets Versus Aerosols

To determine if a virus is airborne the reproductive number R is examined. The reproductive number R describes the average number of individuals that a infected person infects. It depends on how that virus is transmitted as well as how often people come into contact. The factors that could vary depending on the virus strain and on the time and location of an outbreak. The R0 is the basic reproductive number that describes disease transmission at the very beginning of an outbreak in a fully susceptible population. The Re is the effective reproductive number that describes transmission once measures such as social distancing or vaccination have been introduced. Re is typically much lower than R0. [1]

Table 51 - R0 for Diseases SARS MERS COVID-19

| Disease | R0 (log scale) |
|---------------------------------------|-----------------------|
| 2020 COVID-19 early in Wuhan [1] | 1.4 - 5.7 |
| 2014 MERS Saudi Arabia [1] | 0.45 - 3.9 |
| 2014 Ebola [1] | 1.5 - 2.5 |
| 2003 SARS Hong Kong [1] | 1.7 - 3.6 |
| 1918 Influenza US & Europe [1] | 2.2 - 2.9 |
| 20th century Measles in UK and US [1] | 12 - 18 |
| SARS 2003 Airplane [19] | 22 |
| SARS 2018 Airplane [19] | 13.4 - 18 |
| COVID-19 2020 Airplane [19] | 15 |

An R0 value of 6.5 was observed for New York early in the COVID-19 disaster. A key observation is that the world quickly implemented social distancing and masks making it difficult to predict the traditional R0.

This study has performed an analysis to determine the R0 on an airplane. The results are R0 ranging from 13.4 to 22. This is significant because it suggests that the R0 for COVID-19 approaches that of Measles [19].

As of June 2020 many focus on the Droplet Evaporation curves from Wells (1934) ignoring the Wells-Riley equation first published in 1978. The CDC disclosed both of these findings as part of their study on natural ventilation for infection control in health-care settings [2]. Between 1934 and 1978 we went from a natural ventilation society to an enclosed air conditioned society with massive Heating Ventilation and Cooling (HVAC) Systems. Further, with the energy crisis in the 1970's all fresh air systems were converted to recycled air to save on energy costs. The world has been focused on droplets versus aerosols [3]. Unfortunately the reality is that it is not an either or condition. Instead it is a numbers game where the concentration of the aerosols is what matters. There is now sufficient empirical data to suggest that aerosol transmission within enclosed environments cannot be ignored [4] [5] [6] [7] [8] [15] [16].

As of July 2020 Governments are starting to change policies because of concerns that tiny droplets can carry SARS-CoV-2 [9]. In May 2020 the German Department of Health changed its guidance:

- Studies indicate that the novel coronavirus can also be transmitted through aerosols
- These droplet nuclei can remain suspended in the air over longer periods of time and may potentially transmit viruses
- Rooms containing several people should therefore be ventilated regularly

In taped interviews with journalist Bob Woodward on Feb. 7, 2020, President Trump said that the virus was more dangerous than the flu, even as he told the country otherwise [10]. It is clear that it was known from the beginning that the virus is spread through the air. President Trump stated the following in the audio interview.

- "This is deadly stuff,"
- "You just breathe the air and that's how it's passed,"
- "It's also more deadly than even your strenuous flus."

It is obvious that the US Government and media knew that the virus was airborne but they did not inform the public or take action to mitigate the virus spread from the airborne element. This information was made public on September 09, 2020.

The U.S. Centers for Disease Control and Prevention (CDC) has been subjected to massive political pressure from the Trump Administration and Republican party members including elected and unelected officials and citizens undermining the science. In July 2020 the CDC added guidelines language stressing the importance of children returning to schools and saying Covid-19 poses lower risks for children than for adults. In August 2020, the CDC reduced testing recommendations, stating that close contacts of confirmed cases did not need to undergo testing.

A change occurred on October 5, 2020 when the CDC said tiny particles lingering in the air can spread the coronavirus. This is the second announcement after an initial release in September 2020 that was pulled a few days later from public view [11] [12]. This October 5 release of CDC guidance acknowledged:

- Tiny airborne particles can travel beyond 6 feet and can be infectious
- The virus is primarily transmitted via respiratory droplets by people in close contact, physically near, or within about 6 feet, but there is additional transmission risk beyond 6 feet
- The droplets cause infection when they are inhaled or deposited in the nose and mouth
- Infections can spread by exposure to the virus more than 6 feet away in small droplets and particles that can linger in the air for minutes to hours
- Transmissions occurred within enclosed spaces that had inadequate ventilation, by those breathing heavily, for example while singing or exercising
- In such situations, infectious smaller droplets and particles became concentrated enough to spread the virus to others
- People are more likely to become infected the longer and closer they are to an infected person
- Ensure proper ventilation of indoor spaces

- Being outdoors and in spaces with good ventilation reduces the risk of exposure to infectious respiratory droplets

We also know that Airborne transmission is happening in normal situations such as in a restaurant, on a school bus, at a camp. The virus spreads by air in certain environments, such as crowded indoor and poorly ventilated spaces.

There is epidemiological data showing an association between indoor humidity above 40% and reduced healthcare associated infections. The ideal humidity levels are between 40% and 60%. Infection control protocols focus on hand, instrument and surface hygiene, as well as on cough etiquette and facial masks. These approaches interrupt transmission through contact and short distance large droplet spray. Except for masks they do not stop tiny aerosolized droplets which spread infectious microorganisms across significant distances and for extended periods through the air. Droplet nuclei with diameters less than 5 μm are easily inhaled and can go into deep layers of the respiratory tract. Studies indicate that 10 to 33 percent of all healthcare associated infections move through the air at some point between the infected person and the non-infected person. Until transmission of these tiny infectious aerosols are controlled, even excellent compliance with contact hygiene protocols will not stop a healthcare associated infection epidemic in a facility. Humidity control as a prevention strategy is a critical virus spread mitigation strategy and is equally applicable to all public buildings like hospitals, offices, classroom, stores, bars and residential buildings. [13] [14]

There is also evidence to suggest that a low humidity level inside a room may lead to the mucus drying out and lowering the ability of the innate immune system to deal with an infection source. This is typically why many homes have humidifiers that are used during the winter months.

The implications are that all indoor ventilation systems must be examined. However, there are no COVID-19 building ventilation standards based on solid engineering with associated test and evaluation activities that can be provided except for the preliminary **findings in this report**. Most indoor ventilation systems will probably need modifications. It is critical that building ventilation test and evaluation begin immediately using our best tools and facilities to find the answers and minimize the spread of the virus. **Read this full report.** [17] [18]

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Virus and Bacteria Sizes

The whole argument about the nature of the virus airborne element provided to the public centered on the size of the virus and the size of airborne droplets and aerosols. The US Government knew in January of 2020 that the virus was airborne [9]. They allowed disinformation to proceed without closure in the public dialog knowing that it was wrong and that people would be infected, some would lose their health, and others would die.

The marginalized scientists and engineers performing the analysis that were not sworn to secrecy by the US government performed their research and published their results in open forums. They were ignored by the general public. It was not until the research started publishing numbers that the press started to report on the findings and the US government was forced to disclose what they knew in January 2020. Meanwhile a member of the press sat on this grave information for months, until his book was released, as people got sick and died.

Here are some of the sizes associated with various viruses.

Table 52 - Virus Bacteria and Sizes

| Virus / Bacteria | Size | Ref |
|-------------------------|-------------|-------------|
| Respiratory Droplets | 5-10 um | [1] [7] [8] |
| Bacterium | 2 um | [1] |

| Virus / Bacteria | Size | Ref |
|-------------------------|---------------|------------|
| Pitovirus | 1.5 um | [1] |
| Mimivirus | 400 nm | [1] |
| T4 Bacteriophage | 225 nm | [1] |
| HIV | 120 nm | [1] |
| Measles | 100 to 300 nm | [3] |
| Murine Hepatitis MHV | 80-90 nm | [5] |
| SARS-CoV-1 | 78 nm | [6] |
| SARS-CoV-2 | 70-90 nm | [2] |
| SARS-CoV-2 | 60-140 nm | [1] |
| Zika | 45 nm | [1] |
| Parovirus | 18-28 nm | [1] |

1 micron = 1 um = 1000 nm

As a result of this analysis and other analysis produced between March 2020 and October 2020 the COVID-19 virus is now acknowledged as an airborne transmission virus. This is the guidance offered by the state of New Jersey [4]:

Is the coronavirus airborne?

Yes, COVID-19 can spread via airborne transmission.

When people with the COVID-19 infection breathe out, clear their throats, cough, sneeze, speak, or otherwise move air out through their nose or mouth, droplets of all different sizes, which can contain the virus, are ejected into the air. A substantial portion of people infected with SARS-CoV-2 - around 40 percent - wouldn't even know they are ejecting virus-laden droplets, as they may not exhibit symptoms.

Droplets suspended in the air are called an aerosol. Droplets that are large can remain in the air for seconds to minutes before falling to the ground. Smaller droplets stay in the air longer – minutes to even hours.

Outside, the circulation of fresh air disperses the drifting droplets quickly, and so the combination of wearing cloth face coverings and maintaining physical distance (6 feet or more) is very effective at impeding the spread of COVID-19 in outdoor spaces where air moves.

However, in indoor spaces, especially those with poor ventilation, coronavirus-laden droplets can build up to a level that is risky.

To the extent possible, we should all be minimizing the amount of time we spend in any one place, especially if others are nearby, or if you are indoors with other people. This limits the time a person is potentially exposed to the virus.

It is also very important to stay as far away from one another as possible, minimum 6 feet. The farther, the better. Some experts recommend staying at least 25 feet away from others, even when outdoors. And it's a good idea to avoid crowded indoor spaces.

The traditional definition of airborne transmission is that small droplets containing a pathogen remaining viable over long time periods travel long distances in the air and infect other people when the pathogen is breathed in. Measles and tuberculosis are examples of respiratory diseases that remain infectious in the air for long time periods. The measles virus can live for up to two hours in the air where an infected person coughs or sneezes. Tuberculosis can live in the air for up to six hours.

Under experimental conditions, researchers found that the COVID-19 virus stayed viable in the air for three hours. The researchers estimate that in most real-world situations, the virus would remain suspended in the air for about 30 minutes, before settling onto surfaces. This is similar to what was found for SARS and MERS, which some researchers consider likely to be spread via airborne transmission. One study estimates that a person infected with the COVID-19 virus who speaks loudly for one minute produces at least 1,000 virus-containing droplets that remain airborne for more than 8 minutes. Furthermore, the Centers for Disease Control and Prevention recommend airborne precautions for the care of COVID-19 suspected or confirmed patients.

Many unknowns remain about SARS-CoV-2, such as how many virus particles need to be breathed in for an infection to begin. However, active COVID-19 virus travels through the air when ejected by infected people, and can infect cells in the petri dish. By staying as far away from one another as possible, keeping on the move, avoiding touching our faces, frequently washing our hands well with soap and water, coughing or sneezing into the crook of our elbows, wearing cloth face coverings (masks), and staying home when sick, we can protect ourselves and others.

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Virus Mutations & Architecture Solutions

For those reading this report for the first time, this section normally would be at the end of the report after all the analysis and data have been reviewed. It is found in the middle of the report because it logically fits in this section for those that are reading these findings in real time as they are reported. In many ways this section is the culmination of months of research and it is a vision for moving forward in January 2021.

The original title for this analysis was Virus Mutations and now it is Virus Mutations & Architecture Solutions. When the virus mutation systems analysis started there was no intent to identify architecture solutions and perform an architecture tradeoff. Like many systems analysis efforts things tend to self-disclose and it is logical to follow the path of least resistance. In this case it was obvious and easy to identify and compare architecture approaches in the setting of a

future that will obviously have virus mutations. Also, this analysis moved into relating the social to the technical aspect as per the definition of systems engineering from Simon Ramo in the introduction. I also shifted the discussion and inserted a meeting format to provide a feel for what might happen during a systems meeting on this topic. This is a systems engineering perspective on virus mutations.

The COVID-19 virus has been mutating since it has entered the human population. The larger the virus population the larger the mutation rates. Currently a large number of people have been infected and so multiple mutations are being detected and studied to determine their impacts.

On December 01, 2020 a new COVID-19 virus mutation, the SARS-CoV-2 lineage B.1.1.7, now designated Variant of Concern 202012/01 (VOC) by Public Health England, originated in the UK in the late Summer to early Autumn 2020. It has been found to be more contagious than the original virus and other mutations. Evidence in the United Kingdom suggests that infection is growing more rapidly in areas where the B.1.1.7 variant is found. A study from The Centre for the Mathematical Modelling of Infectious Diseases in London shows this particular strain is 56% more transmissible [1] [2]. For the COVID-19 virus to enter a cell it needs to bind to a receptor. The new B.1.1.7 mutation binds tighter and more easily to ACE2 and enters the cell easier than the current COVID-19 virus. [2] [3]

The B.1.1.7 variant was detected in August 2020, officially claimed on December 01, 2020 and as of January 7, 2021 there has been no unique action for mitigation. That is 5 months. It is also unclear how long the B.1.1.7 variant was circulating before being detected.

Given that the COVID B.1.1.7 mutation is 56% more transmissible, the implications are that all the findings in this study relative to COVID-19 probability of infection and associated recommendations need to be adjusted by 56%. For example, if the time before infection in a particular scenario is 2.27 hours then the time before infection for the B.1.1.7 mutation is 1 hour. If the probability of infection is 1% then with the B.1.1.7 mutation the probability of infection is 1.56%. However the situation may not be that simple. The mutant viral particle binds to the ACE2 receptor for a longer period of time than the less-infectious viral particle. The implications are that during the early exposure to the virus equal amounts of the virus will be bound to the ACE2 receptors, but as time moves on the mutant virus level bound to the ACE2 receptors will exceed the level of the original virus.

The South African variant known as 501.V2 has been replacing other strains of the coronavirus as early as November 2020 South African officials reported on December 18, 2020. It appears that it may obviate some of the medical countermeasures, particularly the antibody drugs. As of January 2021 the strain is prevalent in South America and Brazil. The 501.V2 partially escapes prior immunity suggesting that some of the antibodies people produce when they get infected with COVID-19, as well as the antibody drugs, may not be as effective. The 501.V2 variant has mutated a part of the spike protein that antibodies bind to, to try to clear the virus [4].

The 501.V2 variant carries a mutation in the spike protein called E484K, which is not present in the UK strain. The E484K mutation has been shown to reduce antibody recognition which may help the virus bypass immune protection provided by prior infection or vaccination. However, the mutation is not sufficient for the variant to bypass the protection provided by vaccines in general. Current estimates are that it would take 4 to 6 weeks to develop a modified vaccine, if needed [6].

The 501.V2 variant was detected in November 2020, officially claimed on December 18, 2020 and as of January 7, 2021 there has been no unique action for mitigation. That is 2 months. It is also unclear how long the 501.V2 variant was circulating before being detected.

The following analysis summary is presented in a non-prose form using a VU-Graph approach that is typically provided in a systems meeting. One of the advantages of this form of presentation is that the logic and analysis chain is easily followed. The supporting data typically includes dozens if not hundreds of studies, analysis, design artifacts, papers and other information products capturing the work and findings behind the systems effort (e.g. this full report).

From a systems perspective the key issues are:

- Viruses will mutate
- This virus is airborne and very contagious
- This virus has a high death and loss of health rate
- 5 months to detect B.1.1.7 variant
- 2 months to detect 501.V2 variant
- 1.5 months (6 weeks) to develop modified vaccine
- X months to validate modified vaccine safety and effectiveness
- X months to distribute modified vaccine

From a systems perspective the observations are:

- Using just the vaccine subsystem to mitigate a new virus variant will take a minimum 3.5 to 6.5 months
- This assumes zero time for system validation and distribution
- Waiting 3.5 to 6.5 months will lead to an epidemic or pandemic condition
- A modified infrastructure using proper HVAC systems, upper level UV-C, FAR UV-222, will immediately work to help stop the spread of any new virus variants

The system approach to mitigate the current and future virus infection is a complex system solution involving multiple subsystems. The subsystems are:

- Vaccinations that will probably become annual events for decades
- Treatments
- Ceiling level UV-C
- FAR UV-222
- Updated HVAC systems with proper operations

The most effective subsystems in this system are the subsystems that immediately work with no lead time for detection and then roll out of the solution. These subsystems are:

- Updated HVAC systems with proper operations
- Ceiling level UV-C
- FAR UV-222

Final observation:

- Relying on just the vaccine will not provide the most effective system

The following backup slide would probably be presented at this systems meeting:

Table 53 - Virus Mitigation Subsystems Performance

| Naturally Immune | Vaccine Effectiveness | Vaccinated | Exposed Population Starting with 328 million | Deaths @ 2% | Deaths @ 3% | Deaths @ 3.5% | UV-C or FAR UV-222 Kill / Inactivate | Deaths @ 3.5% (With UV) | Ventilation Effectiveness 4 AUC | Deaths @ 3.5% (With UV + Ventilation) |
|-------------------------|------------------------------|-------------------|---|--------------------|--------------------|----------------------|---|--------------------------------|--|--|
| 10% | 70% | 70% | 150,552,000 | 3,011,040 | 4,516,560 | 5,269,320 | 90% | 526,932 | 28% | 379,391 |
| 10% | 90% | 90% | 56,088,000 | 1,121,760 | 1,682,640 | 1,963,080 | 90% | 196,308 | 28% | 141,342 |
| 0% | 70% | 70% | 167,280,000 | 3,345,600 | 5,018,400 | 5,854,800 | 90% | 585,480 | 28% | 421,546 |
| 0% | 90% | 90% | 62,320,000 | 1,246,400 | 1,869,600 | 2,181,200 | 90% | 218,120 | 28% | 157,046 |
| . | | | | | | | | | | |
| 0% | 0% | 0% | 328,000,000 | 6,560,000 | 9,840,000 | 11,480,000 | 90% | 1,148,000 | 28% | 826,560 |
| 10% | 0% | 0% | 295,200,000 | 5,904,000 | 8,856,000 | 10,332,000 | 90% | 1,033,200 | 28% | 743,904 |

Note: This table shows that all three approaches of Vaccine, UV, and Ventilation are needed to eradicate the virus.

The systems discussion would then revolve around virus mutation rate and the expectations for future virus outbreaks.

Infrastructure costs would not even be part of the discussion. The discussion would be on developing the most effective system. The system must work and it will cost what it will cost. Once the system implementation begins, then it must be implemented as efficiently as possible. There is a difference between efficient and cheap. Cheap is a poor solution that will not meet the system requirements. Efficient ensures that all costs are properly monitored and there is no waist.

The reason the cost discussion was added is because of push back from some stakeholders that will use cost as an excuse to prevent an effective system from being established. In this case the costs to implement this system are actually very low [7] [8]. The reasons for one or more stakeholders to use cost as an excuse to prevent a proper system from being developed is simple - they are trying to game the system in their favor. In the process they enlist others that are not aware that they are being used and they just blindly state costs without any logic, justification, or even data. All systems efforts include cost estimates but the costs are never used to invalidate a system. Instead costs are used to determine the effectiveness of each system approach.

As of January 2021 there is sufficient information in this systems engineering analysis effort to perform a tradeoff analysis of different architecture approaches. The architecture approaches are:

- Approach A - Do Nothing
- Approach B - Vaccine
- Approach C - Vaccine + UV + HVAC

The Coronavirus Aid, Relief, and Economic Security (CARES) Act is a \$2.2 trillion dollar economic stimulus bill signed into law on March 27, 2020. As of October 5, 2020 the COVID-19 disaster cost \$4 trillion dollars. [9] The \$4 trillion dollar figure establishes the cost associated with Architecture A. If there is a vaccine infrastructure in place it will still take 6 months before the virus is detected to the full rollout of the updated vaccine. The \$2.2 trillion dollar figure establishes the cost associated with Architecture B. Both architectures A and B have large loss of life and they each have a cost associated with those sad figures. Architecture C has infrastructure costs.

With this information it is now possible to perform a systems engineering tradeoff using the Measure Of Effectiveness (MOE). The MOE is the unit of goodness in each architecture for each dollar spent. The MOE is calculated by dividing the total tradeoff criteria rating of each architecture by its total costs. [10] [11]

MOE = total tradeoff criteria rating / total costs

The following table contains the tradeoff for Architectures A, B and C. [[spreadsheet Arch Trade](#)]

Table 54 - Mutated Virus Mitigation Architecture Tradeoff

| Tradeoff Criteria | Arch A | Arch B | Arch C | Comments |
|------------------------------------|--------|--------|--------|--|
| Ability to prevent future epidemic | 1 | 3 | 5 | Sensitivity analysis shows that the 5 rating |

| Tradeoff Criteria | Arch A | Arch B | Arch C | Comments |
|---|----------|---------|---------|---|
| | | | | for Arch C is irrelevant |
| Ability to stop Pandemic | 1 | 3 | 5 | Sensitivity analysis shows that the 5 rating for Arch C is irrelevant |
| Total Rating | 2 | 6 | 10 | |
| . | | | | |
| Shutdown Costs (\$ billions) | \$4,400 | \$0 | \$0 | |
| Future Potential Shutdown Costs (\$ billions) | \$0 | \$2,200 | \$0 | It will take 6 months for an updated vaccine This is similar to the CARES act level of costs |
| Lives Lost Costs (\$ billions) | \$7,852 | \$2,100 | \$151 | \$7 million per life |
| Infrastructure Costs (\$ billions) | \$0 | \$10 | \$150 | Vaccine for Arch B UV + HVAC upgrades for Arch C |
| Total Costs (\$ billions) | \$12,252 | \$4,310 | \$301 | |
| . | | | | |
| MOE (Rating / Total Costs) | 0.00016 | 0.00139 | 0.03322 | |
| . | | | | |
| MOE Normalized Result | 1 | 9 | 204 | Arch C is as shown times better than Arch A |

Note: Rating Scale: 1 = worst, 5 = best

This analysis suggests that Architecture C is 204 times more effective than Architecture A and 24 times more effective than Architecture B.

After this initial tradeoff analysis is performed it is subjected to a sensitivity analysis where the tradeoff criteria is arbitrarily changed to maximum and lower level ratings. In the case of Architecture C the ratings can never drop below the ratings of Architecture B because Architecture C includes Architecture B as part of the solution. This would mean that the addition of UV + HVAC upgrades would have zero effect on mitigating the virus. In that case the rating would still be the same as Architecture B. The reason is because the infrastructure costs are so low once compared to the lives lost and future potential shutdown costs. In other words there is nothing to lose by just upgrading the infrastructure. Also we know from empirical data, scientific analysis, and engineering data going back into the 1940's that there will be significant virus mitigation benefit and lives will be saved [12].

This is a preliminary tradeoff. As more is learned during the weeks, months, and perhaps years, the tradeoff criteria and ratings will change. The costs of each architecture approach will change. The big question is will the most effective architecture change. The reality is the answer is no

because the cost of shut down and massive loss of life far outstrips any costs of the technologies we currently have to solve this problem of future virus mitigation.

It is important to note that policy makers really selected Architecture A in 2020. Placing an order for some vaccination doses is not a commitment to Architecture B. Everyone must understand that Architecture B exists by January 2021 only because of the scientists from around the world and the commitment by a handful of companies. They pulled off a miracle and we have Architecture B available as an alternative.

Architecture C is not even on the table. There are engineers and scientists pushing for Architecture C but unless there is a massive commitment from the US Federal Government, it will not happen. There are no massive companies able to make the case that everyone should start installing UV systems and upgrading HVAC systems. Further the critical importance of these systems is not clear in the public mind. The general public does not know that Architecture C is needed to bring this pandemic fully under control in the least amount of time and that it is needed for virus events that will now be part of the future because of COVID-19. Making this case with the public is a massive education challenge.

In November 2019 US intelligence reported that something serious was happening in China. The intelligence was in the form of communications intercepts and overhead images showing increased activity at health facilities. The intelligence was distributed to some federal public health officials in the form of a situation report in late November 2019. Current and former officials say there was no formal assessment in November 2019 but that there was raw intelligence data that was part of formal assessments in December 2019 [13]. In late December, doctors in Wuhan were puzzled by many pneumonia cases of unknown cause. On December 30, 2019 the Wuhan CDC sent out an internal memo to all Wuhan hospitals to be alerted and started an investigation into the exact cause of the pneumonia.

So here is what should have happened:

▼ November 2019, A small systems staff would have been aware of the intelligence data. They would have alerted others to prepare for something significant.

▼ December 2019, a small systems team should have formally formed from the informal team that started in November 2019. The team would be about 10 systems engineers where one would be the technical director. There might be a shared program manager. They would have reviewed all the informal analysis.

▼ December 2019, the systems team would have started the formal analysis on topics similar to what is found in this analysis.

▼ January 2020, the small systems team would have been augmented with perhaps 50 others representing different specialty areas. In 2 months they would have produced all the findings in this report which took 11 months to produce (March 2020 and January 2021).

▼ February 2020, systems staff would have been flying around the world to examine UV production facilities and to Washington DC to brief the systems findings. They would be presenting analysis similar to this analysis. Architecture alternatives and tradeoffs would be presented. Legislators, based on the briefings would be drafting legislation such as tax incentives

and direct grants for HVAC upgrades and UV installations. It would have been part of the Coronavirus Aid, Relief, and Economic Security (CARES) act.

➤ March 2020, they would have started to coordinate with the industrial base to develop strategies to roll out upgraded HVAC systems and UV systems. The organizations ILS group that includes facilities experts would be working with the systems team that now might number between 50-75 systems engineers. The project team might now number 200 people.

➤ April 2020, there would be new HVAC and UV standards with testable requirements that include specific performance numbers for roll out to the country in preparation for massive infrastructure upgrades. This would be augmented with a massive education program.

➤ May 2020, small space public building owners and managers would know the importance of managing and upgrading their HVAC systems. They would be introduced to UV systems. Because of tax incentives and direct credits they would start to upgrade their facilities with appropriate UV and HVAC systems.

➤ June - August 2020, there are massive HVAC infrastructure upgrades and new UV systems.

➤ August 2020, metrics might show that 50% of the needed commercial infrastructure and 90% of the public space (airports, etc.) has been upgraded.

➤ September 2020, there would be perhaps 1500 people on the project team. All schools would have been upgraded with appropriate HVAC and UV systems. The reason this would happen is because there would be massive analysis and data to support this policy coming from the most qualified organizations in the US with the systems team driving the systems perspective.

➤ September 2020, the undisputed solid findings from the respected organization and a functioning US Federal Government would have rolled out proper airplane and airport guidance along with appropriate UV and HVAC systems so that the expected Holiday Travel would not lead to disaster.

The above scenario represents what should have been.

Before this topic is closed out the previous architectures need to be addressed. These architectures and their effectiveness are in the following table. Notice that the architecture and tradeoff criteria have exchanged rows and columns. It is easier to capture the comments for each architecture alternative.

Table 55 - Previous Architecture Alternatives

| Previous Architecture Alternatives | Prevent future Epidemic | Stop Pandemic | Cost | MOE for US | MOE for New Zealand | MOE for Hawaii | MOE for Japan | Comments |
|------------------------------------|-------------------------|---------------|--------------------------------------|------------|---------------------|----------------|---------------|---|
| 1. Masks + Social Distance | 0-3 | 0-3 | Infrastructure Partial Shutdown Wash | 0 | 3 | 2 | 3 | Probably explains Japan Unable to implement in US |
| 2. Total | 0-5 | 0-5 | Shutdown | 0 | 5 | NA | NA | Worked in New |

| Previous Architecture Alternatives | Prevent future Epidemic | Stop Pandemic | Cost | MOE for US | MOE for New Zealand | MOE for Hawaii | MOE for Japan | Comments |
|------------------------------------|-------------------------|---------------|---------------|------------|---------------------|----------------|---------------|---|
| Quarantine | | | Wash | | | | | Zealand Unable to implement in US |
| 3. Partial Quarantine | 0-3 | 0-3 | Shutdown Wash | 0 | 3 | 3 | 3 | Somewhat successful in Hawaii Unable to implement in US |

Note: Rating Scale: 1 = worst, 5 = best

The costs for the above architectures are considered a wash. In this case the MOE becomes the tradeoff criteria ratings. The above table shows that the key to a successful architecture is to consider the people in the system. We can argue about the ratings but the results documented in the comments are now part of history. They are irrefutable empirical data.

Meanwhile the work continues. SEPTA and Drexel Team up to Battle COVID-19 in December of 2020. The partnership will focus on understanding the role of masks, **ventilation**, **air treatment** and surface cleaning in preventing transmission of the virus, developing strategies that SEPTA can deploy in the near future and guiding the agency in communicating these new safety protocols [14].

This analysis has gone from virus mutation, to a tradeoff for the most effective architecture, to a potential vision of how that architecture might be realized. It is never too late to make corrections and 2021 is the start of a new year for a new path.

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Virus Diffusion

Understanding how the virus will diffuse in an environment is critical to understanding how to mitigate the risk of exposure. In this analysis there are multiple approaches that were used to understand virus diffusion. Some of the analysis approaches are based on analogies of how the virus might behave and they come from other unrelated engineering areas. They are used to compare the results with analysis that more closely matches a diffusion analysis approach.

The following analysis was considered and the analysis that was developed have tables that show different scenarios and results. They use the simple particle dispersion and the density models:

- Virus Density by Distance (Electrical Engineering)
- Virus Diffusion by Distance and Windspeed (Nuclear Engineering)
- Virus Density by Volume and Air Mixing (Engineering)
- Virus Density by Mask Filtering Levels (Engineering)
- NIST FaTIMA - not developed
- Virus Probability of Infection (Wells-Riley) - developed further in this text

Virus Density by Distance (Electrical Engineering)

This analysis is based on electrical engineering and comes from trying to understand the radiation exposure from a transmitter antenna. There are IEEE standards that identify limits of safe exposure based on milli-watts per square centimeter. The equation eventually boils down to the power density being inversely proportional to the square of the distance.

$Pd=Ps/d^2$

Pd = Power density at the target surface
 Ps = Power at the source
 d = distance

Even though it comes from electrical engineering it is a generic equation that uses distance to determine the density of an emitter at a distance. The equation applies to any emitter including the virus. It is a volume geometry equation. In the case of the virus we can easily translate the parameters that apply to virus diffusion:

Virus Load Destination = Pd
 Virus Load Source = Ps
 Distance = d

The following analysis is based on electrical engineering power density. The parameters were replaced with the relevant virus parameters. This model does not include wind speed. [[spreadsheet](#) Diffusion]

Table 56 - Dilution Based On Distance

| Ps | d | Pd | |
|-------------------------|----------------------|------------------------------|-----------------------------|
| Source Virus/min | Distance Feet | Destination Virus/min | Time to Reach Ps Min |
| 1200 | 6 | 33.3333 | 36 |
| 1200 | 16 | 4.6875 | 256 |
| 1200 | 26 | 1.7751 | 676 |
| 1200 | 36 | 0.9259 | 1296 |
| 1200 | 46 | 0.5671 | 2116 |
| 1200 | 56 | 0.3827 | 3136 |

| Ps | d | Pd | |
|-----------------------------|--------------------------|----------------------------------|---------------------------------|
| Source Virus/min | Distance Feet | Destination Virus/min | Time to Reach Ps Min |
| 1200 | 66 | 0.2755 | 4356 |
| 1200 | 76 | 0.2078 | 5776 |

Virus Diffusion by Distance and Windspeed (Nuclear Engineering)

The third analysis comes from nuclear engineering and is based on trying to understand the spread of radiation in the event of a release [1]. This is a more useful model because it considers wind speed along with the distance from a source. The equation is:

$$Ca = B \cdot Qi / (u \cdot x^2)$$

Ca = concentration at the point of interest (Bq/m³)

Qi = released concentration per unit of time (Bq/s)

x = distance between release vent and point of interest [m]

u = speed of the wind [m/s]

B = Unitless constant accounts for increase in air concentration along vertical wall because of air stagnation created by wakes.

B = 30 against wall, B = 1 open air

Radionuclides Atmospheric Dispersion, Source and Receptor on same building surface

If x is greater than three times the diameter of the stack or vent below to calculate the air concentration with B = 30

Even though it comes from nuclear engineering it is a generic equation that uses distance, wind speed, and an emitter with some rate of emission. The equation applies to any emitter including the virus. It is a particle dispersion model that uses a volume geometry equation with the additional factor of a wind speed that is used to consider a continuous emitter. The constant B is arbitrary to deal with the situation of dead air in settings like being up against a wall. In the case of the virus we can easily translate the parameters that apply to virus diffusion:

Virus Load Destination = Ca

Virus Load Source = Qi

Distance = x

Wind Speed = u

Open Air = B = 1

Against a Wall = B = 30

This analysis is based on nuclear engineering and it shows the spread of radiation in the event of a release. The equation parameters have been replaced with relevant virus parameters.

[[spreadsheet](#) Diffusion]

Table 57 - Dilution Based on Wind and Distance

| B | Qi | u | u | x | Ca | |
|----------|-----------|----------|----------|----------|-----------|--|
|----------|-----------|----------|----------|----------|-----------|--|

| B | Source Virus/min | Wind Miles/Hr | Wind Feet/Min | Distance Feet | Destination Virus/min | Time to Reach Qi Min |
|----------|-----------------------------|--------------------------|--------------------------|--------------------------|----------------------------------|---------------------------------|
| 30 | 1200 | 1 | 88 | 6 | 11.3636 | 106 |
| 30 | 1200 | 1 | 88 | 16 | 1.5980 | 751 |
| 30 | 1200 | 1 | 88 | 26 | 0.6052 | 1983 |
| 30 | 1200 | 1 | 88 | 36 | 0.3157 | 3802 |
| 30 | 1200 | 1 | 88 | 46 | 0.1933 | 6207 |
| 30 | 1200 | 1 | 88 | 56 | 0.1304 | 9199 |
| 30 | 1200 | 1 | 88 | 66 | 0.0939 | 12778 |
| 30 | 1200 | 1 | 88 | 76 | 0.0708 | 16943 |

This is a worst case analysis where the uninfected person is up against a wall where B = 30. The level of virus exposure is a function of distance and wind speed.

This analysis is based on the nuclear engineering model. It has been augmented to reflect Risk, Locations, and Scenarios. [[spreadsheet](#) Diffusion]

Table 58 – Dilution Wind Distance Risks Locations Scenarios

| B | Qi | u | u | x | Ca | | | | |
|----------|-------------------------|----------------------|----------------------|----------------------|------------------------------|-----------------------------|---------------------|----------------------|--|
| B | Source Virus/min | Wind Miles/Hr | Wind Feet/Min | Distance Feet | Destination Virus/min | Time to Reach Qi Min | Risk | Location | Scenarios |
| 30 | 1200 | 1 | 88 | 1 | 409.09 | 3 | Unacceptable | Outside wall | Up against wall |
| 30 | 1200 | 1 | 88 | 6 | 11.36 | 106 | High | Outside wall | Up against wall |
| 30 | 1200 | 1 | 88 | 16 | 1.60 | 751 | Low to Unacceptable | Outside wall | Up against wall, common sense needs to apply, if infection source is downwind then Risk = Unacceptable |
| . | | | | | | | | | |
| 30 | 1200 | 0.01136 | 1 | 1 | 36000.00 | 0 | Unacceptable | Inside | Up against wall No air movement, this is after a period of time (B becomes T) to build up against the wall |
| 30 | 1200 | 0.01136 | 1 | 6 | 1000.00 | 1 | Unacceptable | Inside | Up against wall No air movement |
| 30 | 1200 | 0.01136 | 1 | 16 | 140.63 | 9 | Unacceptable | Inside | Up against wall No air movement |
| . | | | | | | | | | |
| 1 | 1200 | 1 | 88 | 1 | 13.64 | 88 | High | Outside, Beach, Park | Free space air movement, at 1 foot this is really up against a wall and you are the wall |
| 1 | 1200 | 1 * | 88 | 6 | 0.38 | 3168 * | Low | Outside, Beach, Park | Free space air movement |
| 1 | 1200 | 1 | 88 | 16 | 0.05 | 22528 | Low | Outside, Beach, Park | Free space air movement |
| . | | | | | | | | | |

| B | Qi | u | u | x | Ca | | | | |
|---|------------------|---------------|---------------|---------------|-----------------------|----------------------|--------------|-----------------------|--|
| B | Source Virus/min | Wind Miles/Hr | Wind Feet/Min | Distance Feet | Destination Virus/min | Time to Reach Qi Min | Risk | Location | Scenarios |
| 1 | 1200 | 0.01136 | 1 | 1 | 1200.00 | 1 | Unacceptable | Outside No Wind, Tent | Free space no air movement, Equation check |
| 1 | 1200 | 0.01136 | 1 | 6 | 33.33 | 36 | Unacceptable | Outside No Wind, Tent | Free space no air movement |
| 1 | 1200 | 0.01136 | 1 | 16 | 4.69 | 256 | High | Outside No Wind | Free space no air movement |

* Wind speed used in the design of a classroom

This analysis shows that **Inside Locations are Unacceptable**. This is obvious to engineers that are used to dealing with relationships like power density and air friction. It is not obvious to others and that is a serious issue. The relationship is clear, because there is no wind and no place for the virus to diffuse, the virus will settle in the environment. This analysis also shows that certain outdoor scenarios and locations are just as dangerous as indoor settings. This table has 12 scenarios and only 2 scenarios have Low Risk. There are 6 scenarios out of 12 that are Unacceptable.

Virus Density by Volume and Air Mixing (Engineering)

The next analysis shows the effects of mixing the virus in the indoor space and then exchanging the air. This strategy significantly changes the results and shows a path towards establishing safe indoor spaces. In this analysis there is a mechanism that is able to distribute the virus evenly throughout the room before anyone next to the infected person can get a whiff of the virus load. For example, fans are used to distribute the virus fully every minute. The next step is to determine how long it will take for the entire room to reach the virus load. So an infected person breathing 20 viruses per breath, taking 1 breath per second will produce 1200 virus particles around their head (about 1 cu-ft) in one minute. If the room is 10,800 cu-ft, it will take 9,000 minutes for the entire room space to be filled with 1000 virus particles for each cu-ft in the room. If the room is able to constantly distribute the virus and then change the room air with clean air then infection will be prevented. In the case of breathing and a cough the analysis suggests that even a very small AUC will have very low risk of infection. In the case of a sneeze the air must be fully exchanged with an AUC of 14.81. The challenge with this model is to ensure that the air in the room is constantly moving and random so that the virus is evenly diluted before being expelled from the room. Although this analysis is deterministic

and based on simple math the real world scenario and results will be less optimistic. An alternative analysis based on the Well-Riley equation is more representative of what is observed in real world settings.

This mental model of an infection cloud building up around an infected person is important and should be considered in all analysis checks. In 1 minute the cloud is relatively small. A male exhales 6 liters per breath or about .21 cu-ft per breath. In 5 seconds that is about 1 cu-ft. In 50 seconds that is about 10 cu-ft. Some of the virus particles will fall to the ground and some will stay in the air. As time moves on the virus cloud grows first placing individuals near the infected person at risk and then eventually those farther away from the infected person are at risk as time moves on. This is common sense and intuitive. [[spreadsheet](#) Diffusion]

Table 59 - Indoor Space With Massive Air Mixing

| Source Virus/min Per Cubic-Ft | L | W | H | Cubic-Ft | Virus/Cubic-ft per min | Time to Reach V=1000 Min | Req'd ACH With Massive Air Mixing for uniform Virus Distribution | Risk | Location | Scenarios |
|-------------------------------|-----|-----|----|----------|------------------------|--------------------------|--|------------------|---|-----------------------------------|
| 1,200 | 30 | 30 | 12 | 10,800 | 0.11 | 9,000 | 0.01 | Virtually none * | Classroom, restaurant, office, small shop | Breathing |
| 720 | 30 | 30 | 12 | 10,800 | 0.07 | 15,000 | 0.00 | Virtually none * | Classroom, restaurant, office, small shop | Cough 6/hr 80% Droplet Infection |
| 2,666,667 ** | 30 | 30 | 12 | 10,800 | 246.91 | 4 | 14.81 ** | Low * | Classroom, restaurant, office, small shop | Sneeze 1/hr 80% Droplet Infection |
| . | | | | | | | | | | |
| 1,200 | 100 | 100 | 40 | 400,000 | 0.00 | 333,333 | 0.00 | Virtually none | Grocery store, big box store, garage, warehouse | Breathing |
| 720 | 100 | 100 | 40 | 400,000 | 0.00 | 555,556 | 0.00 | Virtually none | Grocery store, big box store, garage, warehouse | Cough 6/hr 80% Droplet Infection |
| 2,666,667 | 100 | 100 | 40 | 400,000 | 6.67 | 150 | 0.40 | Virtually none | Grocery store, big box store, garage, warehouse | Sneeze 1/hr 80% Droplet Infection |

* Note that the Wells-Riley equation suggests that the risks are very high. This analysis is provided further in the document.

** AUC used in the design of a classroom

To not lose the perspective of the effects of air mixing the following table shows the results when there is no air mixing. The size of the space becomes irrelevant. What matters is the distance between the infected and uninfected people. The table shows that all the scenarios become unacceptable because of the massive AUC levels that are needed to mitigate the virus exposure. [[spreadsheet](#) Diffusion]

Table 60 - Indoor Space With No Air Mixing

| Source Virus/min Per Cubic-Ft | L | W | H | Cubic-Ft | Virus/Cubic-ft per min | Time to Reach V=1000 Min | Req'd ACH With NO Air Mixing for uniform Virus Distribution | Risk | Location | Scenarios |
|-------------------------------|-----|-----|----|----------|------------------------|--------------------------|---|--------------|---|-----------------------------------|
| 1,200 | 30 | 30 | 12 | 10,800 | 1,200 | 0.83 | 72 | Unacceptable | Classroom, restaurant, office, small shop | Breathing |
| 720 | 30 | 30 | 12 | 10,800 | 720 | 1.39 | 43 | Unacceptable | Classroom, restaurant, office, small shop | Cough 6/hr 80% Droplet Infection |
| 2,666,667 | 30 | 30 | 12 | 10,800 | 2,666,667 | 0.00 | 160,000 | Unacceptable | Classroom, restaurant, office, small shop | Sneeze 1/hr 80% Droplet Infection |
| . | | | | | | | | | | |
| 1,200 | 100 | 100 | 40 | 400,000 | 1,200 | 0.83 | 72 | Unacceptable | Grocery store, big box store, garage, warehouse | Breathing |
| 720 | 100 | 100 | 40 | 400,000 | 720 | 1.39 | 43 | Unacceptable | Grocery store, big box store, garage, warehouse | Cough 6/hr 80% Droplet Infection |
| 2,666,667 | 100 | 100 | 40 | 400,000 | 2,666,667 | 0.00 | 160,000 | Unacceptable | Grocery store, big box store, garage, warehouse | Sneeze 1/hr 80% Droplet Infection |

Virus Density by Mask Filtering Levels (Engineering)

The following analysis shows that masks provide significant reduction in the virus counts but they must be coupled with social distancing and indoor settings that condition the air to minimize the amount of the virus.

This table shows the mask with No social distancing scenarios. [[spreadsheet](#) Diffusion]

Table 61 - Indoor Mask Effects No Social Distancing No Ventilation

| Source Virus/min Per Cubic-Ft | Mask Person 1 | Mask Person 2 | Filter Effect | Virus/Cubic-ft per min | Time to Reach V=1000 Min | Risk * | Scenarios |
|-------------------------------|---------------|---------------|---------------|------------------------|--------------------------|--------------|----------------------------------|
| 1200 | 0.25 | 1 | 0.25 | 300 | 3 | Unacceptable | 1 Mask filter effectiveness 75% |
| 1200 | 0.25 | 0.25 | 0.0625 | 75 | 13 | Unacceptable | 2 Masks filter effectiveness 75% |
| 1200 | 0.1 | 1 | 0.1 | 120 | 8 | Unacceptable | 1 Mask filter effectiveness 90% |
| 1200 | 0.1 | 0.1 | 0.01 | 12 | 83 | Unacceptable | 2 Masks filter effectiveness 90% |
| 1200 | 0.01 | 1 | 0.01 | 12 | 83 | Unacceptable | 1 Mask filter effectiveness 99% |
| 1200 | 0.01 | 0.1 | 0.001 | 1.2 | 833 | Low | 2 Masks filter effectiveness 99% |

* Does not include the effects of social distancing. Social distancing effects are found in the particle dispersion model and the density model.

Virus Density by Distance and Mask Filtering Levels (Engineering)

This analysis shows the mask with indoor social distancing scenarios. The virus density model is used because it is indoors with no natural wind and unknown ventilation characteristics. The ventilation is assumed to be off. Distance is the only variable that is considered. In this analysis we see that distance reduces the virus density more than the masks in Virus Density by Mask Filtering Levels analysis. Even when masks are worn it is critical to maintain social distance. [[spreadsheet](#) Diffusion]

Table 62 - Indoor Mask Effects With Social Distancing No Ventilation

| Source Virus/min Per Cubic-Ft | Indoor Distance Feet | Destination Virus/min | Mask Filter Effect | Destination Virus/min With Mask | Time to Reach V=1000 Min | Risk Ventilation Assumed to be Off | Scenarios |
|-------------------------------|----------------------|-----------------------|--------------------|---------------------------------|--------------------------|------------------------------------|----------------|
| 1200 | 6 | 33.33 | 0.25 | 8.33 | 120 | This is why | Indoor, 1 Mask |

| Source Virus/min Per Cubic-Ft | Indoor Distance Feet | Destination Virus/min | Mask Filter Effect | Destination Virus/min With Mask | Time to Reach V=1000 Min | Risk Ventilation Assumed to be Off | Scenarios |
|-------------------------------|----------------------|-----------------------|--------------------|---------------------------------|--------------------------|------------------------------------|--|
| | | | | | | outdoors is good | filter effectiveness 75% |
| 1200 | 6 | 33.33 | 0.0625 | 2.08 | 480 | Med | Indoor, 2 Masks filter effectiveness 75% |
| 1200 | 6 | 33.33 | 0.1 | 3.33 | 300 | This is why outdoors is good | Indoor, 1 Mask filter effectiveness 90% |
| 1200 | 6 | 33.33 | 0.01 | 0.33 | 3000 | Low | Indoor, 2 Masks filter effectiveness 90% |
| 1200 | 6 | 33.33 | 0.01 | 0.33 | 3000 | Low | Indoor, 1 Mask filter effectiveness 99% |
| 1200 | 6 | 33.33 | 0.001 | 0.03 | 30000 | Virtually None | Indoor, 2 Masks filter effectiveness 99% |

Unfortunately this table suggests that indoor ventilation must be properly engineered to reduce the virus exposure rate.

Just like the masks reduce the level of virus exposure, the design of the ventilation also reduces the level of virus exposure. The amount of virus exposure reduction is significant:

1. Ventilation Filter Effect = 0.000092593 for a 10,800 cu-ft room (1/10,800)
2. Ventilation Filter Effect = 0.000002500 for a 400,000 cu-ft room (1/400,000)

The use of a mask is for scenarios where the ventilation in an indoor space is not working and is unsafe or is unable to keep up with the virus load and provide a safe environment.

To summarize the results of this analysis:

- Free space in settings like a beach or a park with air movement and minimal crowds practicing social distancing is low risk
- Indoor spaces are only low risk with massive air dilution, supported with air exchange, and the use of masks

- The only way the masks can go away is if the air dilution and replacement is consistent - Safe Outdoor Setting made Indoors

NIST FaTIMA

This analysis is based on a modeling tool available from the National Institute Of Standards (NIST) - A Tool to Model the Fate and Transport of Indoor Microbiological Aerosols (FaTIMA). The tool allows the determination of the fate of indoor microbiological aerosols associated with ventilation, filtration, deposition, and inactivation mechanisms. It provides a representation of a single, well-mixed zone that is served by a mechanical ventilation system and uses source and removal mechanisms for an aerosol with a single, user-defined representative particle size. The simple mechanical ventilation system model allows specification of supply, return, and outdoor air intake rates to represent either a positive, negative or balanced ventilation system. Aerosol sources are provided to enable any combination of continuous, e.g., breathing-related emissions, or intermittent, e.g., coughing-related emissions. Aerosol removal mechanisms include filters within the ventilation system, room air cleaners, and deposition onto floors, walls, and ceilings. Simulations can be run for a 24-h period, with the results including the time history of the airborne concentration and surface loading, as well as integrated exposure of an occupant. Exposure is based on a uniform aerosol concentration within the zone and does not account for spatial differences in aerosol concentrations such as those due to momentum effects of respiratory emissions [2]. The equation is:

$$(1) V(dCz/dt) = PQinfCoa(t) + QsCs(t) + G(t) - (Qr + Qix + MacQac)Cz(t) - \text{Sum [(i=1 to Ns) VdiAsiCz(t)]}$$

$$(2) Asi(dLsi/dt) = VdiAsiCz(t)$$

C = particle concentration in air [kg/m³], subscripts: zone, outdoor air, and supply

Q = volumetric airflow rate [m³/s], subscripts: supply, return, infiltration, air cleaner, and local exhaust

Lsi = surface loading for surface i [kg/m²]

V = zone volume [m³]

Asi = deposition surface area for surface i [m²]

Vdi = particle deposition velocity for surface i [m/s] (Vdi = kd V /As)

Ns = number of surfaces (floor, walls, and ceiling)

Mac = particle filtration efficiency of air cleaner [-]

kd = particle deposition rate [1/s]

G = particle generation rate [kg/s]

P = particle penetration factor [-]

t = time [s]

This model is available online at: <https://pages.nist.gov/CONTAM-apps/webapps/FaTIMA/index.html>, July 2020. [FaTIMA](#). This analysis was not expanded because it uses specific design parameters. As building ventilation is checked and modified, this and similar models should be used to understand the virus behavior.

Wells-Riley Equation

This model is based on the Wells-Riley equation which provides a probability of infection. The Wells–Riley equation provides the probability of airborne infection risk as a function of ventilation rate. The key concept is that the higher the ventilation rate, the more rapid the decay of particles (droplet nuclei) in the room air. According to the Wells–Riley equation, the probability of infection from droplet nuclei is inversely related to the ventilation rate. The parameters used in the Wells–Riley equation include ventilation rate, generation of infection droplet nuclei from the source, and the duration of exposure. This model is expanded to show the resulting AUC level in the modeled space, the actual affected US population counts, categories of ventilation, the role of masks, and scenarios.

Wells-Riley Summary

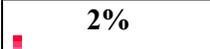
The following is a summary of the Wells-Riley equation applied to different living scenarios. We see that small indoor spaces have extremely high levels of probability of infection. We also see that it is unrealistic for someone to wear a mask constantly and that there will be times when the mask must come off to deal with real world life situations. During these times, when in small indoor spaces, there will be infection. We also see that living outside shows very low probability of infection. [[spreadsheet](#) Probability]

In the school scenario when the children are infected they bring it home. Basically when they go to school everyone goes to school. The same applies for any of the other scenarios.

Low income populations are affected more by COVID-19 and the suggestions are high risk working conditions and more underlying health issues [3]. However there also may be connections to the huge risks of small indoor spaces at work and at home. In the home, there may be more people living in the same house because of the high cost of housing. So when one person gets infected in a 3 person house the result is very different than in a house with 6, 7, 8, 9, 10 people where children, parents, grandparents, and even aunts, uncles, nieces and nephews may live. Expecting people at home to wear masks 100% of the time is unreasonable. Knowing how to reduce or eliminate the risk of infection in these settings with proper ventilation is critical. Opening the windows and installing attic fans seems like such a simple solution yet there is no detailed guidance other than to just open the windows.

The outside beach park scenarios show relatively low probability of infection. This assumes only 1 infection source. As the number of infected people increase over time the number in these settings will increase. One approach is to assume social distance practices and then assume a certain percentage of the population is infected. The square footage of the social distance divided into the scenario square footage will provide the number of people in the environment. The percentage of infected population will then provide the number of Infectors. The impact is approximately linear. With a 10% infected population the social distance will need to increase to 16 feet to keep the same levels of relatively low probability of infection for the outside beach park scenarios. It is also interesting to see that as the outside venue increases in size there is a larger impact on the number of infectors. This may not be appropriate because it is unlikely the virus will travel such long distances without be completely diluted.

Table 63 - Wells-Riley Equation Scenarios Summary

| time hour | Masks | P | Chance of Infection | Space cu-ft | AUC | Population | Infected | Deaths | Ventilation | Scenario |
|-----------|-------------------------|-----------|--|-------------|---------------------------------|-------------|-------------|------------|-----------------|---|
| 1 | Yes | 0.0449626 | 4%  | 10,800 | 4.00 | 328,000,000 | 14,747,747 | 516,171 | Expected | Small indoor space Small Restaurant Not sure how to eat with a mask |
| 1 | No | 0.7194023 | 72%  | 10,800 | 4.00 | 328,000,000 | 235,963,957 | 8,258,738 | Expected | Small indoor space Small Restaurant Reality no mask while eating |
| 8 | Yes | 0.0624976 | 6%  | 10,800 | 4.00 | 328,000,000 | 20,499,212 | 717,472 | Expected | Small indoor space Best case school & work Setting |
| 1 | Yes | 0.0021082 | ~ 0%  | 400,000 | 4.00 | 328,000,000 | 691,475 | 24,202 | Expected | Large indoor space Shopping |
| 8 | Yes | 0.0150030 | 2%  | 400,000 | 4.00 | 328,000,000 | 4,920,984 | 172,234 | Expected | Large indoor space Retail Work |
| 1 | Yes but 1 hour mask off | 0.9938008 | 99%  | 10,800 | 1.00 | 328,000,000 | 325,966,659 | 11,408,833 | Poor | Small indoor space School Setting Small Restaurant |
| 1 | Yes but 1 hour mask off | 0.7194023 | 72%  | 10,800 | 4.00 | 328,000,000 | 235,963,957 | 8,258,738 | Expected | Small indoor space School Setting |
| 1 | Yes but 1 hour mask off | 0.1193397 | 12%  | 10,800 | 40.00 Open windows with fans | 328,000,000 | 39,143,428 | 1,370,020 | Massive Natural | Small indoor space School Setting |

| time hour | Masks | P | Chance of Infection | Space cu-ft | AUC | Population | Infected | Deaths | Ventilation | Scenario |
|-----------|-------|-----------|---------------------|-------------|-------|-------------|-----------|--------|------------------|----------------------------------|
| 1 | No | 0.0056322 | 1% | 10,800 | 3600 | 328,000,000 | 1,915,155 | 67,030 | wind 1 mile / hr | Outside small enclosed back yard |
| 1 | No | 0.0011290 | 0.11% | 10,800 | 18000 | 328,000,000 | 370,309 | 12,961 | wind 5 mile / hr | Outside small enclosed back yard |
| 1 | No | 0.0001525 | 0.02% | 400,000 | 3600 | 328,000,000 | 50,016 | 1,751 | wind 1 mile / hr | Outside beach park |
| 1 | No | 0.0000305 | 0.00% | 400,000 | 18000 | 328,000,000 | 10,004 | 350 | wind 5 mile / hr | Outside beach park |
| 1 | No | 0.0000152 | 0.00% | 4,000,000 | 3600 | 328,000,000 | 5,002 | 175 | wind 1 mile / hr | Outside large beach park |
| 1 | No | 0.0000030 | 0.00% | 4,000,000 | 18000 | 328,000,000 | 1,000 | 35 | wind 5 mile / hr | Outside large beach park |

Wells-Riley equation:

$$P = D/S = 1 - \exp(-I p q t / Q)$$

P = probability of infection for susceptibles

D = number of disease cases

S = number of susceptibles

I = number of infectors

p = breathing rate per person (m³/s)

q = quantum generation rate by an infected person (quanta/s)

t = total exposure time (s)

Q = outdoor air supply rate (m³/s)

Q = Space Cubic Feet * AUC

quanta = virus

$$\text{Infection Load} * \text{Virus} / \text{Breath} * \text{Breaths} / \text{Sec} * \text{Sec to Infection} = q / \text{sec}$$

$$1000 * 20 * 1 * 50 = 0.0200$$

L x W x H = cu-ft:

$$30 * 30 * 12 = 10,800$$

$$100 * 100 * 40 = 400,000$$

$$1000 * 100 * 40 = 4,000,000$$

| Social Distance feet | Space sq-ft | Parties | Infected | I |
|----------------------|-------------|---------|----------|-----|
| 6 | 900 | 25 | 10% | 3 |
| 6 | 10,000 | 278 | 10% | 28 |
| 6 | 100,000 | 2,778 | 10% | 278 |
| . | | | | |
| 16 | 900 | 4 | 10% | 0.4 |
| 16 | 10,000 | 39 | 10% | 4 |
| 16 | 100,000 | 391 | 10% | 3 |

Wells-Riley Details Indoors

There has been evidence that our buildings have been spreading illness for decades after the energy crisis when the building ventilation systems reduced the ventilation rates to save on energy costs [4]. Fortunately there were few life threatening diseases that were partially airborne. People would get sick with the flu or the cold and just complain about the poor air in buildings. Now there is a virus that kills so it is now clear that the ventilation systems of small spaces must be modified to allow for a reasonable return to life. It is also clear the large indoor spaces should also have their ventilation systems modified even though the risk of infection is much lower. The following table shows various indoor scenarios and contrasts them with the outside scenarios. [[spreadsheet](#) Probability]

Table 64 - Wells-Riley Equation Scenarios Details Indoors

| I | p cu-in/sec | q / sec | time hour | lpqt | Q cu-in/sec | 2 Masks @ 75% | Masks | P | Chance of Infection | Q cu-ft/hr | Space cu-ft | AUC | Population | Infected | death rate | Deaths | Ventilation | Scenario |
|---|-------------|---------|-----------|--------|-------------|---------------|-------|-----------|---------------------|------------|-------------|-----|-------------|------------|------------|---------|-------------|--------------------|
| 2 | 366 | 0.0200 | 1 | 52,704 | 5,184 | 0.0625 | Yes | 0.0624976 | 6% | 10,800 | 10,800 | 1 | 328,000,000 | 20,499,212 | 0.035 | 717,472 | Poor | Small indoor space |

| I | p cu-in/sec | q / sec | time hour | lpqt | Q cu-in/sec | 2 Masks @ 75% | Masks | P | Chance of Infection | Q cu-ft/hr | Space cu-ft | AUC | Population | Infected | death rate | Deaths | Ventilation | Scenario |
|---|-------------|---------|-----------|--------|-------------|---------------|-------|-----------|---------------------|------------|-------------|-----|-------------|-------------|------------|-----------|-----------------|---|
| 1 | 366 | 0.0200 | 1 | 26,352 | 5,184 | 0.0625 | Yes | 0.0621125 | 6% | 10,800 | 10,800 | 1 | 328,000,000 | 20,372,916 | 0.035 | 713,052 | Poor | Small indoor space |
| 1 | 366 | 0.0200 | 1 | 26,352 | 20,736 | 0.0625 | Yes | 0.0449626 | 4% | 43,200 | 10,800 | 4 | 328,000,000 | 14,747,747 | 0.035 | 516,171 | Expected | Small indoor space Small Restaurant Not sure how to eat with a mask |
| 1 | 366 | 0.0200 | 1 | 26,352 | 20,736 | no mask | No | 0.7194023 | 72% | 43,200 | 10,800 | 4 | 328,000,000 | 235,963,957 | 0.035 | 8,258,738 | Expected | Small indoor space Small Restaurant Reality no mask while eating |
| 1 | 366 | 0.0200 | 1 | 26,352 | 51,840 | 0.0625 | Yes | 0.0249064 | 2% | 108,000 | 10,800 | 10 | 328,000,000 | 8,169,307 | 0.035 | 285,926 | Rare | Small indoor space |
| 1 | 366 | 0.0200 | 1 | 26,352 | 207,360 | 0.0625 | Yes | 0.0074587 | 1% | 432,000 | 10,800 | 40 | 328,000,000 | 2,446,464 | 0.035 | 85,626 | Massive Natural | Small indoor space |
| . | | | | | | | | | | | | | | | | | | |
| 2 | 366 | 0.0200 | 1 | 52,704 | 192,000 | 0.0625 | Yes | 0.0150030 | 2% | 400,000 | 400,000 | 1 | 328,000,000 | 4,920,984 | 0.035 | 172,234 | Poor | Large indoor space |
| 1 | 366 | 0.0200 | 1 | 26,352 | 192,000 | 0.0625 | Yes | 0.0080155 | 1% | 400,000 | 400,000 | 1 | 328,000,000 | 2,629,079 | 0.035 | 92,018 | Poor | Large indoor space |
| 1 | 366 | 0.0200 | 1 | 26,352 | 768,000 | 0.0625 | Yes | 0.0021082 | 0% | 1,600,000 | 400,000 | 4 | 328,000,000 | 691,475 | 0.035 | 24,202 | Expected | Large indoor space |

| I | p cu-in/sec | q / sec | time hour | lpqt | Q cu-in/sec | 2 Masks @ 75% | Masks | P | Chance of Infection | Q cu-ft/hr | Space cu-ft | AUC | Population | Infected | death rate | Deaths | Ventilation | Scenario | |
|---|-------------|---------|-----------|---------|-------------|------------------|----------------|-----------|---------------------|------------|-------------|-----|-------------|-------------|------------|------------|-----------------|--|--|
| 1 | 366 | 0.0200 | 1 | 26,352 | 1,920,000 | 0.0625 | Yes | 0.0008520 | 0% | 4,000,000 | 400,000 | 10 | 328,000,000 | 279,440 | 0.035 | 9,780 | Rare | Large indoor space | |
| 1 | 366 | 0.0200 | 1 | 26,352 | 7,680,000 | 0.0625 | Yes | 0.0002141 | 0% | 16,000,000 | 400,000 | 40 | 328,000,000 | 70,220 | 0.035 | 2,458 | Massive Natural | Large indoor space | |
| . | | | | | | | | | | | | | | | | | | | |
| 1 | 366 | 0.0200 | 1 | 26,352 | 5,184 | 0.0625 | Yes | 0.0621125 | 6% | 10,800 | 10,800 | 1 | 328,000,000 | 20,372,916 | 0.035 | 713,052 | Poor | Small indoor space | |
| 1 | 366 | 0.0200 | 1 | 26,352 | 20,736 | 0.0625 | Yes | 0.0449626 | 4% | 43,200 | 10,800 | 4 | 328,000,000 | 14,747,747 | 0.035 | 516,171 | Expected | Small indoor space | |
| 1 | 366 | 0.0200 | 8 | 210,816 | 20,736 | 0.0625 | Yes | 0.0624976 | 6% | 43,200 | 10,800 | 4 | 328,000,000 | 20,499,212 | 0.035 | 717,472 | Expected | Small indoor space Best case school & work Setting | |
| . | | | | | | | | | | | | | | | | | | | |
| 1 | 366 | 0.0200 | 1 | 26,352 | 192,000 | 0.0625 | Yes | 0.0080155 | 1% | 400,000 | 400,000 | 1 | 328,000,000 | 2,629,079 | 0.035 | 92,018 | Poor | Large indoor space | |
| 1 | 366 | 0.0200 | 1 | 26,352 | 768,000 | 0.0625 | Yes | 0.0021082 | 0% | 1,600,000 | 400,000 | 4 | 328,000,000 | 691,475 | 0.035 | 24,202 | Expected | Large indoor space Shopping | |
| 1 | 366 | 0.0200 | 8 | 210,816 | 768,000 | 0.0625 | Yes | 0.0150030 | 2% | 1,600,000 | 400,000 | 4 | 328,000,000 | 4,920,984 | 0.035 | 172,234 | Expected | Large indoor space Retail Work | |
| . | | | | | | | | | | | | | | | | | | | |
| 1 | 366 | 0.0200 | 1 | 26,352 | 5,184 | mask failures in | Yes but 1 hour | 0.9938008 | 99% | 10,800 | 10,800 | 1 | 328,000,000 | 325,966,659 | 0.035 | 11,408,833 | Poor | Small indoor space | |

| I | p cu-in/sec | q / sec | time hour | lpqt | Q cu-in/sec | 2 Masks @ 75% | Masks | P | Chance of Infection | Q cu-ft/hr | Space cu-ft | AUC | Population | Infected | death rate | Deaths | Ventilation | Scenario |
|---|-------------|---------|-----------|---------|-------------|-------------------------|-------------------------|-----------|---------------------|------------|-------------|-----|-------------|-------------|------------|------------|-----------------|--------------------------------------|
| | | | | | | school | mask off | | | | | | | | | | | School Setting Small Restaurant |
| 1 | 366 | 0.0200 | 1 | 26,352 | 20,736 | mask failures in school | Yes but 1 hour mask off | 0.7194023 | 72% | 43,200 | 10,800 | 4 | 328,000,000 | 235,963,957 | 0.035 | 8,258,738 | Expected | Small indoor space School Setting |
| 1 | 366 | 0.0200 | 1 | 26,352 | 207,360 | mask failures in school | Yes but 1 hour mask off | 0.1193397 | 12% | 432,000 | 10,800 | 40 | 328,000,000 | 39,143,428 | 0.035 | 1,370,020 | Massive Natural | Small indoor space School Setting |
| 1 | 366 | 0.0200 | 8 | 210,816 | 20,736 | no mask | No | 0.9999616 | 100% | 43,200 | 10,800 | 4 | 328,000,000 | 327,987,395 | 0.035 | 11,479,559 | Expected | Small indoor space |
| 1 | 366 | 0.0200 | 8 | 210,816 | 207,360 | no mask | No | 0.6382011 | 64% | 432,000 | 10,800 | 40 | 328,000,000 | 209,329,951 | 0.035 | 7,326,548 | Massive Natural | Small indoor space |
| | | | | | | | | | | | | | | | | | | |
| 1 | 366 | 0.0200 | 1 | 26,352 | 192,000 | no mask | No | 0.1282477 | 13% | 400,000 | 400,000 | 1 | 328,000,000 | 42,065,258 | 0.035 | 1,472,284 | Poor | Large indoor space |
| 1 | 366 | 0.0200 | 1 | 26,352 | 768,000 | no mask | No | 0.0337305 | 3% | 1,600,000 | 400,000 | 4 | 328,000,000 | 11,063,605 | 0.035 | 387,226 | Expected | Large indoor space |
| 1 | 366 | 0.0200 | 1 | 26,352 | 7,680,000 | no mask | No | 0.0034254 | 0.34% | 16,000,000 | 400,000 | 40 | 328,000,000 | 1,123,521 | 0.035 | 39,323 | Massive Natural | Large indoor space |
| 1 | 366 | 0.0200 | 8 | 210,816 | 768,000 | no mask | No | 0.2400480 | 24% | 1,600,000 | 400,000 | 4 | 328,000,000 | 78,735,743 | 0.035 | 2,755,751 | Expected | Large indoor space |
| 1 | 366 | 0.0200 | 8 | 210,816 | 7,680,000 | no mask | No | 0.0270767 | 3% | 16,000,000 | 400,000 | 40 | 328,000,000 | 8,881,149 | 0.035 | 310,840 | Massive Natural | Large indoor |

| I | p cu-in/sec | q / sec | time hour | lpqt | Q cu-in/sec | 2 Masks @ 75% | Masks | P | Chance of Infection | Q cu-ft/hr | Space cu-ft | AUC | Population | Infected | death rate | Deaths | Ventilation | Scenario |
|---|-------------|---------|-----------|---------|----------------|---------------|-------|-----------|---------------------|----------------|-------------|-------|-------------|-----------|------------|--------|------------------|----------------------------------|
| | | | | | | | | | | | | | | | | | | space |
| 1 | 366 | 0.0200 | 4 | 105,408 | 18,662,400 | no mask | No | 0.0056322 | 1% | 38,880,000 | 10,800 | 3600 | 328,000,000 | 1,847,371 | 0.035 | 64,658 | wind 1 mile / hr | Outside small enclosed back yard |
| 1 | 366 | 0.0200 | 4 | 105,408 | 93,312,000 | no mask | No | 0.0011290 | 0.11% | 194,400,000 | 10,800 | 18000 | 328,000,000 | 370,309 | 0.035 | 12,961 | wind 5 mile / hr | Outside small enclosed back yard |
| 1 | 366 | 0.0200 | 4 | 105,408 | 691,200,000 | no mask | No | 0.0001525 | 0.02% | 1,440,000,000 | 400,000 | 3600 | 328,000,000 | 50,016 | 0.035 | 1,751 | wind 1 mile / hr | Outside beach park |
| 1 | 366 | 0.0200 | 4 | 105,408 | 3,456,000,000 | no mask | No | 0.0000305 | 0.00% | 7,200,000,000 | 400,000 | 18000 | 328,000,000 | 10,004 | 0.035 | 350 | wind 5 mile / hr | Outside beach park |
| 1 | 366 | 0.0200 | 4 | 105,408 | 6,912,000,000 | no mask | No | 0.0000152 | 0.00% | 14,400,000,000 | 4,000,000 | 3600 | 328,000,000 | 5,002 | 0.035 | 175 | wind 1 mile / hr | Outside large beach park |
| 1 | 366 | 0.0200 | 4 | 105,408 | 34,560,000,000 | no mask | No | 0.0000030 | 0.00% | 72,000,000,000 | 4,000,000 | 18000 | 328,000,000 | 1,000 | 0.035 | 35 | wind 5 mile / hr | Outside large beach park |

Wells-Riley Details Outside

The following table shows the outside scenario with different levels of population infection and social distance. [[spreadsheet](#) Outside P]

Table 65 - Wells-Riley Equation Scenarios Details Outside

| Distance ft | Infected % | I | p cu-in/sec | q / sec | time hour | lpqt | Q cu-in/sec | 2 Masks @ 75% | P | Chance of Infection | Q cu-ft/hr | Space cu-ft | AUC | Population | Infected | death rate | Deaths | Ventilation |
|-------------|------------|---|-------------|---------|-----------|---------|-------------|---------------|-----------|---------------------|------------|-------------|------|-------------|-----------|------------|---------|------------------|
| 6 | 10% | 3 | 366 | 0.0200 | 4 | 263,520 | 18,662,400 | no mask | 0.0140211 | 1% | 38,880,000 | 10,800 | 3600 | 328,000,000 | 4,598,936 | 0.035 | 160,963 | wind 1 mile / hr |

| Distance ft | Infectd % | I | p cu-in/sec | q / sec | time hour | lpqt | Q cu-in/sec | 2 Masks @ 75% | P | Chance of Infection | Q cu-ft/hr | Space cu-ft | AUC | Population | Infected | death rate | Deaths | Ventilation |
|-------------|-----------|-----|-------------|---------|-----------|-------------|----------------|---------------|-----------|---------------------|----------------|-------------|-------|-------------|------------|------------|---------|------------------|
| 6 | 10% | 3 | 366 | 0.0200 | 4 | 263,520 | 93,312,000 | no mask | 0.0028201 | 0.28% | 194,400,000 | 10,800 | 18000 | 328,000,000 | 924,990 | 0.035 | 32,375 | wind 5 mile / hr |
| 6 | 10% | 28 | 366 | 0.0200 | 4 | 2,928,000 | 691,200,000 | no mask | 0.0042272 | 0.42% | 1,440,000,000 | 400,000 | 3600 | 328,000,000 | 1,386,506 | 0.035 | 48,528 | wind 1 mile / hr |
| 6 | 10% | 28 | 366 | 0.0200 | 4 | 2,928,000 | 3,456,000,000 | no mask | 0.0008469 | 0.08% | 7,200,000,000 | 400,000 | 18000 | 328,000,000 | 277,771 | 0.035 | 9,722 | wind 5 mile / hr |
| 6 | 10% | 278 | 366 | 0.0200 | 4 | 29,280,000 | 6,912,000,000 | no mask | 0.0042272 | 0.42% | 14,400,000,000 | 4,000,000 | 3600 | 328,000,000 | 1,386,506 | 0.035 | 48,528 | wind 1 mile / hr |
| 6 | 10% | 278 | 366 | 0.0200 | 4 | 29,280,000 | 34,560,000,000 | no mask | 0.0008469 | 0.08% | 72,000,000,000 | 4,000,000 | 18000 | 328,000,000 | 277,771 | 0.035 | 9,722 | wind 5 mile / hr |
| . | | | | | | | | | | | | | | | | | | |
| 12 | 10% | 1 | 366 | 0.0200 | 4 | 65,880 | 18,662,400 | no mask | 0.0035239 | 0.35% | 38,880,000 | 10,800 | 3600 | 328,000,000 | 1,155,829 | 0.035 | 40,454 | wind 1 mile / hr |
| 12 | 10% | 1 | 366 | 0.0200 | 4 | 65,880 | 93,312,000 | no mask | 0.0007058 | 0.07% | 194,400,000 | 10,800 | 18000 | 328,000,000 | 231,492 | 0.035 | 8,102 | wind 5 mile / hr |
| 12 | 10% | 7 | 366 | 0.0200 | 4 | 732,000 | 691,200,000 | no mask | 0.0010585 | 0.11% | 1,440,000,000 | 400,000 | 3600 | 328,000,000 | 347,177 | 0.035 | 12,151 | wind 1 mile / hr |
| 12 | 10% | 7 | 366 | 0.0200 | 4 | 732,000 | 3,456,000,000 | no mask | 0.0002118 | 0.02% | 7,200,000,000 | 400,000 | 18000 | 328,000,000 | 69,465 | 0.035 | 2,431 | wind 5 mile / hr |
| 12 | 10% | 69 | 366 | 0.0200 | 4 | 7,320,000 | 6,912,000,000 | no mask | 0.0010585 | 0.11% | 14,400,000,000 | 4,000,000 | 3600 | 328,000,000 | 347,177 | 0.035 | 12,151 | wind 1 mile / hr |
| 12 | 10% | 69 | 366 | 0.0200 | 4 | 7,320,000 | 34,560,000,000 | no mask | 0.0002118 | 0.02% | 72,000,000,000 | 4,000,000 | 18000 | 328,000,000 | 69,465 | 0.035 | 2,431 | wind 5 mile / hr |
| . | | | | | | | | | | | | | | | | | | |
| 6 | 50% | 13 | 366 | 0.0200 | 4 | 1,317,600 | 18,662,400 | no mask | 0.0681672 | 7% | 38,880,000 | 10,800 | 3600 | 328,000,000 | 22,358,833 | 0.035 | 782,559 | wind 1 mile / hr |
| 6 | 50% | 13 | 366 | 0.0200 | 4 | 1,317,600 | 93,312,000 | no mask | 0.0140211 | 1.40% | 194,400,000 | 10,800 | 18000 | 328,000,000 | 4,598,936 | 0.035 | 160,963 | wind 5 mile / hr |
| 6 | 50% | 139 | 366 | 0.0200 | 4 | 14,640,000 | 691,200,000 | no mask | 0.0209578 | 2.10% | 1,440,000,000 | 400,000 | 3600 | 328,000,000 | 6,874,166 | 0.035 | 240,596 | wind 1 mile / hr |
| 6 | 50% | 139 | 366 | 0.0200 | 4 | 14,640,000 | 3,456,000,000 | no mask | 0.0042272 | 0.42% | 7,200,000,000 | 400,000 | 18000 | 328,000,000 | 1,386,506 | 0.035 | 48,528 | wind 5 mile / hr |
| 6 | 50% | 138 | 366 | 0.0200 | 4 | 146,400,000 | 6,912,000,000 | no | 0.020957 | 2.10% | 14,400,000,000 | 4,000,000 | 3600 | 328,000,000 | 6,874,166 | 0.035 | 240,596 | wind 1 |

| Distance ft | Infectd % | I | p cu-in/sec | q / sec | time hour | lpqt | Q cu-in/sec | 2 Masks @ 75% | P | Chance of Infection | Q cu-ft/hr | Space cu-ft | AUC | Population | Infected | death rate | Deaths | Ventilation |
|-------------|-----------|------|-------------|---------|-----------|-------------|----------------|---------------|-----------|---------------------|----------------|-------------|-------|-------------|------------|------------|-----------|------------------|
| | | 9 | | 0 | | 0 | | mask | 8 | | 0 | 0 | | 0 | | | | mile / hr |
| 6 | 50% | 1389 | 366 | 0.0200 | 4 | 146,400,000 | 34,560,000,000 | no mask | 0.0042272 | 0.42% | 72,000,000,000 | 4,000,000 | 18000 | 328,000,000 | 1,386,506 | 0.035 | 48,528 | wind 5 mile / hr |
| | | | | | | | | | | | | | | | | | | |
| 12 | 50% | 3 | 366 | 0.0200 | 4 | 329,400 | 18,662,400 | no mask | 0.0174956 | 1.75% | 38,880,000 | 10,800 | 3600 | 328,000,000 | 5,738,559 | 0.035 | 200,850 | wind 1 mile / hr |
| 12 | 50% | 3 | 366 | 0.0200 | 4 | 329,400 | 93,312,000 | no mask | 0.0035239 | 0.35% | 194,400,000 | 10,800 | 18000 | 328,000,000 | 1,155,829 | 0.035 | 40,454 | wind 5 mile / hr |
| 12 | 50% | 35 | 366 | 0.0200 | 4 | 3,660,000 | 691,200,000 | no mask | 0.0052811 | 0.53% | 1,440,000,000 | 400,000 | 3600 | 328,000,000 | 1,732,215 | 0.035 | 60,628 | wind 1 mile / hr |
| 12 | 50% | 35 | 366 | 0.0200 | 4 | 3,660,000 | 3,456,000,000 | no mask | 0.0010585 | 0.11% | 7,200,000,000 | 400,000 | 18000 | 328,000,000 | 347,177 | 0.035 | 12,151 | wind 5 mile / hr |
| 12 | 50% | 347 | 366 | 0.0200 | 4 | 36,600,000 | 6,912,000,000 | no mask | 0.0052811 | 0.53% | 14,400,000,000 | 4,000,000 | 3600 | 328,000,000 | 1,732,215 | 0.035 | 60,628 | wind 1 mile / hr |
| 12 | 50% | 347 | 366 | 0.0200 | 4 | 36,600,000 | 34,560,000,000 | no mask | 0.0010585 | 0.11% | 72,000,000,000 | 4,000,000 | 18000 | 328,000,000 | 347,177 | 0.035 | 12,151 | wind 5 mile / hr |
| | | | | | | | | | | | | | | | | | | |
| 6 | 100% | 25 | 366 | 0.0200 | 4 | 2,635,200 | 18,662,400 | no mask | 0.1316876 | 13% | 38,880,000 | 10,800 | 3600 | 328,000,000 | 43,193,528 | 0.035 | 1,511,773 | wind 1 mile / hr |
| 6 | 100% | 25 | 366 | 0.0200 | 4 | 2,635,200 | 93,312,000 | no mask | 0.0278457 | 2.78% | 194,400,000 | 10,800 | 18000 | 328,000,000 | 9,133,389 | 0.035 | 319,669 | wind 5 mile / hr |
| 6 | 100% | 278 | 366 | 0.0200 | 4 | 29,280,000 | 691,200,000 | no mask | 0.0414764 | 4.15% | 1,440,000,000 | 400,000 | 3600 | 328,000,000 | 13,604,264 | 0.035 | 476,149 | wind 1 mile / hr |
| 6 | 100% | 278 | 366 | 0.0200 | 4 | 29,280,000 | 3,456,000,000 | no mask | 0.0084364 | 0.84% | 7,200,000,000 | 400,000 | 18000 | 328,000,000 | 2,767,150 | 0.035 | 96,850 | wind 5 mile / hr |
| 6 | 100% | 2778 | 366 | 0.0200 | 4 | 292,800,000 | 6,912,000,000 | no mask | 0.0414764 | 4.15% | 14,400,000,000 | 4,000,000 | 3600 | 328,000,000 | 13,604,264 | 0.035 | 476,149 | wind 1 mile / hr |
| 6 | 100% | 2778 | 366 | 0.0200 | 4 | 292,800,000 | 34,560,000,000 | no mask | 0.0084364 | 0.84% | 72,000,000,000 | 4,000,000 | 18000 | 328,000,000 | 2,767,150 | 0.035 | 96,850 | wind 5 mile / hr |
| | | | | | | | | | | | | | | | | | | |
| 12 | 100% | 6 | 366 | 0.0200 | 4 | 658,800 | 18,662,400 | no mask | 0.0346851 | 3.47% | 38,880,000 | 10,800 | 3600 | 328,000,000 | 11,376,718 | 0.035 | 398,185 | wind 1 mile / hr |
| 12 | 100% | 6 | 366 | 0.0200 | 4 | 658,800 | 93,312,000 | no | 0.007035 | 0.70% | 194,400,000 | 10,800 | 1800 | 328,000,000 | 2,307,585 | 0.035 | 80,765 | wind 5 |

| Distance ft | Infected % | I | p cu-in/sec | q / sec | time hour | lpqt | Q cu-in/sec | 2 Masks @ 75% | P | Chance of Infection | Q cu-ft/hr | Space cu-ft | AUC | Population | Infected | death rate | Deaths | Ventilation |
|-------------|------------|-----|-------------|---------|-----------|------------|----------------|---------------|-----------|---------------------|----------------|-------------|-------|-------------|-----------|------------|---------|------------------|
| | | | | 0 | | | | mask | 3 | | | | 0 | 0 | | | | mile / hr |
| 12 | 100% | 69 | 366 | 0.0200 | 4 | 7,320,000 | 691,200,000 | no mask | 0.0105344 | 1.05% | 1,440,000,000 | 400,000 | 3600 | 328,000,000 | 3,455,283 | 0.035 | 120,935 | wind 1 mile / hr |
| 12 | 100% | 69 | 366 | 0.0200 | 4 | 7,320,000 | 3,456,000,000 | no mask | 0.0021158 | 0.21% | 7,200,000,000 | 400,000 | 18000 | 328,000,000 | 693,987 | 0.035 | 24,290 | wind 5 mile / hr |
| 12 | 100% | 694 | 366 | 0.0200 | 4 | 73,200,000 | 6,912,000,000 | no mask | 0.0105344 | 1.05% | 14,400,000,000 | 4,000,000 | 3600 | 328,000,000 | 3,455,283 | 0.035 | 120,935 | wind 1 mile / hr |
| 12 | 100% | 694 | 366 | 0.0200 | 4 | 73,200,000 | 34,560,000,000 | no mask | 0.0021158 | 0.21% | 72,000,000,000 | 4,000,000 | 18000 | 328,000,000 | 693,987 | 0.035 | 24,290 | wind 5 mile / hr |

With an infected population level of more than 10% the social distance will need to increase to 12 feet to keep the same levels of relatively low probability of infection for the outside beach park scenarios. As the outside venue increases in size there is a larger number of infectors. Using this increase in the number of infectors may not be appropriate because it is unlikely the virus will travel such long distances without being completely diluted.

The outside numbers are very low for population infection levels of 10%.

As the population infection level reaches 100% it is possible that this model starts to break down because the numbers are still very low and this conflicts with this analysts mental model of the situation. The nuclear engineering model based on wind speed and distance with the B factor may be a better predictor of the outcome. See section [Virus Diffusion by Distance and Windspeed \(Nuclear Engineering\)](#).

Table 66 - Nuclear Engineering Model Outside Infection Scenarios

| B | Source Virus/min | Wind Miles/Hr | Wind Feet/Min | Distance Feet | Destination Virus/min | Time to Reach Qi Min | Risk | Location | Scenarios |
|-----------|------------------|---------------|---------------|---------------|-----------------------|----------------------|--------------|--------------|-----------------|
| 30 | 1200 | 1 | 88 | 1 | 409.09 | 3 | Unacceptable | Outside wall | Up against wall |
| 30 | 1200 | 1 | 88 | 6 | 11.36 | 106 | High | Outside wall | Up against wall |

| B | Source Virus/min | Wind Miles/Hr | Wind Feet/Min | Distance Feet | Destination Virus/min | Time to Reach Qi Min | Risk | Location | Scenarios |
|-----------|-------------------------|----------------------|----------------------|----------------------|------------------------------|-----------------------------|----------------------------|----------------------|--|
| 30 | 1200 | 1 | 88 | 16 | 1.60 | 751 | Low to Unacceptable | Outside wall | Up against wall, common sense needs to apply, if infection source is downwind then Risk = Unacceptable |
| . | | | | | | | | | |
| 1 | 1200 | 1 | 88 | 1 | 13.64 | 88 | High | Outside, Beach, Park | Free space air movement, at 1 foot this is really up against a wall and you are the wall |
| 1 | 1200 | 1 | 88 | 6 | 0.38 | 3168 | Low | Outside, Beach, Park | Free space air movement |
| 1 | 1200 | 1 | 88 | 16 | 0.05 | 22528 | Low | Outside, Beach, Park | Free space air movement |

Distance and virus load as set by **B** are key factors in driving the potential of virus infection. The **B** factor multiplies the virus load by that amount. With it set to 30 it is equivalent to being subjected to 30 infection sources rather than 1 infection source. This may be a reasonable assumption in a large outdoor venue because the other infection sources will be subjected to dispersion by the wind and large outdoor space.

The Virus Diffusion by Distance and Windspeed (Nuclear Engineering) model also shows the impact of distance from a virus emitter. We see that for distances of less than 1 foot even though the venue is outside, people will be infected. A social distance of approximately 1 foot is found on college campuses as students gather for parties, airplanes, and cruise ships at various entertainment and pool side venues.

References

[1] Generic Models For Use In Assessing The Impact Of Discharges Of Radioactive Substances To The Environment, Safety Reports Series No.19, International Atomic Energy Agency (IAEA), Vienna, 2001. Printed by the IAEA in Austria September 2001, STI/PUB/1103. webpage https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1103_scr.pdf, July 2020.

[Generic Models For Use In Assessing The Impact Of Discharges Of Radioactive Substances To The Environment](#) . local

[2] A Tool to Model the Fate and Transport of Indoor Microbiological Aerosols (FaTIMA), NIST Technical Note 2095, U.S. Department of Commerce, June 2020. webpage

<https://doi.org/10.6028/NIST.TN.2095> [A Tool to Model the Fate and Transport of Indoor Microbiological Aerosols \(FaTIMA\)](#) . local

[3] Webinar: Social Inequities and COVID-19 Community Response | COVID-19 Healthcare Coalition Response, c19hcc.org/insights August 26, 2020. webpage <https://c19hcc.org/insights>,

August 2020. [Webinar: Social Inequities and COVID-19 Community Response | COVID-19 Healthcare Coalition Response](#)

[4] The Sick Building Syndrome, Indian Journal of Occupational and Environmental Medicine, August 12, 2008. webpage <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2796751>, August,

2020. [The sick building syndrome](#)

Current US Infrastructure Virus Concentration

This analysis uses the current US Infrastructure standards to determine the virus concentration in different settings. The settings and resulting scenarios are:

- Subway Car
- Narrow Body Aircraft
- Wide Body Aircraft
- Classroom Grades 9+
- Auditorium Theater
- Classroom Grades 3-8
- Stadium
- Office

Virus Concentration (HVAC Industry Engineering)

This model calculates aerosol exposure based on Heating Ventilation and Cooling (HVAC) industry engineering using in-practice values for spatial volume, ventilation rate, filtration effectiveness, air recirculation rate, outside air rate, and normal at rest inhalation quantities for various settings including aircraft [1] [2]. The additional parameters are time and virus generation rate. For consistency the virus generation rate is the same as used in all the other models in this text. The model has been expanded with mask parameters so that stakeholders can see the conditions where an infection will occur given a set of different scenarios and typical HVAC systems that exist in the current infrastructure.

There are a few items to note in the model. The first is that the original parameters are using mixed units. The parameters all need to be converted to common units. The second is that some of the units are difficult for people to relate to - in the US people relate to Feet, Square Feet, Cubic Feet. They can visualize the space. It is difficult to visualize a space in terms of Liters. However when parameters are compared to a single breath and a single breath is provided in terms of Liters, suddenly people can relate to a parameter based on Liters. To allow for better visualization some of the parameters are shown in multiple units.

The model does not shed any new light on the situation. The results are basically the same. There is a deep understanding that surfaces once the model is examined and understood. All the previous analysis was based on a physical space, a room or outdoor area of some size. In this model the space moves from a macro level to the lowest common denominator, a single person. As the model results are examined that concept needs to be kept mind. [[Spreadsheet Concentration](#)]

The time dependence of airborne infectious disease (the virus) caused by occupant generated infectious aerosol concentration (the virus) in a uniformly mixed system, like any occupant bioeffluent concentration (e.g. human breath carbon dioxide, and perspiration, perfume, clothing and skin oil volatile organic compound emissions), is based on occupancy density (OD), air supply rate per person, the HVAC system effectiveness in getting that supply air to the breathing zone, and the quality of the supply air. The equations and parameters are:

$$C1 = [N/(V*Ve) * [1-\exp(-V*Ve*t/v)]]$$

C1 or C = Bioeffluent infectious aerosol concentration in the space at time t, virus/L

N = Rate of bioeffluent infectious aerosol generation/person, virus/s per person, based on this analysis

t = Duration of infectious aerosol generation, sec

v = OD = Spatial volume/person, L/person

V = Infectious aerosol-free ventilation rate per person, L/s per person

(HVAC outdoor air + virus filtered recirculation air + envelope infiltration air)

Ve = efficiency of supplying ventilation air to each person's breathing zone

Ve = 1 in uniformly mixed system

Ve = 0.65 Fully loaded subway car and a narrow-body aircraft

Ve = 0.90 Stadium

Ve = 1.00 Remaining settings

Ve tends to be lower the higher the occupancy density

D = IC integration => D = IC * time exposed

D = IC = p * [NI/VVe] * {t + [OD/VVe] * [exp(-VVet/OD)-1] }

D = Virus inhaled or virus dose

I = Inhalation rate L/s

p = Fraction of infected persons = 1, the person next to you is infected

Infected when D > 1000

1 cu-m = 1000 liters

1 cu-m = 35.3 cu-feet

Ver = Virus Exposure Risk factor

Ver = D/Baseline when worse = -Baseline/D when better

e.g. Ver = 3 suggests the exposure risk is 3 time worse than the baseline, Ver = -2 suggests the exposure risk is 2 times less

Table 67 - Current US Infrastructure Virus Concentration

| Scenarios | N virus / sec | t hr | t sec | v vol per person cu-ft | v vol per person cu-m | v vol per person L | V=V*Ve Infection Free Ventilation Air all sources L/Sec | liters / hr | cu-m / hr | V/v note units do not match | Effective AUC | C1 Virus / L | I Inhalation Rate L | D1 Virus Inhaled Infected at 1000+ | p | D Virus Inhaled Infected at 1000+ | 1 mask 75% Infected at 1000+ | 2 masks 75% Infected at 1000+ | Ver Baseline / D |
|-----------------------------|---------------|-------|-------|------------------------|-----------------------|--------------------|---|-------------|-----------|-----------------------------|---------------|--------------|---------------------|------------------------------------|---|-----------------------------------|------------------------------|-------------------------------|------------------|
| Office | 20 | 1 | 3600 | 999 | 28.3 | 28300 | 23.1 | 83160 | 83.16 | 0.8 | 2.9 | 0.82 | 0.15 | 443 | 1 | 467 | 117 | 29 | -1.30 |
| Office | 20 | 8 | 28800 | 999 | 28.3 | 28300 | 23.1 | 83160 | 83.16 | 0.8 | 2.9 | 0.87 | 0.15 | 3740 | 1 | 3740 | 935 | 234 | 6.17 |
| | | | | | | | | | | | | | | | | | | | |
| Subway Car | 20 | 0.50 | 1800 | 25 | 0.70 | 700 | 8.90 | 32040 | 32.04 | 12.7 | 45.8 | 2.25 | 0.15 | 607 | 1 | 606 | 152 | 38 | 1.00 |
| Narrow Body Aircraft | 20 | 6.00 | 21600 | 35 | 1.00 | 1000 | 6.10 | 21960 | 21.96 | 6.1 | 22.0 | 3.28 | 0.15 | 10623 | 1 | 10622 | 2656 | 664 | 17.52 |
| Wide Body Aircraft | 20 | 14.00 | 50400 | 56 | 1.60 | 1600 | 11.80 | 42480 | 42.48 | 7.4 | 26.6 | 1.69 | 0.15 | 12814 | 1 | 12813 | 3203 | 801 | 21.13 |
| Classroom Grades 9+ | 20 | 6.00 | 21600 | 286 | 8.10 | 8100 | 10.90 | 39240 | 39.24 | 1.3 | 4.8 | 1.83 | 0.15 | 5945 | 1 | 5945 | 1486 | 372 | 9.80 |
| Auditorium Theater | 20 | 4.00 | 14400 | 360 | 10.20 | 10200 | 10.60 | 38160 | 38.16 | 1.0 | 3.7 | 1.89 | 0.15 | 4075 | 1 | 4075 | 1019 | 255 | 6.72 |
| Classroom Grades 3-8 | 20 | 6.00 | 21600 | 399 | 11.30 | 11300 | 12.10 | 43560 | 43.56 | 1.1 | 3.9 | 1.65 | 0.15 | 5355 | 1 | 5355 | 1339 | 335 | 8.83 |
| Stadium | 20 | 4.00 | 14400 | 939 | 26.60 | 26600 | 11.30 | 40680 | 40.68 | 0.4 | 1.5 | 1.77 | 0.15 | 3815 | 1 | 3823 | 956 | 239 | 6.30 |
| Office | 20 | 8.00 | 28800 | 999 | 28.30 | 28300 | 23.10 | 83160 | 83.16 | 0.8 | 2.9 | 0.87 | 0.15 | 3740 | 1 | 3740 | 935 | 234 | 6.17 |

Notes:

1. V=V*Ve Infection Free Ventilation air all sources L/Sec includes the effects of filtered recirculated air and outside air mixing [1].
2. Minimum outside air supply rates for building environments ASHRAE Standard 62.17 [1].
3. Transportation environment outside air supply rates ASHRAE Standard 161 (aircraft) [1].
4. Filtration ASHRAE Standard 161
5. UV-C is not considered in this model.
6. At rest Inhalation is 0.15 Liters it can go as high as 4 (female) to 6 (male) Liters

Current US Infrastructure Key Findings

This analysis models the space around a person. For example the Auditorium Theater scenario space is 360 cu-ft. With a 10 ft ceiling the floor space is 6 ft X 6 ft. The ventilation rate translates into an AUC of 3.7. So a building packed with people that are spaced 6 feet apart with a 10 ft ceiling and an AUC of 3.7 will result in 4075 virus particles being inhaled in 4 hours. Since the infection threshold is 1000 virus particles, there will be infection. If 1 mask is introduced the virus inhaled count will be 1019 and with 2 masks it will be 255.

This analysis shows that in each of these scenarios everyone gets infected without a mask except for the Subway. We see airplanes are the worst case scenarios, which is what this text speculated when it was started in April 2020. As the at rest inhalation rate increases because of activity (e.g. laughter, talking, singing, exercise), the infection rate increases. We see that if we increase the personal space, the level of infection drops. We also see that as we increase the AUC, the level of infection drops.

Other analysis in this text suggests that the scenarios are worse than suggested in this analysis. Extreme care must be taken when examining these numbers. The Wells-Riley Probability of infection is a better predictor of the results because this model assumes uniform distribution and that is not the case in a real world setting. This analysis suggests that all will be well for some scenarios if masks are worn but the Wells-Riley Probability of infection suggests that even with masks there is a relatively high probability of infection (Office Scenario) [3].

A key question remains and that is what happens with repeated exposure. Is the virus cumulative or does something act to eliminate the non-infectious virus load, such as the Innate Immune System. Something is clearing the low dose virus exposure or else the virus spread would have been significantly worse than we have experienced to date (October 2020). However, we do see the extreme danger in small spaces packed with people like classrooms, bars, and restaurants. The occupancy rates must be controlled and the AUC must be drastically increased in these settings.

Infrastructure Modifications

Obviously others are working to determine how to mitigate the risk of infection within indoor spaces. The body of knowledge goes back into the last century. In 1943 there was a 6 year study in Philadelphia on the effects of the use of UV-C ceiling level lights. The study begins with: the prevalence of respiratory infection during the season of indoor congregation suggests a natural relationship between ventilation and communicable disease and concludes that the level of infection was much lower in the irradiated classroom compared to the unirradiated classroom despite the fact that there were more susceptibles in the irradiated classroom than the unirradiated classroom. According to CDC guidelines there is upwards of 90 percent effectiveness applying UV-C lights and they effectively boost the air changes per hour where there can be 17 additional air changes per hour. However, they need to be properly managed to ensure hot air is not trapped at the ceiling level, the air must circulate. [4]

Do we have the technology to modify our infrastructure? The short answer is yes. This is not a technology problem. Given that the US has spent trillions of dollars thus far on this disaster, this is not an economic problem. This is a social problem. It is all just a matter of national will and

leadership. Proposed legislation text was prepared in July 2020 but there has been no action as of October 2020 [5].

Author Comment: The US issued trillions of dollars to maintain a status quo, basically doing nothing except for parking people and resources. A fraction of that money could have been used to update all the buildings leading up to the Winter of 2020. Instead the virus will spread at a higher rate and the US Infrastructure will continue to be a source of all types of infection spread. In this case the infection death rate is very high and there is large loss of long term health yet to be quantified.

References:

[1] Germs and Flying: Developing Ventilation System Criteria, SAE International, October 18, 2011. webpage http://indoorair.ca/veft/pdf/SAE_paper_Germs_and_Flying_2011-01-2690.pdf, October 2020. [Germs and Flying: Developing Ventilation System Criteria](#)

[2] COVID-19 and Beyond A Brief Introduction To Passenger Aircraft Cabin Air Quality, ASHRAE Journal, October 2020. webpage https://www.ashrae.org/file%20library/technical%20resources/covid-19/12-19_walkinshaw.pdf, October 2020. [COVID-19 and Beyond A Brief Introduction To Passenger Aircraft Cabin Air Quality](#)

[3] See section [Wells Riley Probability of Infection](#).

[4] [How Can Airborne Transmission of COVID-19 Indoors be Minimized?](#), May 01, 2020. <https://www.youtube.com/watch?v=jK6Cef5A8FQ>. [local transcript](#)

[5] See section [Proposed Legislation](#).

Classroom & Other Designs

When this analysis was started there was no idea that it would lead to a potential design for a classroom. The goal of the analysis was to gain further insight into the behavior of the virus from an engineering perspective. As the analysis unfolded the possibility of developing indoor venue designs surfaced.

The key to virus safe classroom design is proper ventilation. Ventilation moves outdoor air into a building or a room and distributes the air to provide healthy air for breathing. Ventilation is accomplished by both diluting internal pollutants and removing the pollutants. In this case there is a need to dilute as quickly as possible, capture, and remove any floating virus in the air. The recycled air must be subjected to UV-C and virus level filters. There are three methods used to ventilate a building: natural, mechanical and hybrid (mixed-mode) ventilation. Ventilation has three elements:

1. Ventilation Rate: This is the amount of outdoor air that is provided into the space, and the quality of the outdoor air
2. Airflow Direction: This is the overall airflow direction in a building, which should be from clean zones to dirty zones

3. Air distribution or Airflow Pattern: The external air should be delivered and the airborne pollutants should be removed in each part of the space

One of the key reports to review to gain a better understanding of ventilation and common sense building management is from the WHO [1]. Look at the pictures of the designs of the buildings. Look at the natural ventilation ACH numbers throughout the report. [Natural Ventilation for Infection Control in Health-Care Settings, WHO, 2009](#) . [local](#)

In addition to ventilation the use of ceiling level UV-C lights is a key element to the system that will reduce the risk of infection. The UV-C lights boost the air changes per hour where there can be 17 additional air changes per hour. However, they need to be properly managed to ensure hot air is not trapped at the ceiling level, the air must circulate.

All this analysis can now be used to develop a potential design for an generic enclosed space. The selected generic space is a classroom. These are the system requirements:

1. The classroom size is 30 X 30 X 12 feet. As the volume decreases the AUC must increase. [[spreadsheet](#) Diffusion]
2. It has 4 ceiling level oscillating fans to randomize the air flow with UV-C ceiling lights, a central ceiling large diameter fan, and 3 exhaust fans.
3. The oscillating fans create a turbulent random airflow that mixes any virus in the full volume of the room and ensures the ceiling air is is not trapped.
4. The fans should provide a gentle breeze of approximately 1 mile per hour.
5. The exhaust fans remove the air with an AUC of 14.81 (sneeze event). [[spreadsheet](#) Diffusion]
6. The students are placed along the windows and along the opposite room wall.
7. They are separated by 6 feet. This allows for 16 students and 1 teacher.
8. The windows and door are open allowing for fresh air to enter through the door via the hall that connects other classrooms.
9. In the winter months this will reduce the temperature in the classroom and there will be tradeoffs associated with the cost of heat.
10. To deal with the winter months the exhaust fans can connect to flexible ducts leading to UV-C lights plus filter assembly and recycle the air back into the building.
11. Do not remove the oscillating fans with UV-C ceiling level lights or exhaust fans, they work together to diffuse and remove the virus.
12. Examine the section on [Wells Riley Probability of Infection](#), it suggests that this design may be insufficient because the AUC level is too low, this is why the section on [Proposed Legislation](#) is so critical.

Those are the key requirements to be used to upgrade the classroom.

Each school district in the US should build a prototype classroom adapted to their unique needs using this generic classroom design. It should then be subjected to validation using a test and evaluation effort that will tweak the design (described below). This should then be used to update all the classrooms and common areas in the school district.

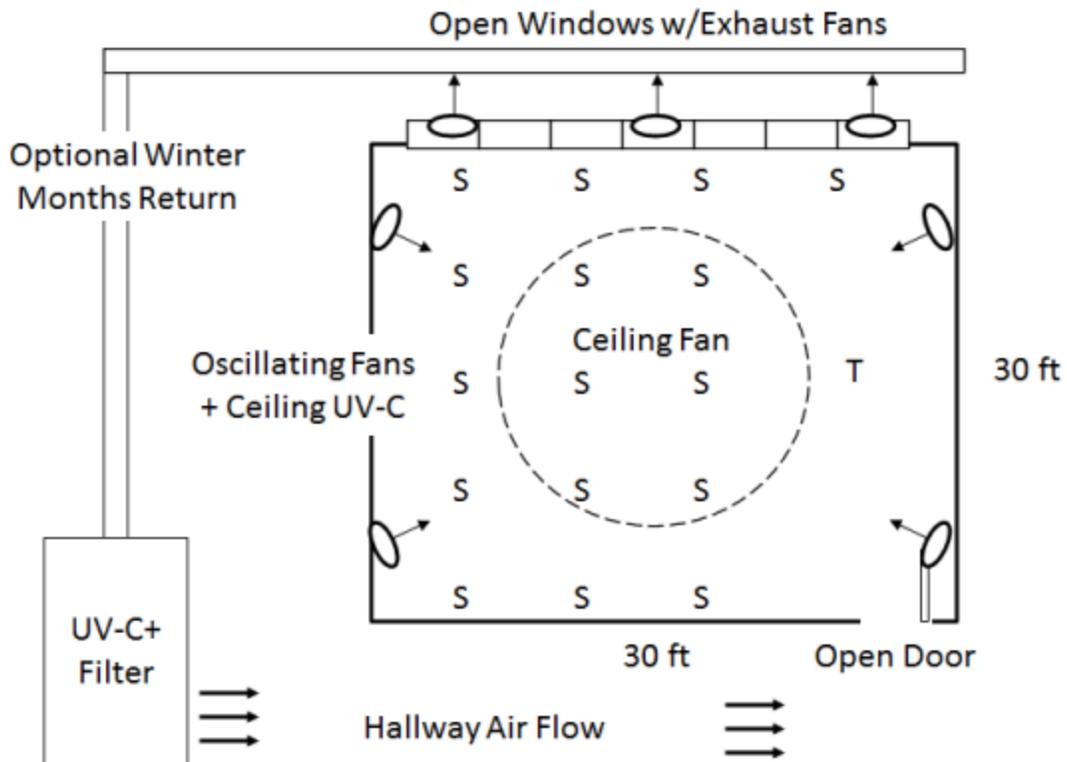


Figure 35 - Indoor Classroom Converted to Outdoor Environment



Source: Library of Congress

Figure 36 - Open Windows Public School Cafeteria circa 1908

In the early 1900s while dealing with tuberculosis it was detected that children do better in the open air. The first fresh-air school in the US for tubercular children opened in Providence in 1908 and by 1910 there were 65 fresh-air schools in the country [2]. Some are currently suggesting that classrooms be moved outside to prevent the spread of the virus to school children

and teachers [3]. They also suggest that plastic shields going up around desks is not the answer and they cynically state that - That's our creative solution? [3].

What is missing in the dialog is sound engineering. It is over 100 years since 1908 when there were few engineering alternatives. The proposed classroom design suggested by this analysis can be accomplished in any school in the US with minimal costs. The capability and industrial infrastructure exists and can be quickly rolled out across the country.

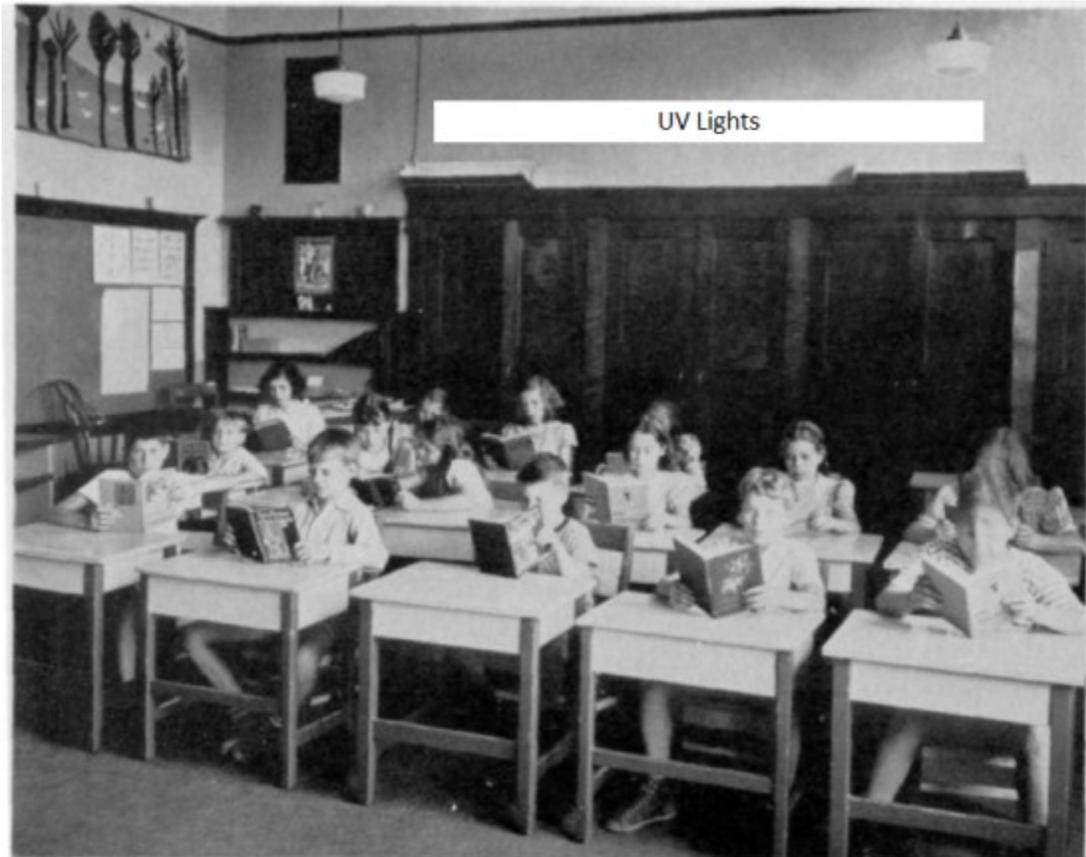


Figure 37 - Classroom Design Swarthmore Public School

UV Lights to reduce risk of infection previous century

Classroom Design Validation

The prototype classroom and each resulting modified classroom can be validated using a common sense test and evaluation program.

The testing and evaluation is performed by placing smoke emitters at the different student desks. The smoke is monitored with and without the ventilation turned on. Test subjects are placed at each desk to monitor the airflow and look for dead air zones. The test subjects can be parents or students from the community. The smoke emitter is placed at each of the student desks as part of separate test events. This entire project can be made part of the science classes offered when the school session is started.

Can higher tech testing be done - Yes. This is the lowest common denominator validation approach and it will also instill confidence in the community because everyone will see and understand the results.

At this point few will trust a report based on high tech testing. Does that mean the high tech testing should not be performed - No. Do the high tech testing approach and then do the simple common sense smoke test before a classroom is certified as being as safe as modern engineering can make the classroom safe.

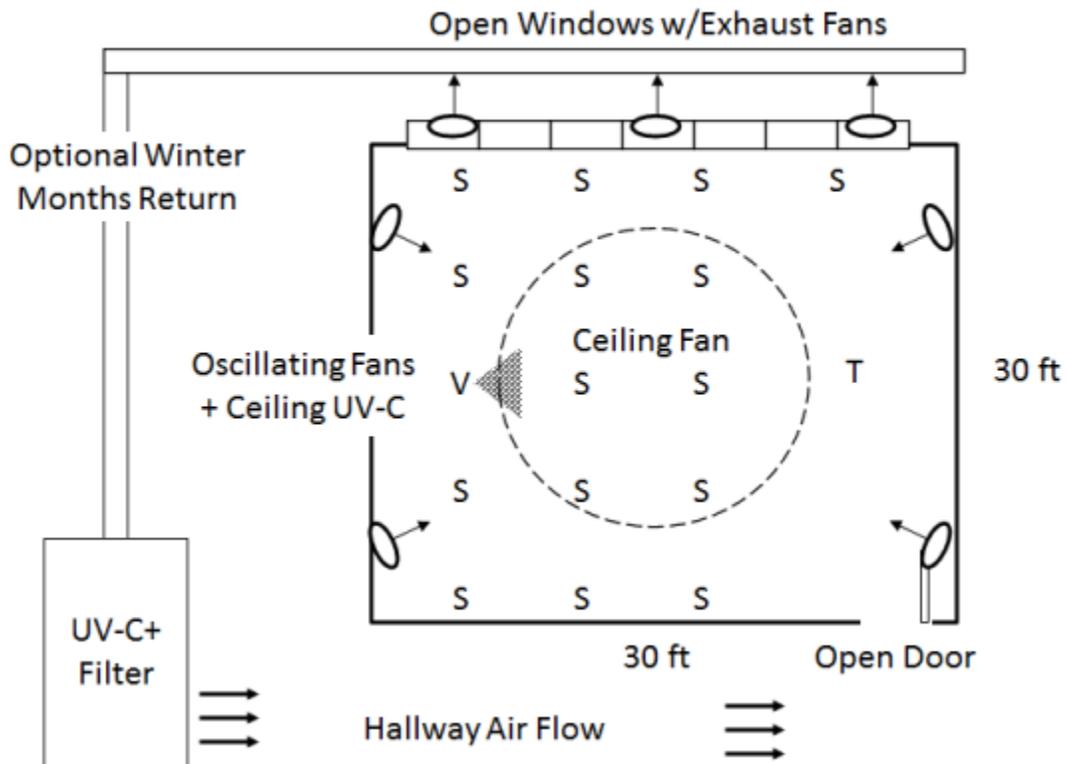


Figure 38 - Classroom Ventilation On

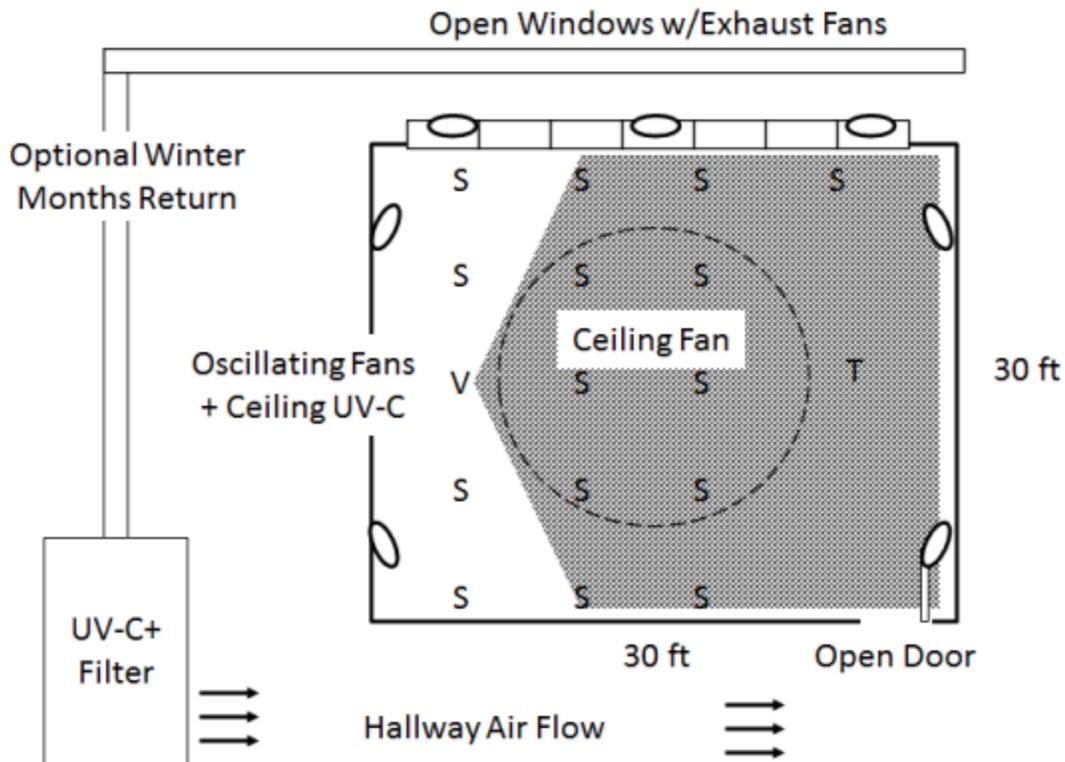


Figure 39 - Classroom Ventilation Off

As of July 2020, 31% of the children in Florida are positive for the virus and the Florida statewide average is 11% [4]. Each school district has the following options:

1. Do nothing with the school ventilation systems - children and teachers will get sick and die while others will probably have to live with long health issues [5]
2. Use this analysis as the basis to validate and if needed update your ventilation needs in each classroom and other school rooms
3. Follow the recommendations of your facility staff and their contractors, however be aware they may be ignorant on how to proceed, if they have not provided valid answers as of July 2020 you have a problem

It is gravely important that if option #3 is followed you behave as an educated stakeholder and ask the questions raised in this analysis. They must educate you and what they provide must make sense. You now know the air needs to be mixed to dilute the virus. You also know that the air needs to be exchanged at a rate (AUC) to remove the virus. If the recommendations are less, then you must be convinced using logic, common sense, and transparent engineering analysis that is understood by everyone including the parents and older children. The children are the most important stakeholder in this system.

Do not open the schools until the virus is under control and the students can be properly screened before entering the building. Realize that school children will not social distance, constantly wear masks, wash their hands, and may even come to school sick. Respect that reality, any management driven desires or talking points are irrelevant, the virus is in control.

To view the analysis that supports this design go back and read the section: [Virus Diffusion Classroom Design](#)

Key Stakeholder Statements

The Essex County Education Association provided a statement on the in-person reopening of schools [6]. The position titles were kept but many of the names have been removed from the statement.

Essex County Education Association Statement on the In-Person Reopening of Schools

July 24, 2020

To:

Interim Executive County Superintendent; Assemblywoman, Vice-Chair of the Assembly Education Committee; Assemblyman, Member of the Assembly Education Committee; Essex County Executive; Sen. Richard Codey; Sen. Teresa Ruiz, Chair of the Senate Education Committee; Sen. Ron Rice; Sen. Nia Gill; Sen. Kristin Corrado; Sen. Joe Pennacchio; Assemblywoman various; Assemblyman various; and the Essex County Freeholder Board.

Out of the more than three thousand counties in the United States, Essex County New Jersey ranks in the top ten nationally for the number of Covid-19 deaths. We mourn for the more than two thousand residents who lost their lives and recognize that each one represents a family that will never be the same. As president of the Essex County Education Association, I represent more than twelve thousand educators across the county and for us the danger that Covid-19 presents is all too real.

For the last several weeks our members have been faithfully participating in reopening committees in our districts. We would like nothing more than to return to our classrooms and offices to educate our students in a safe environment. However, it is clear that the science supports that reopening school buildings this fall is unsafe.

Therefore, the Essex County Education Association cannot, in good faith, support the reopening of public schools for in-person instruction in September. Simply put, despite the best of intentions and planning, the risk to the health and safety of our students and staff is too high.

We know that indoor activities in small spaces for long periods of time presents the highest risk for the spread of Covid-19. Currently, the NJ Department of Health acknowledges that short term, indoor dining is not safe. The World Health Organization now agrees that Covid-19 may spread through the air in indoor enclosed spaces [A].

Just this week it was reported that scientists also believe that Covid-19 may be spread by HVAC units [B]. Enclosed spaces and long periods of time describe the exact conditions in our classrooms. In addition, chronic problems with HVAC systems in our buildings are prevalent across the county even in well-resourced districts. To address just that one issue it would likely take tens of millions of dollars and probably more than a year. This reflects the magnitude of the problems we face.

There are countless other health and safety issues that are equally daunting, including busing and Covid testing and tracing and they come during a time when we are facing budget shortfalls and no guarantee of assistance from the Federal Government.

The other huge issue that makes resuming in-person instruction unsafe is compliance. Small children are not developmentally able to understand or undertake social distancing. It will be an impossible task to keep them apart. As educators, we are problem solvers and inherently optimistic. Just try to teach a lesson on Halloween and you will see optimism personified. But this is not a challenge to be overcome, it is an impossibility.

If we open buildings for in-person instruction, make no mistake, students will not maintain social distance and the results may be deadly. For some of our students, compliance with rules is often difficult. Therefore, regardless of age level, the maintenance of safety protocols is utterly unrealistic.

The guidelines from both the NJDOE and the AAP are simply that, guidelines. They are unproven and untested. They cannot assure parents that their children are safe from contracting the virus or bringing it home. The guidelines cannot guarantee that teachers will not get sick and die.

In a large-scale, systematic study of 65,000 people in South Korea, results found students between ages 10 and 19 spread the virus at the same rate as adults [C]. What are the implications for our middle and high school students, their families, and educators?

We have already seen camps and summer schools with small groups, who followed social distancing guidelines and mask requirements, report cases of Covid 19 and close, some within a few days of opening.

- *Newark summer school site was temporarily closed due to coronavirus case [D]*
- *Covid Case Suspends In-person Summer School At Norwalk High [E]*
- *Reopening New Jersey: Manasquan Pauses Summer Camp Program After Workers Test Positive For Covid-19 [F]*

We understand that parents want to resume a sense of normalcy for their children. We want that too. But we all need to understand the new realities of classrooms in the age of Covid. As a teacher for the last twenty-four years I can attest that educators have spent the last decade engaged in an effort to emphasize the social and emotional development of our students.

*Simply put, we understand now more than ever that for students to learn they must feel safe, welcome, and part of the community. How exactly will they do that with desks spaced 6 ft apart? How will they feel as they are constantly reminded to stay apart from their friends, and to not touch their masks, and to not share supplies and keep to their plexiglass “personal space” in the classroom? **How will that work exactly, with kindergarteners?** Many schools will require a “door to door” mask policy. The teacher will be wearing a mask and face shield. One to one help will be restricted under the guidelines. Group work and labs with shared supplies will not occur. The simple gesture of a reassuring smile or fist bump will vanish.*

The school day may be abbreviated with students either eating lunch at home, getting a boxed lunch to take home, or eating in their classroom. Going to the bathroom will now require the careful orchestration and logistics of an air traffic controller at Newark Airport.

Precious instructional time will be lost to monitor sanitizing and compliance to social distancing and mask wearing. Socially and emotionally every single person - both students and adults - present in these buildings under these conditions will be totally stressed out all the time. Yet, even with all these draconian measures, there is still no guarantee that students will be safe from Covid-19.

Impact on Families

The Essex County Education Association recognizes the severe burden that closed school buildings presents for working families and we did not arrive at this decision to support a remote start lightly. Many teachers are working parents too. However, an intermittent start and stop due to an outbreak of new cases is far more disruptive and unstable than planning now for remote learning for all families.

While some European schools have opened with limited transmission, schools in China, Israel and South Korea have been forced to close.

Next Steps

We are asking that you recognize the obvious, that it is totally unrealistic to expect that we can safely open our schools for in-person instruction in September.

By declaring a remote start for school in September now, this will provide parents time to arrange for childcare and educators to better prepare for remote instruction. Time though, is of the essence. Districts are wasting precious weeks creating plans with convoluted schedules and Plexiglas dividers that are plainly unworkable.

Staffing these plans will prove to be impossible. We had a severe substitute shortage before the pandemic. Many educators are preparing to leave the profession rather than risk their lives in buildings that they know cannot be made safe over the next six weeks.

Ultimately, once cases of Covid start showing up - and they will - these plans fall apart like a house of cards.

Where do districts, families and students end up in that case? Right back in remote learning anyway, but without the benefit of planning and preparation because we were too busy figuring out who is going to be taking temperatures and sanitizing every surface each day.

- *Educators can use the remaining weeks before school to engage in professional development in effective remote instruction*
- *Administrators can work to provide technology support for those families in need.*
- *Districts can focus on public/private partnerships and other funding sources to help their students as outlined by Governor Murphy's initiative, "Closing the Digital Divide."*
- *Districts that had successes with remote learning could share best practices with districts that struggled.*

As always, our members stand ready to work with the communities we serve to help reduce the burden of remote instruction. We are interested in creative ideas that can help working families and support students, but do not put lives at risk.

We are simply asking that as leaders you take the next step and support a remote start to the year so that during this unprecedented crisis we can continue to deliver the best quality education that made NJ schools the best in the nation.

Sincerely,

President Essex County Education Association and Livingston Education Association, Co-President: Essex Fells Education Association, President: Irvington Education Association, President: Cedar Grove Education Association, Co-President: West Essex Regional Education Association, President: Orange Education Association, Co-President: Essex Fells Education Association, President: Education Association of Nutley, Co-President: West Essex Regional Education Association, Co-President: Essex Fells Education Association, President: Bloomfield Education Association, President: Millburn Education Association, President: South Orange-Maplewood Education Association, President: West Orange Education Association, President: East Orange Resource Professionals Association, President: Caldwell-West Caldwell Education Association, President: Belleville Education Association, President: East Orange Education Association, President: Roseland Education Association, President: Essex County Vocational & Technical Education Association, Co-President: Glen Ridge Education Association, Co-President: Glen Ridge Education Association, President: East Orange Service & Maintenance Association, President: Verona Education Association, President: East Orange Charter School Education Association

American Federation of Teachers

The nation's second largest teachers union with 1.7 million members, American Federation of Teachers (AFT), issued a resolution saying it will support any local chapter that decides to strike over reopening plans because of unsafe working conditions in schools due to the coronavirus pandemic. According to the union the safeguards must include [7]:

1. Comprehensive contact tracing in areas where classes resume
2. Mandatory masking
3. Updated ventilation systems in facilities

HVAC Industry

The HVAC and ventilation issue has started to surface in popular media as of July 28, 2020. There is acknowledgement that upgrading building HVAC systems will help to mitigate the risk of infection and companies are being asked to provide potential solutions. Property managers are upgrading heating, ventilation and air conditioning systems before reopening buildings. Building specialists are examining filters that block microbes, systems that use ultraviolet light or electrically charged particles in the ductwork to kill the virus, air monitoring sensors, and portable filter machines to help make up for deficiencies in central ventilation systems. There are many tradeoffs [8]:

- It's best to let in more fresh air, but that impacts cooling or heating levels

- Dense filters trap more microbes, but they choke off airflow and worsen ventilation, and if a building's fans aren't powerful enough it can make a bad situation worse
- And all solutions require more energy consumption which means higher operational costs

Many approaches to reduce pathogens have been available for decades, such as UV light and bipolar ionization, which releases electrically charged atoms that attach to and neutralize viruses and bacteria. These technologies are geared more to hospitals than commercial buildings, which put more of an emphasis on saving energy than killing germs. Demand is now coming from schools and small offices [8]

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Virus Diffusion Other Indoor Designs

All the information needed to understand virus diffusion and develop working designs is in section [Virus Diffusion Classroom Design](#). The generic classroom design can be adapted for restaurants, bars, small office spaces, movie theaters, small retail shops. Large office buildings should engage large HVAC companies to develop the designs based on findings of the analysis that resulted in the generic classroom design. The issue is who will test and certify these spaces.

This begs the question - what is going on with the HVAC industry because there is no serious dialog in the public media on this subject as of July 2020.

1. Is this a liability issue where no one wants to touch this with a 10 foot pole?

2. Is this something that is so obvious that everyone thinks someone else is doing this?
3. Is this analysis and conclusion of mixing and exhaust flawed?
4. Is this A failure of Imagination similar to the Apollo 1 fire on January 27, 1967 where - We just didn't think of it?
5. Why haven't the individual small business owners put in fans both indoors and in their tents outdoors?

Personally Dealing With Enclosed Spaces

The data from the previous analysis has been reduced to provide personal guidance on dealing with enclosed spaces. The enclosed spaces are both indoor and outdoor settings.

The analysis findings are significant. Wearing a mask in a small enclosed space with social distancing but no ventilation or poor ventilation may still quickly lead to virus infection. Big spaces like big box stores are less risk because of the massive space for the virus to diffuse allowing enough time for it to be exhausted. Personal experience suggests that many big box stores turned on their ventilation systems to the maximum levels. Outdoor venues can have the same characteristics as small spaces with no ventilation and they are at the same high risk of virus infection. However outdoor settings with a gentle breeze, minimal crowds and social distancing are low risk.

The following guidance is offered on how to proceed and the data follows the guidance.

🚩 When you enter a small space check for ventilation, if there is no ventilation that you can feel and hear get out as soon as possible, follow up and tell the management why you left

🚩 When in an outdoor space in a large crowd, if there is no open wind that you can feel get out as soon as possible, avoid the middle of the crowd, follow up and tell the management why you left

🚩 Enjoy the outside when there are gentle winds in places with few crowds where people are spaced 6 to 12 feet apart, a distance of 1 foot will lead to infection.

🚩 Enjoy walking, running, bike riding outside in places with few crowds where people are spaced 6 feet apart

🚩 Wear a mask, masks are critical but do not fully rely on the masks to protect you, you must use your common sense about ventilation, it is instinctive

The analysis that led to these findings are from:

- Virus Diffusion by Distance and Windspeed (Nuclear Engineering)
- Virus Density by Volume and Air Mixing (Engineering)
- Virus Density by Distance (Electrical Engineering)
- Virus Density by Mask Filtering Levels (Engineering)
- Virus Probability of Infection (Wells-Riley)

All the analysis is consistent, appears to match the empirical data, and appears to match what people are experiencing. Before the analysis summary is offered the following relationships are provided to further help people understand how the virus can be transmitted.

- When an infected person breathes they exhale 20 virus particles with each breath
- In general people breath about once per second
- The assumed virus infection load is 1000 virus particles
- Eventually as they breathe a cloud starts to form and expand
- The virus cloud moves and eventually fills an enclosed space
- As hard as it is to believe an infected person can quickly fill a small space
- The spaces analyzed were a classroom, big box store, and outside - remember a car is much smaller than a classroom

Words are cheap. It is always about the performance characteristics. All performance characteristics are stated in terms of numbers. Any system that does not have a full understanding of the performance characteristics is a very bad and potentially dangerous system. For example, someone can say that a car stops, but there is a big difference between stopping within 250 feet and stopping within 1000 feet from a speed of 60 miles per hour. This is what may happen when there is a primary brake hydraulic failure. Only the rear brakes work. In the first scenario people are shaken up but okay. In the second scenario people are going to the hospital and someone may die or lose their health.

All systems must have their performance clearly stated using numbers, even televisions and stereos. Otherwise there is no way to compare different solutions and take appropriate actions. In all systems the performance must be clearly understood. The understanding eventually leads to some key relationships. These are some key relationships to understand the COVID-19 disaster and its system space.

- If you are 1 foot away from an infected person you will be infected in 1 minute ($20 \times 60 = 1200$)
- If you are 1 foot away from an infected person and you are wearing a mask at 75% effectiveness you will be infected in 4 minutes
- If you are 1 foot away from an infected person and you are wearing a mask at 90% effectiveness you will be infected in 10 minutes
- If you are 1 foot away from an infected person and you are wearing a mask at 95% effectiveness you will be infected in 20 minutes
- If you are 6 foot away from an infected person you will be infected in 36 minutes if the cloud hits you directly, however that is unlikely, instead the virus is diluted into the space
- Being further away even in the worst case where the cloud hits you is better than wearing a mask (36 verses 4, 10, or 20 minutes)
- You must keep your distance, period
- The Wells-Riley equation is what is used to determine how likely it is for infection to occur, based on the space size, look at the numbers in the summary
- Once again you must keep your distance and understand the space that you are inhabiting
- Cars are much worse than classrooms and classrooms are much worse than big box stores, outside is significantly safer as long as it is not converted to an indoor setting
- Time is critical, 8 hours per day 5 days per week is 10 times worse than 4 hours of shopping per week, this is a Virus Exposure Risk (Ver) measurement
- Examine the Vre for different scenarios in this analysis

- Because the indoor spaces range from very unsafe to unsafe you must wear a mask to get the benefit of 4, 10, or 20 times reduction in the virus count
- If everyone wears a mask the benefit is then 16, 100, or 400 times reduction in the virus count

This is why mask wearing is so critical especially in the unsafe indoor spaces. This analysis shows that the indoor spaces can be made safe but it will cost lots of money and no one wants to pay for it at this time. The government knew all this day one, never forget that as long as you live, make sure your children and their children never forget this.

This is the analysis summary details. Remember this is just the summary. The detailed analysis is provided in other sections of this report.

Virus Diffusion by Distance and Windspeed

From the empirical data from around the world as of July 2020 we know that it is safer to be outside than indoors. From the analysis we have numbers to show that this is a valid observation. The analysis also shows that there are unsafe outdoor scenarios and they include being up against a wall even if there is a 1 mile per hour wind and being outside when there is no wind such as inside a tent or a swimming pool setting surrounded by people. The wind must blow or you must leave the setting. Also the wind must blow freely and not stop where you are standing or sitting. (Diffusion of particles as a function of distance and windspeed) [[spreadsheet](#) Diffusion]

Table 68 - Outdoor Risk Settings

| Source Virus/min | Wind Miles/Hr | Distance Feet | Time to Reach Virus Infection Load Minutes | Risk | Location | Scenarios |
|------------------|---------------|---------------|--|--------------|-----------------------|----------------------------|
| 1200 | 1 | 6 | 3168 | Low | Outside, Beach, Park | Free space air movement |
| 1200 | 1 | 16 | 22528 | Low | Outside, Beach, Park | Free space air movement |
| 1200 | 1 | 6 | 106 | High | Outside wall | Up against wall |
| 1200 | 0.01136 | 6 | 36 | Unacceptable | Outside No Wind, Tent | Free space no air movement |
| 1200 | 0.01136 | 16 | 256 | High | Outside No Wind, Tent | Free space no air movement |

From the empirical data from around the world as of July 2020 we know that it is unsafe being indoors under many conditions. From the analysis we have numbers to show that this is a valid observation. The analysis shows that it is critical that the spaces are ventilated to dilute the virus and then the air is exhausted so that the virus is removed from the space, both as soon as possible. Small spaces are more unsafe than large spaces.

Virus Density by Volume and Air Mixing

The following table shows that the time before the virus load is reached in a ventilated space to dilute the virus is high except for the sneeze event.

In this analysis there is a mechanism that is able to distribute the virus evenly throughout the room before anyone next to the infected person can get a whiff of the virus load. For example, fans are used to distribute the virus fully every minute. The next step is to determine how long it will take for the entire room to reach the virus load. So an infected person breathing 20 viruses per breath, taking 1 breath per second will produce 1200 virus particles around their head (about 1 cu-ft) in one minute. If the room is 10,800 cu-ft, it will take 9,000 minutes for the entire room space to be filled with 1000 virus particles for each cu-ft in the room. If the room is able to constantly distribute the virus and then change the room air with clean air then infection will be prevented. In the case of breathing and a cough the analysis suggests that even a very small AUC will have very low risk of infection. In the case of a sneeze the air must be fully exchanged with an AUC of 14.81. The challenge with this model is to ensure that the air in the room is constantly moving and random so that the virus is evenly diluted before being expelled from the room. Although this analysis is deterministic and based on simple math the real world scenario and results will be less optimistic. An alternative analysis based on the Well-Riley equation is more representative of what is observed in real world settings.

This mental model of an infection cloud building up around an infected person is important and should be considered in all analysis checks. In 1 minute the cloud is relatively small. A male exhales 6 liters per breath or about .21 cu-ft per breath. In 5 seconds that is about 1 cu-ft. In 50 seconds that is about 10 cu-ft. Some of the virus particles will fall to the ground and some will stay in the air. As time moves on the virus cloud grows first placing individuals near the infected person at risk and then eventually those farther away from the infected person are at risk as time moves on. This is common sense and intuitive. [[spreadsheet](#) Diffusion]

Table 69 - Indoor Ventilated Risk Settings

| Source Virus/min Per Cubic-Ft | L | W | H | Cubic-Ft | Virus/Cubic-ft per min | Virus Fully Diluted Via Massive Ventilation | Time to Reach V=1000 Min | Risk | Location | Scenarios |
|-------------------------------|-----|-----|----|----------|------------------------|---|--------------------------|-----------------------------|---|-----------------------------------|
| 1,200 | 30 | 30 | 12 | 10,800 | 0.11 | Yes | 9,000 | Virtually none * | Classroom, restaurant, office, small shop | Breathing |
| 720 | 30 | 30 | 12 | 10,800 | 0.07 | Yes | 15,000 | Virtually none * | Classroom, restaurant, office, small shop | Cough 6/hr 80% Droplet Infection |
| 2,666,667 * | 30 | 30 | 12 | 10,800 | 246.91 | Yes | 4 | Low only with massive AUC * | Classroom, restaurant, office, small shop | Sneeze 1/hr 80% Droplet Infection |
| . | | | | | | | | | | |
| 1,200 | 100 | 100 | 40 | 400,000 | 0.00 | Yes | 333,333 | Virtually none | Grocery store, big box store, garage, warehouse | Breathing |
| 720 | 100 | 100 | 40 | 400,000 | 0.00 | Yes | 555,556 | Virtually none | Grocery store, big box store, garage, warehouse | Cough 6/hr 80% Droplet Infection |
| 2,666,667 | 100 | 100 | 40 | 400,000 | 6.67 | Yes | 150 | Virtually none | Grocery store, big box store, garage, warehouse | Sneeze 1/hr 80% Droplet Infection |

* Note that the Wells-Riley equation suggests that the risks are very high. This analysis is provided further in the document.

The following table shows that the time before the virus load is reached in an unventilated space is very low. It is less than a minute in some cases. This does assume the infected person is near you not practicing social distancing. (Density as a function of volume and air mixing) [[spreadsheet](#) Diffusion]

Table 70 - Indoor Unventilated Risk Settings

| Source Virus/min Per Cubic-Ft | L | W | H | Cubic-Ft | Virus/Cubic-ft per min | Virus Fully Diluted Via Ventilation | Time to Reach V=1000 Min | Risk | Location | Scenarios |
|-------------------------------|-----|-----|----|----------|------------------------|-------------------------------------|--------------------------|--------------|---|-----------------------------------|
| 1,200 | 30 | 30 | 12 | 10,800 | 1,200 | No | 0.83 | Unacceptable | Classroom, restaurant, office, small shop | Breathing |
| 720 | 30 | 30 | 12 | 10,800 | 720 | No | 1.39 | Unacceptable | Classroom, restaurant, office, small shop | Cough 6/hr 80% Droplet Infection |
| 2,666,667 | 30 | 30 | 12 | 10,800 | 2,666,667 | No | 0.00 | Unacceptable | Classroom, restaurant, office, small shop | Sneeze 1/hr 80% Droplet Infection |
| . | | | | | | | | | | |
| 1,200 | 100 | 100 | 40 | 400,000 | 1,200 | No | 0.83 | Unacceptable | Grocery store, big box store, garage, warehouse | Breathing |
| 720 | 100 | 100 | 40 | 400,000 | 720 | No | 1.39 | Unacceptable | Grocery store, big box store, garage, warehouse | Cough 6/hr 80% Droplet Infection |
| 2,666,667 | 100 | 100 | 40 | 400,000 | 2,666,667 | No | 0.00 | Unacceptable | Grocery store, big box store, garage, warehouse | Sneeze 1/hr 80% Droplet Infection |

Virus Density by Distance and Mask Filtering Levels

From the empirical data from around the world as of July 2020 we know that wearing a mask will reduce the risk of infection. From the analysis we have numbers to show that this is a valid observation. The problem is that when we enter a small enclosed space that is not ventilated and exhausted the risk of reaching the virus load with a mask is still unacceptable in many settings even when everyone is wearing a consumer grade mask. (Density as a function of distance and Mask filtering levels) [[spreadsheet](#) Diffusion]

Table 71 - Mask Risk Settings

| Source Virus/min Per Cubic-Ft | Indoor Distance Feet | Time to Reach V=1000 Min | Work / School Risk 8 Hour Day 480 min | Shopping Risk 2 Hour Event 120 min | Scenarios |
|-------------------------------|----------------------|--------------------------|---------------------------------------|------------------------------------|---|
| 1200 | 6 | 120 | Unacceptable | Unacceptable | Indoor, 1 Mask filter effectiveness 75% consumer grade |
| 1200 | 6 | 480 | Unacceptable | Med | Indoor, 2 Masks filter effectiveness 75% consumer grade |
| 1200 | 6 | 300 | Unacceptable | High | Indoor, 1 Mask filter effectiveness 90% consumer grade |
| 1200 | 6 | 3000 | Low | Low | Indoor, 2 Masks filter effectiveness 90% consumer grade |
| 1200 | 6 | 3000 | Low | Low | Indoor, 1 Mask filter effectiveness 99% |
| 1200 | 6 | 30000 | Virtually None | Virtually None | Indoor, 2 Masks filter effectiveness 99% |

This analysis assumes there is no mask failure. Mask failure includes the leaks around the face where the mask does not make full contact and also when the mask is removed periodically as needed to deal with different life scenarios and unexpected events. There is a big difference between a medical practitioner that may have breaks where the mask is removed and a person or child wearing a mask for 8 straight hours.

Unfortunately, until the virus is gone we will need to change our physical building ventilation systems and we will need to change how we behave in situations where the ventilation is poor or nonexistent.

Wells Riley Probability of Infection

The following analysis is very sobering and difficult to present. Hopefully this analysis will never come to pass. It is offered to show the risks associated with different size indoor spaces, the time spent in the spaces, and the role of masks. It is based on the Wells-Riley equation that

was previously discussed in the other analysis areas. (Wells-Riley Probability of Infection) [[spreadsheet](#) Probability]

In the school scenario when the children are infected they bring it home. Basically when they go to school everyone goes to school. The same applies for any of the other scenarios.

The outside beach park scenarios show relatively low probability of infection. This assumes only 1 infection source. As the number of infected people increase over time the number in these settings will increase [1]. One approach is to assume social distance practices and then assume a certain percentage of the population is infected. The square footage of the social distance divided into the scenario square footage will provide the number of people in the environment. The percentage of infected population will then provide the number of Infectors. The impact is approximately linear. See section [Wells-Riley Equation](#).

This analysis is also much less optimistic about a small enclosed room such as a classroom with natural ventilation. This is why testing must be performed in the National Labs using the best science and engineering a nation state like the US can provide. See section [Proposed Legislation](#).

Table 72 - Wells-Riley Probability Scenarios Summary

| time hour | Masks | P | Chance of Infection | Space cu-ft | AUC | Population | Infected | Deaths | Ventilation | Scenario |
|------------------|--|-----------|----------------------------|--------------------|---|-------------------|-----------------|-------------------|--------------------|--|
| 1 | Yes | 0.0449626 | 4% | 10,800 | 4.00 | 328,000,000 | 14,747,747 | 516,171 | Expected | Small indoor space Small Restaurant Not sure how to eat with a mask |
| 1 | No | 0.7194023 | 72% | 10,800 | 4.00 | 328,000,000 | 235,963,957 | 8,258,738 | Expected | Small indoor space Small Restaurant Reality no mask while eating |
| 8 | Yes | 0.0624976 | 6% | 10,800 | 4.00 | 328,000,000 | 20,499,212 | 717,472 | Expected | Small indoor space Best case school & work Setting |
| 1 | Yes | 0.0021082 | ~ 0% | 400,000 | 4.00 | 328,000,000 | 691,475 | 24,202 | Expected | Large indoor space Shopping |
| 8 | Yes | 0.0150030 | 2% | 400,000 | 4.00 | 328,000,000 | 4,920,984 | 172,234 | Expected | Large indoor space Retail Work |
| 1 | Yes but 1 hour mask off | 0.9938008 | 99% | 10,800 | 1.00 | 328,000,000 | 325,966,659 | 11,408,833 | Poor | Small indoor space School Setting Small Restaurant |
| 1 | Yes but 1 hour mask off | 0.7194023 | 72% | 10,800 | 4.00 | 328,000,000 | 235,963,957 | 8,258,738 | Expected | Small indoor space School Setting |
| 1 | Yes but 1 hour mask off | 0.1193397 | 12% | 10,800 | 40.00 Open windows with fans | 328,000,000 | 39,143,428 | 1,370,020 | Massive Natural | Small indoor space School Setting |
| 1 | No | 0.0056322 | 1% | 10,800 | 3600 | 328,000,000 | 1,915,155 | 67,030 | wind 1 mile / | Outside small enclosed |

| time hour | Masks | P | Chance of Infection | Space cu-ft | AUC | Population | Infected | Deaths | Ventilation | Scenario |
|------------------|--------------|-----------|----------------------------|--------------------|------------|-------------------|-----------------|---------------|--------------------|----------------------------------|
| | | | | | | | | | hr | back yard |
| 1 | No | 0.0011290 | 0.11% | 10,800 | 18000 | 328,000,000 | 370,309 | 12,961 | wind 5 mile / hr | Outside small enclosed back yard |
| 1 | No | 0.0001525 | 0.02% | 400,000 | 3600 | 328,000,000 | 50,016 | 1,751 | wind 1 mile / hr | Outside beach park |
| 1 | No | 0.0000305 | 0.00% | 400,000 | 18000 | 328,000,000 | 10,004 | 350 | wind 5 mile / hr | Outside beach park |
| 1 | No | 0.0000152 | 0.00% | 4,000,000 | 3600 | 328,000,000 | 5,002 | 175 | wind 1 mile / hr | Outside large beach park |
| 1 | No | 0.0000030 | 0.00% | 4,000,000 | 18000 | 328,000,000 | 1,000 | 35 | wind 5 mile / hr | Outside large beach park |

Public Transportation

As the research has started to suggest that the virus may have an airborne element and this research has shown the effects of virus infection based on different ventilation scenarios the popular media has started to report on the ventilation story. The Southeastern Pennsylvania Transportation Authority (SEPTA) has released information on ventilation rates of their public transportation systems. It has also been stated that most of these ground based transportation systems have similar ventilation characteristics and that they do not appear to be a source of virus infection as of August 2020. [2]

There are no standards from the Federal Transit Administration that regulate ventilation. New air refreshes cars on both the Broad Street Line and Market-Frankford Line every 2 to 3 minutes and there are similar rates across the system: on Buses, Regional Rail and Trolley Cars. SEPTA's rate is probably common across many ground transportation system because many transit authorities use similar vehicles. [2]

Vents at the top of all SEPTA's subway cars are constantly pushing air in and out with the natural movement of the vehicle. The train's airflow is always in flux, leading to a full exchange of air every 2 to 3 minutes. On buses, there's a hatch at the top of the vehicle that can be opened in good weather to increase airflow. More air circulates when the doors open and close. The following are the ventilation rates for the SEPTA systems [2]:

- Trolleys: every 2 to 3 minutes this is an AUC of 30 to 20
- Norristown High Speed Line trains: every 2 minutes this is an AUC of 30
- 40-foot buses (standard size): every 2 minutes this is an AUC of 30
- 60-foot buses (articulated): every 2.5 minutes this is an AUC of 24
- Regional Rail trains: every 2 to 3 minutes this is an AUC of 30 to 20
- Coach cars (small part of fleet): every 3 minutes this is an AUC of 20
- Silverliner 4 cars (majority of the fleet, the older trains): every 3 minutes this is an AUC of 20
- Silverliner 5 cars (about one-third of the fleet, newer cars): every 2.5 minutes this is an AUC of 24

New York's subway cars ventilate roughly 18 times per hour (equivalent to once every 3.3 minutes). [3]. This is similar to SEPTA's ventilation rate.

A contact tracing effort in Paris found that none of the city's 150 coronavirus clusters from early May to early June spread on public transit. As of July 15, four transport clusters had been identified in Paris, accounting for roughly 1% of 386 total clusters. Japan, a country known for crowded commuter trains failed to connect a single cluster to the country's commuter trains. [5] In Japan, subway windows are left open to enhance airflow.

Fully ventilating all the air in an indoor space every 2 to 3 minutes far exceeds the recommendations for physical spaces like restaurants. Under most current codes, a restaurant replaces all of its air with outside air about once every hour. [6]

Unlike in a restaurant where people spend a long time eating and enjoying the time out in a social setting, people usually spend little time on commuter public transit. The trip may last from

5 to 15 minutes within a city. Commuting from outside the city may be a 45 minute trip. A restaurant session typically lasts from 1 to 3 hours.

These scenarios and ventilation rates have been plugged into the Well-Riley equation and the results are as follows. [[spreadsheet](#) Public Transit]

Table 73 - Ground Public Transit Probability of Infection

| Scenario | Masks | Chance of Infection | AUC | Ventilation |
|-----------------------------------|-------|---------------------|-------|---------------------------|
| Trolley, Bus, Train | Yes | < 1% to 1% | 20-30 | Transit |
| Trolley, Bus, Train | No | 10% to 20% | 20-30 | Transit |
| Trolley, Bus, Train | Yes | 6% | 1 * | Poor like in a restaurant |
| Trolley, Bus, Train | No | 97% to 99% | 1 * | Poor like in a restaurant |
| Japan Commuter Train open windows | Yes | 0% | 3600 | outside 1 mile / hr wind |
| Japan Commuter Train open windows | No | 0.07% ** | 3600 | outside 1 mile / hr wind |

* These extremely low AUC rates are not in ground transportation systems. This is shown here to demonstrate the importance of proper ventilation.

** This assumes there are no dead air conditions such as up against a wall or someone is not downwind from a close infection source - wear a mask until the virus is gone. See section [Virus Diffusion Classroom Design & Other Takeaways](#) nuclear engineering model.

The analysis appears to match the findings from France. The analysis also shows the importance of ventilation and wearing a mask. When there is poor ventilation it is clear that a mask will significantly reduce the risk of infection. This analysis and empirical data of the transportation systems also shows that ventilation systems must be upgraded in small spaces to reduce the risk of infection.

References:

[1] 24 LBI lifeguards positive for coronavirus after attending social gatherings together, NJ.com, July 25, 2020. webpage <https://www.nj.com/coronavirus/2020/07/20-lbi-lifeguards-test-positive-for-coronavirus-after-attending-parties-together.html>, July 2020. [LBI lifeguards positive for coronavirus after attending social gatherings together](#)

[2] SEPTA trains and buses have great airflow - which means less coronavirus risk for riders, WHYY PBS Philadelphia whyy.org, August 7, 2020, webpage <https://why.org/articles/septa-trains-and-buses-have-great-airflow-which-means-less-coronavirus-risk-for-riders>, August 2020. [SEPTA trains and buses have great airflow - which means less coronavirus risk for riders](https://why.org/articles/septa-trains-and-buses-have-great-airflow-which-means-less-coronavirus-risk-for-riders)

[3] Is the Subway Risky? It May Be Safer Than You Think, New York Times, August 2, 2020. Webpage <https://www.nytimes.com/2020/08/02/nyregion/nyc-subway-coronavirus-safety.html>, August 2020. [Is the Subway Risky? It May Be Safer Than You Think](https://www.nytimes.com/2020/08/02/nyregion/nyc-subway-coronavirus-safety.html)

[4] Japan has long accepted COVID's airborne spread, and scientists say ventilation is key, CBS News, July 13, 2020. webpage <https://www.cbsnews.com/news/coronavirus-japan-has-long-accepted-covids-airborne-spread-and-scientists-say-ventilation-is-key>, August 2020. [Japan has long accepted COVID's airborne spread, and scientists say ventilation is key](https://www.cbsnews.com/news/coronavirus-japan-has-long-accepted-covids-airborne-spread-and-scientists-say-ventilation-is-key)

[5] There Is Little Evidence That Mass Transit Poses a Risk of Coronavirus Outbreaks, Scientific American, July 28, 2020. webpage <https://www.scientificamerican.com/article/there-is-little-evidence-that-mass-transit-poses-a-risk-of-coronavirus-outbreaks> August 2020. [There Is Little Evidence That Mass Transit Poses a Risk of Coronavirus Outbreaks](https://www.scientificamerican.com/article/there-is-little-evidence-that-mass-transit-poses-a-risk-of-coronavirus-outbreaks)

[6] As restaurants reopen, here's what you should know about air conditioning, air flow and the coronavirus, Washington Post, May 28, 2020, webpage <https://www.washingtonpost.com/news/voraciously/wp/2020/05/28/as-restaurants-reopen-heres-what-you-should-know-about-air-conditioning-air-flow-and-the-coronavirus>, August 2020. [As restaurants reopen, here's what you should know about air conditioning, air flow and the coronavirus](https://www.washingtonpost.com/news/voraciously/wp/2020/05/28/as-restaurants-reopen-heres-what-you-should-know-about-air-conditioning-air-flow-and-the-coronavirus)

Virus Exposure Risk (Ver)

It is very difficult personally dealing with all these numbers. The stakeholders want to know what to do. To help guide this decision a Virus Exposure Risk (Ver) scale is provided that compares the exposure risk against one or more baselines that are considered safe. The comparison results in a scale that is based on how many times more or less risky one living scenario is compared to another living scenario. This is a multiplication factor. For example scenario 1 is 10 times more risk than scenario 2 where scenario 2 is considered the most safe scenario. The Ver can be calculated for each of the analysis approaches that were used to determine the risk of virus infection. The following analysis was used to determine the Virus Exposure Risk (Ver) scales.

- Virus Density by Distance (Electrical Engineering)
- Virus Diffusion by Distance and Windspeed (Nuclear Engineering)
- Virus Probability of Infection (Wells-Riley)

If the number is negative it means that the scenario is worse than the baseline scenario. So -60 means it is 60 times worse. This can be used to apply to a time factor. For example if it takes 1 hour to reach the virus load in the baseline, then it will take 1 minute to reach that same virus load in the scenario with a rating of -60 Ver. Conversely if it takes 1 hour to reach the virus load in the baseline, then it will take 60 hours to reach the virus load in the scenario with a rating of 60 Ver.

The following analysis shows the Ver using Virus Density by Distance (Electrical Engineering). The results show that you must keep your distance.

Table 74 - Virus Exposure Risk - Distance

| Scenario | Distance Feet | Virus Exposure Risk (Ver) | Comment | Scale -100 to 100 |
|----------|---------------|---------------------------|----------------------------|----------------------|
| 1 | 0.5 | -144 | Times Worse than 6 feet | |
| 2 | 1 | -36 | Times Worse than 6 feet | |
| 3 | 6 | 1 | Baseline Standard Guidance | |
| 4 | 16 | 7 | Times Better than 6 feet | |
| 5 | 26 | 19 | Times Better than 6 feet | |
| 6 | 36 | 36 | Times Better than 6 feet | |
| 7 | 46 | 59 | Times Better than 6 feet | |
| 8 | 56 | 87 | Times Better than 6 feet | |
| 9 | 66 | 121 | Times Better than 6 feet | |
| 10 | 76 | 160 | Times Better than 6 feet | |

The following analysis shows the Ver using Virus Diffusion by Distance and Windspeed (Nuclear Engineering). The results show that you must keep your distance. It becomes more critical to keep your distance as the wind speed drops. This will happen in the middle of a crowd or up against a wall.

Table 75 - Virus Exposure Risk - Distance and Wind

| Scenario | Distance Feet | Ver 1 mile / hour wind | Ver 0.5 mile / hour wind | Ver 0.25 mile / hour wind | Worse (-) or Better than baseline Scale -100 to 100 |
|----------|---------------|------------------------|--------------------------|---------------------------|---|
| 1 | 0.5 | -144 | -288 | -576 | |
| 2 | 1 | -36 | -72 | -144 | |
| 3 | 6 | 1 | 1 mile per hour | 1 mile per hour | Baseline Standard Guidance 1 mile per hour wind |
| 4 | 16 | 7 | 4 | 2 | |
| 5 | 26 | 19 | 9 | 5 | |
| 6 | 36 | 36 | no need | no need | |

| Scenario | Distance Feet | Ver 1 mile / hour wind | Ver 0.5 mile / hour wind | Ver 0.25 mile / hour wind | Worse (-) or Better than baseline Scale -100 to 100 |
|----------|---------------|------------------------|--------------------------|---------------------------|---|
| 7 | 46 | 59 | no need | no need |  |
| 8 | 56 | 87 | no need | no need |  |
| 9 | 66 | 121 | no need | no need |  |
| 10 | 76 | 160 | no need | no need |  |

The following analysis shows the Ver using Virus Probability of Infection (Wells-Riley). There are 2 different baselines that are used to make the comparison. Both baselines are a large indoor space but Baseline 1 does not use a mask and Baseline 2 uses a masks where both the infected and uninfected individuals are wearing mask. The results are more difficult to see but they show that small indoor spaces like classrooms and restaurants have a very high Ver. Also it shows that a mask should be worn in large indoors spaces. Finally we see that outdoor spaces have the best Ver and allow for normal life to proceed as long as the outdoor space is not converted to an indoor type of space because of large crowds and blocked areas such as up against a wall.

Table 76 - Virus Exposure Risk - Well-Riley Probability

| No | Scenario | time hour | Masks | Chance of Infection | Space cu-ft | AUC | Ver Baseline 1 (no mask large indoor) | Ver Baseline 2 (mask large indoor) | Worse (-) or Better than baseline Scale -100 to 100 |
|----|---|-----------|-------------------------------|---------------------|-------------|------|---------------------------------------|------------------------------------|---|
| 1 | Small indoor space Small Restaurant Not sure how to eat with a mask | 1 | Yes | 4% | 10,800 | 4.00 | -1 | -21 | |
| 2 | Small indoor space Small Restaurant Reality no mask while eating | 1 | No | 72% | 10,800 | 4.00 | -21 | -341 | |
| 3 | Small indoor space Best case school & work Setting | 8 | Yes | 6% | 10,800 | 4.00 | -2 | -30 | |
| 4 | Large indoor space Shopping | 1 | Yes | ~ 0% | 400,000 | 4.00 | 16 | 1 | |
| 5 | Large indoor space Retail Work | 8 | Yes | 2% | 400,000 | 4.00 | 2 | -7 | |
| 6 | Large indoor space | 1 | No | 3% | 400,000 | 4.00 | 1 | -16 | |
| 7 | Small indoor space School Setting Small Restaurant | 1 | Yes but 1 hour mask off | 99% | 10,800 | 1.00 | -29 | -471 | |

| No | Scenario | time hour | Masks | Chance of Infection | Space cu-ft | AUC | Ver Baseline 1 (no mask large indoor) | Ver Baseline 2 (mask large indoor) | Worse (-) or Better than baseline Scale -100 to 100 |
|----|---|-----------|-------------------------|---------------------|-------------|---------------------------------|---------------------------------------|------------------------------------|---|
| 8 | Small indoor space School Setting | 1 | Yes but 1 hour mask off | 72% | 10,800 | 4.00 | -21 | -341 | |
| 9 | Small indoor space School Setting | 1 | Yes but 1 hour mask off | 12% | 10,800 | 40.00 Open windows with fans | -4 | -57 | |
| 10 | Outside small enclosed back yard 1 mile / hr wind | 1 | No | 1% | 10,800 | 3600 | 6 | -3 | |
| 11 | Outside small enclosed back yard 5 mile / hr wind | 1 | No | 0.11% | 10,800 | 18000 | 30 | -1 | |
| 12 | Outside beach park 1 mile / hr wind | 1 | No | 0.02% | 400,000 | 3600 | 221 | 14 | |
| 13 | Outside beach park 5 mile / hr wind | 1 | No | 0.00% | 400,000 | 18000 | 1106 | 69 | |
| 14 | Outside large beach park 1 mile / hr wind | 1 | No | 0.00% | 4,000,000 | 3600 | 2212 | 138 | |
| 15 | Outside large beach park 5 mile / hr wind | 1 | No | 0.00% | 4,000,000 | 18000 | 11059 | 691 | |

The scenario associated with Retail Work shows a -7. That is because it is compared against the ideal case where a stakeholder spends only 1 hour in a large retail store while the worker is in that environment 8 hours during a 1 day snapshot. The issue is to ensure that the large retail space is safe for the retail staff. This can only happen with a larger AUC (more than 4). Using a higher quality mask such as one that moves from the analysis baseline of 75% (4X reduction) to 90% (10X reduction) is also important.

Although the Ver can be a useful guide for stakeholders to compare different living scenarios, ultimately the probability of infection must be known and understood for each living scenario. That means looking at the detailed numbers and getting a feel for the level of safety in each scenario.

Modeling Equations

The following is a disclosure of the modeling equations used and considered in this analysis.

Table 77 - Modeling Equations

| Equation | Used In This Analysis | Source |
|---|-----------------------|--|
| <p>$C1 \cdot V1 = C2 \cdot V2$</p> <p>C1 = infection event (breathing, cough, sneeze) V1 = lung capacity volume C2 = infection level (dose needed) V2 = physical space volume</p> <p>V1 = TL = Total lung capacity (cu ft) = assumption C1 = IE = Infection event = Infected Sneeze (droplets) = assumption C2 = IL = Infection Level (droplets) = assumption IS = Infected Sneeze/cu ft (droplets) = IE * TL V2 = VIL = volume needed for infection level (cu ft) = IS/IL Idb = Infected Dose Received (breaths) = IL/1000 Ids = Infected Dose Received (seconds) = Idb AUC = Required Air Exchanges (per hour) = 3600/Ids</p> | <p>Yes</p> | <p>Sneeze Analysis Model. Based on Boyle's Law: $P1V1 = P2V2$.</p> |
| <p>$AUC = Idh / IL = Isb * Bs * 3600 / IL$</p> <p>Isb = Infected Single Breath (virus load) = assumption Bs = Breaths / Second = assumption Idh = Infected Droplets / Hour = Isb * Bs * 3600 IL = Infection Level (droplets) = assumption Sv1 = Seconds Needed to Reach Virus Load = IL / (Isb * Bs) AUC = Required Air Exchanges (per hour) = Idh / IL</p> <p>$AUC = Idh/IL = Ed * Ip * Epe * Eph / IL$</p> | <p>Yes</p> | <p>Virus Load Air Exchanges Needed Model. Engineering based.</p> |

| Equation | Used In This Analysis | Source |
|--|-----------------------|--|
| <p>Ed = Event - Cough (droplets) = assumption Ip = Infection percentage = assumption VL = Virus Load = Ed * Ip Epe = Event - Coughs / Event = assumption Eph = Event - Cough Events / Hour = assumption Eth = Event - Total Coughs / Hour = Epe * Eph Idh = Infected Droplets / Hour = VL * Eth IL = Infection Level (droplets) = assumption AUC = Required Air Exchanges / Hour = Idh / IL</p> | | |
| <p>AUC = Eth * N</p> <p>Epe = Event - Sneeze / Event = assumption Eph = Event - Events / Hour = assumption Eth = Event - Total Sneeze / Hour = Epe * Eph N = Number of People = assumption AUC = Required Air Exchanges / Hour = Eth * N Pie = Potential Infection Exposure (min) = 60 - AUC Pi = Probability of Infection = Pie / 60</p> <p>This led to an analysis based on probability of exposure.</p> | Yes | Event Based Air Exchanges Needed Model. Engineering based. |
| <p>t2 - t1 = - [ln (C2 / C1) / (Q / V)] X 60, with t1 = 0</p> <p>t1 = initial timepoint in minutes t2 = final timepoint in minutes C1 = initial concentration of contaminant C2 = final concentration of contaminant C2 / C1 = 1 - (removal efficiency / 100) Q = air flow rate in cubic feet/hour V = room volume in cubic feet Q / V = ACH</p> | Yes | CDC Airborne Contaminant Removal Model. [1] [2] |
| <p>TBIL = IL/(Bs * (3600/AUC) * VL)</p> <p>TBIL = IL/Vi1 TBIL = IL/(Bae * VL) TBIL = IL/(Bae * VL) TBIL = IL/(Bs * Es * VL) TBIL = IL/(Bs * (3600/AUC) * VL)</p> <p>AUC = AUC/Hour = Assumptions Bs = Breaths/Sec = Assumptions Es = Exposure/Sec = 3600/AUC Bae = Breaths/Air Exchange = Bs * Es (needed for when the Breaths/sec changes e.g. 0.5 or 2.0) Em = Exposure Min = (Exposure/Sec)/60 (to get a feel for exposure time) VL= Virus load = Assumption IL = Infection load = Assumption Vi1 = Virus inhaled (1 hr) = Bae * VL (any value above the Infection Load will lead to infection) Vi2 = Virus inhaled (2 hr) = Vi1 * 2 Vi3 = Virus inhaled (3 hr) = Vi2 * 3</p> | Yes | Full Picture Static Model. Engineering based. |

| Equation | Used In This Analysis | Source |
|---|-----------------------|--|
| TBIL = hr before infected load = IL/Vi1 | | |
| Infection Prediction = Virus Load * Time | Yes | Virus Transmission Mental Model. |
| <p>Pd=Ps/d²</p> <p>Pd = Power density at the target surface Ps = Power at the source d = distance</p> <p>Virus Load Destination = Pd Virus Load Source = Ps Distance = d</p> | Yes | Virus Density by Distance (Electrical Engineering). |
| <p>Ca= B*Qi / (u*x²)</p> <p>Ca = concentration at the point of interest (Bq/m³) Qi = released concentration per unit of time (Bq/s) x = distance between release vent and point of interest [m] u = speed of the wind [m/s] B = Unitless constant accounts for increase in air concentration along vertical wall because of air stagnation created by wakes.</p> <p>B = 30 against wall, B = 1 open air Radionuclides Atmospheric Dispersion, Source and Receptor on same building surface If x is greater than three times the diameter of the stack or vent below to calculate the air concentration with B = 30</p> <p>Virus Load Destination = Ca Virus Load Source = Qi Distance = x Wind Speed = u Open Air = B = 1 Against a Wall = B = 30</p> | Yes | Virus Diffusion by Distance and Windspeed (Nuclear Engineering). [3] |
| <p>(1) $V(dCz/dt) = PQinfCoa(t) + QsCs(t) + G(t) - (Qr + Qix + MacQac)Cz(t) - \sum_{i=1}^{Ns} VdiAsiCz(t)$</p> <p>(2) $Asi(dLsi/dt) = VdiAsiCz(t)$</p> <p>C = particle concentration in air [kg/m³], subscripts: zone, outdoor air, and supply Q = volumetric airflow rate [m³/s], subscripts: supply, return, infiltration, air cleaner, and local exhaust Lsi = surface loading for surface i [kg/m²] V = zone volume [m³] Asi = deposition surface area for surface i [m²] Vdi = particle deposition velocity for surface i [m/s]</p> | No | National Institute Of Standards (NIST) - A Tool to Model the Fate and Transport of Indoor Microbiological Aerosols (FaTIMA). [4] |

| Equation | Used In This Analysis | Source |
|--|-----------------------|---|
| <p>$(V_{di} = kd V / As)$ Ns = number of surfaces (floor, walls, and ceiling) Mac = particle filtration efficiency of air cleaner [-] kd = particle deposition rate [1/s] G = particle generation rate [kg/s] P = particle penetration factor [-] t = time [s]</p> | | |
| <p>$P = D/S = 1 - \exp(-Ipqt/Q)$</p> <p>P = probability of infection for susceptibles D = number of disease cases S = number of susceptibles</p> <p>I = number of infectors p = breathing rate per person (m³/s) q = quantum generation rate by an infected person (quanta/s) t = total exposure time (s) Q = outdoor air supply rate (m³/s)</p> <p>quanta = virus</p> <p>Infection Load * Virus / Breath * Breaths / Sec * Sec to Infection = q / sec</p> | Yes | Wells-Riley Probability of Infection. World Health Organization Natural Ventilation. [5] |
| <p>$P = D/S = 1 - \exp(-Ipqt/Q)$</p> <p>P = probability of infection for susceptibles D = number of disease cases S = number of susceptibles</p> <p>I = number of infectors p = breathing rate per person (m³/s) q = quantum generation rate by an infected person (quanta/s) t = total exposure time (s) Q = outdoor air supply rate (m³/s)</p> <p>Q = Space Cubic Feet * AUC</p> <p>quanta = virus</p> <p>Infection Load * Virus / Breath * Breaths / Sec * Sec to Infection = q / sec</p> | Yes | Wells-Riley Probability of infection. World Health Organization Natural Ventilation. Expanded to include various scenarios and AUC. [5] |
| . | | |
| <p>$C1 = [N/(V*Ve) * [1-\exp(-V*Ve*t/v)]]$</p> <p>C1 or C = Bioeffluent infectious aerosol concentration in the space at time t, virus/L N = Rate of bioeffluent infectious aerosol generation/person, virus/s per person t = Duration of infectious aerosol generation, sec</p> | Yes | HVAC industry. [6] [7] |

| Equation | Used In This Analysis | Source |
|---|-----------------------|-----------------------------------|
| <p>v = OD = Spatial volume/person, L/person V = Infectious aerosol-free ventilation rate per person, L/s per person (HVAC outdoor air + virus filtered recirculation air + envelope infiltration air) Ve = efficiency of supplying ventilation air to each person's breathing zone Ve = 1 in uniformly mixed system</p> <p>Ve = 0.65 Fully loaded subway car and a narrow-body aircraft Ve = 0.90 Stadium Ve = 1.00 Remaining settings Ve tends to be lower the higher the occupancy density</p> <p>D = IC integration => D = IC * time exposed D = IC = p * [NI/VVe] * {t + [OD/VVe] * [exp(-VVet/OD)-1] }</p> <p>D = Virus inhaled or virus dose I = Inhilaion rate L/s p = Fraction of infected persons = 1</p> <p>Infected when D > 1000 1 cu-m = 1000 liters 1 cu-m = 35.3 cu-feet</p> | | |
| . | | |
| . | | |
| <p>AUC = Air Updates / Hour - Air Update Change ACH = Air Changes / Hour - Air Change Rates Changes = Updates Note: fresh air exchange is identified separately such as Air <u>Exchange</u> Rates Min/Chg - Minutes / Change l/s = Liters / Second cfm = Cubic Feet / Minute</p> | Yes | Used in the various calculations. |

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[\[Library/Building-Ventilation\]](#)

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Airplanes and Airports

This analysis identifies the number of potential infected people and deaths as a result of holiday travel in 2020 using airplanes. There are three key numbers that drive the analysis: Number of Travelers, Percent of Population Infected, R0 basic reproduction number, the average number of new infections caused by each case.

The R0 number is based on examining various studies and performing a cross check using a passenger movement study [1] [2].

- An R0 of 22 comes from a 2003 study of the spread of SARS on a 3 hour flight from Hong Kong to Beijing on March 15, 2003 [1].
- An R0 of 15 comes from a 2020 study of the spread of SARS-CoV-2 on a 10 hours flight from London to Hanoi on March 2, 2020 [4].
- An R0 of 11 comes from the World Health Organization which defines contact with an infected person as being seated within two rows of one another [3].

This figure shows the seating of the passengers for the SARS outbreak that occurred on a flight from Hong Kong to Beijing on March 15, 2003:

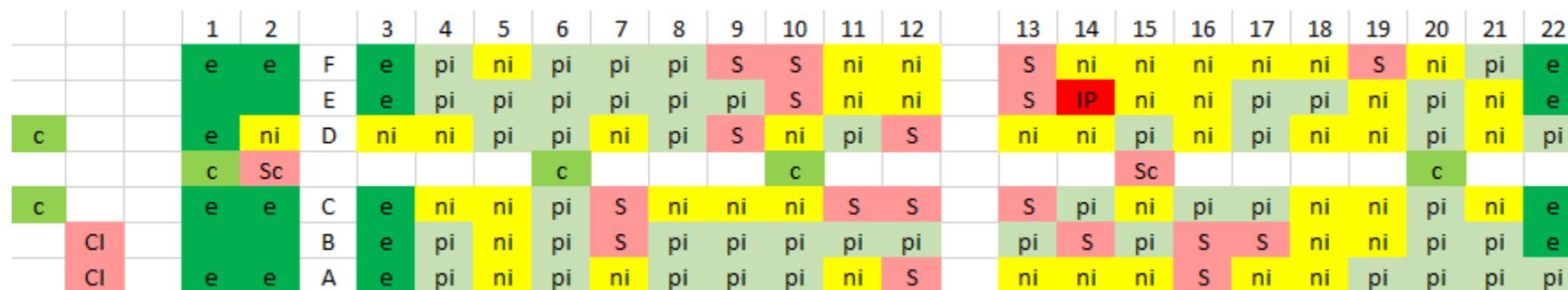


Figure 40 - R0 Airplane Flight Hong Kong to Beijing on March 15, 2003

Observation: There is a large cluster of people sitting near the infected person that were not interviewed.

| Categories | Count |
|--|-------|
| IP - Infected | 1 |
| S - Probable SARS Case | 18 |
| e - Empty Seat | 17 |
| ni - No Illness Person Not Interviewed | 46 |
| pi - No Illness Person Interviewed | 47 |
| c - Crew | 7 |
| Sc - Sick Crew | 2 |
| CI - Chinese officials unknown seats | 2 |
| Total New SARS Cases = R0 | 22 |

The total new SARS cases experienced on this airplane flight is the R0 for this setting.

This figure shows the seating of the passengers for the COVID-19 outbreak that occurred on a flight London to Hanoi on March 2, 2020:

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|---|---|---|----|----|----|---|----|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|----|--|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | 10 | 11 | 12 | - | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | | 39 | 40 | | | | |
| K | e | pi | S | S | IP | e | e | G | ni | pi | pi | - | pi | pi | K | e | e | pi | e | pi | ni | pi | pi | pi | K | e | pi | pi | pi | ni | pi | pi | ni | pi | K | e | | | |
| | | | | | | | | | | | | | | | | G | e | e | e | e | pi | ni | pi | pi | ni | G | e | pi | pi | pi | e | pi | e | e | pi | e | e | e | e | pi | pi | G | e | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Sc | |
| G | pi | e | pi | S | S | S | S | F | pi | pi | ni | - | pi | pi | F | e | pi | e | e | pi | pi | pi | pi | ni | F | e | pi | pi | pi | e | e | pi | pi | pi | e | pi | e | pi | e | pi | pi | F | e | e | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| D | pi | e | S | S | S | S | S | D | pi | pi | pi | - | pi | pi | D | pi | pi | e | e | pi | pi | pi | e | S | E | e | pi | pi | pi | pi | pi | e | pi | D | e | e | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| A | pi | ni | pi | pi | S | e | e | A | ni | pi | pi | - | ni | ni | A | e | pi | A | e | ni | pi | ni | ni | ni | pi | ni | e | pi | ni | e | pi | e | pi | pi | A | e | | | |

Figure 41 - R0 Airplane Flight London to Hanoi on March 2, 2020

Observation: The infection cluster suggests that the business class cabin area had poor ventilation.

| Categories | Count |
|--|-------|
| IP - Infected | 1 |
| S - Probable SARS Case | 14 |
| e - Empty Seat | 80 |
| ni - No Illness Person Not Interviewed | 30 |
| pi - No Illness Person Interviewed | 160 |
| c - Crew | 4 |
| Sc - Sick Crew | 1 |
| . | . |
| Total New COVID-19 Cases = R0 | 15 |

The total new COVID-19 cases experienced on this airplane flight is the R0 for this setting.

This is the probability of being in contact with the infected person based on passenger movement in an airplane with an infected person sitting in the middle of the cabin area [2]:

[[spreadsheet](#) Travel, Airplane R0]

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | |
|---|----|----|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|----|------------------|-----|
| F | 10 | 10 | 10 | 10 | 10 | 20 | 30 | 30 | 30 | 20 | 40 | 40 | 50 | 40 | 40 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| E | 30 | 30 | 30 | 30 | 30 | 30 | 40 | 40 | 50 | 50 | 60 | 60 | 90 | 90 | 90 | 70 | 70 | 70 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| D | 30 | 30 | 30 | 40 | 50 | 40 | 50 | 50 | 60 | 60 | 60 | 60 | 100 | 100 | 100 | 80 | 80 | 70 | 70 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | flight attendant | 100 |
| C | 30 | 30 | 30 | 40 | 40 | 40 | 50 | 60 | 70 | 60 | 60 | 60 | 100 | 100 | 100 | 80 | 80 | 70 | 70 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| B | 40 | 30 | 30 | 30 | 30 | 30 | 40 | 40 | 50 | 50 | 60 | 60 | 100 | 100 | 100 | 70 | 70 | 70 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| A | 10 | 10 | 10 | 10 | 10 | 20 | 30 | 30 | 30 | 30 | 40 | 40 | 100 | 100 | 100 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |

Figure 42 - Probability Of Contact With Infected Person On Airplane

This information was used to determine a possible R0. From the figure we see an R0=11 as represented by the seats marked with 100. The question then becomes what are the additional factors that might contribute to the R0. The approach was to multiply the contact probability by the number of seats at that level and then apply a 10% probability of infection to that factor. That results in an R0 of 18. This matches the 2003 empirical data study [1].

R0a = R0 addition factor = contact probability * number of seats at that level * 10% probability of infection (based on ~ wells-riley with some time mask off)

e.g. 80% * 4 = 3.2 * 10% = 0.32

R0 final = R0 + sum (R0a) results in an R0 of 18.

This is the probability of being infected in airplane with an infected person sitting in the middle of the cabin area [2]:

[[spreadsheet](#) Travel, Airplane R0]

The analysis results are:

[\[spreadsheet](#) Travel, Airplane R0]

Table 78 - 2020 Holiday Travel Infections and Deaths

| Events | Travelers | Newly Infected Population | % Infected Pop | R0 Travel | Infections | Deaths @ 3% | Comment |
|-------------------|----------------|---------------------------|----------------|------------|------------------------|--------------------------|--|
| Thanksgiving 2020 | 9,400,000 [5] | 4,000,000 [D] | 1.22% | 18 13.4 | 2,063,415 1,536,098 | 61,902 46,083 | More than 9.4 million people screened in Thanksgiving travel window, which began on Friday before holiday [5]. |
| Christmas 2020 | 14,379,042 [6] | 5,000,000 [D] | 1.52% | 18 13.4 | 3,945,469 2,937,182 | 118,364 88,115 | TSA screened 7,189,521 people to Christmas Eve. People who left for the holiday will come home [6]. |

Multiple areas of this analysis have suggested that the initial transmission of the virus was via airplanes and airports. This was all clearly published March 6, 2020 [3]. The behavior of SARS on an airplane was studied in 2003 and 2018 [1] [2] with simple results that should have translated into policy when COVID-19 broke out in 2020 with an emphasis on maintaining that policy through the holiday travel rush. The policy was simple:

1. One passenger or family group every other row or every second row
2. Immediate transfer to pre 9/11 passenger screening procedures, post 9/11 TSA screening unable to control crowd size

We see that during the 2020 Thanksgiving and Christmas holidays the infection rate spiked with each event. It was clear that numbers did not need to be provided because all the other analysis provided overwhelming evidence that airplane and airport crowd control modifications were needed [A] [B]. They did not happen. The policy makers gravely failed once again [C] [F] [G].

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[A] See section [Current US Infrastructure Virus Concentration](#).

[B] See section [Virus Diffusion](#).

[C] See section [System Collapse](#).

[D] See section [Death Rates](#).

[E] See section [Droplets Versus Aerosols](#).

[F] See section [Return To Life Systems Performance](#).

[G] See section [Second Wave Accountability](#).

Certification

Certification applies to systems that must be safe and secure under all conditions including in the presence of multiple failures. This is typically accomplished with inherent system safety and security and with significant levels of fault detection, fault tolerance, and fail-safe mechanisms. Trying to certify a system without fault detection, fault tolerance, and failsafe mechanisms is usually a sign of a severely compromised organization. It is rare when a system can be certified with just inherent safety and or security in the architecture and the resulting implementation.

Certification is given by a third-party entity such as a government agency.

Certification includes analysis of the process and the solution. It can involve proof like elements. The developers need to show that there was a consistent process that was followed to design and implement the system. Deviation from the process raises concern because it may represent compromises in system. The solution needs to be documented and show strong traceability, especially to the tests. Without the traceability there is concern because once again it may represent compromises in the system.

During certification all information products (plans, analysis, specifications, design artifacts, tests, manuals, etc.) are examined and a confidence level is achieved so that the system can be certified.

A separate body of people based on the certification evidence certifies the system. This is the certification board. The certification board consists of representatives from: Engineering, Test, Quality, Production, Users, Maintenance, Support, Logistics, Training, Deployment, Users. Since most systems use machines and significant technology the greatest weight is carried by the Engineers and Testers. The other organizations will typically approve the system because their concerns are easiest to address. Engineering on the other hand looks inside the system and has an enormous responsibility to ensure nothing was missed. Next comes test who provide the test results. The issue with test is similar to engineering to ensure in this case that no tests were missed or incorrectly performed.

The certification process starts with the architecture. If the architecture is flawed the system cannot be certified . It continues with the design, implementation, production, distribution, and use. At any point the certification can be rejected. This suggests that certification begins with the start of the project. Information products are developed and offered to the certification board. The information products in sequence are:

1. Plans
2. Process Description
3. Analysis Results
4. Architecture Description
5. Design Artifacts
6. Production Plans
7. Deployment Plans
8. Integrated Logistics Support (ILS) Plans
9. Test Results

As the system unfolds the information products are updated and provided to the certification board. This ensures that the board is not overwhelmed with data and the board can check the system to see if there may be certification problems moving forward. Most automation-based system developers run at risk and continue with system development and do not wait for the board to provide comments. This is contrary to physical systems like an office building where activity stops or slows significantly until there is an official signal from the certification authority to continue.

Most people equate diagnostics with maintenance and trying to isolate a fault so that it can be repaired. However, diagnostics are also used to certify that a system is ready to be used. Well

check or certification diagnostics are used to surface faults in an operational system. The idea is that the diagnostics stimulate all the critical points in the system that normal operations may not immediately stimulate.

The diagnostics can be manual or automated. Most people think in terms of automated diagnostics especially in computer-based systems. However, manual diagnostics are just as important. A manual diagnostic might be a visual inspection using an approved or certified checklist. For example, those who fly small personal airplanes check the airplane using an approved checklist prior to starting the engine and proceeding to taxi. The checklist includes visual inspection of the tires, landing gear, rudder, tail, ailerons, wings, flaps, propeller, fuselage, etc. When the automobile was new it was not uncommon for people to check the belts, tires, fluids, brakes, lights, and filters prior to a long trip.

System or Product Certification

This is a description of a certification strategy for a generic system or product. With each new activity the artifacts from the previous activities are updated. The issue is that all the artifacts must be current and consistent or certification will be rejected because of a loss of confidence in the process and execution.

Table 79 - Certification Approach

| Activity | Formal Systems Practice | Artifact | Comment |
|--|--|--|---|
| Description of Certification Process | - Planning | Certification Plan | Provided to the certification authority at the start of the project. |
| Identification of Unsafe Events | - Safety analysis | Unsafe Events List | Provided to the certification authority as soon as the project technical work begins and is refined during the project. |
| Identification of Safety Critical requirements | - Safety requirements analysis - Refined safety analysis | Safety Critical Requirements Specification | Provided to the certification authority as soon as the project technical work begins and is refined during the project. |
| Fault Tolerant Failsafe Architecture | - Safety architecture development - Traceability to safety requirements | Fail Safe Architecture Analysis Document | Provided to the certification authority as soon as it is available and is refined during the |

| Activity | Formal Systems Practice | Artifact | Comment |
|---|--|---|---|
| | <ul style="list-style-type: none"> - Fault Tree Analysis - Performance Analysis - Refined safety critical requirements | | project. |
| Fault Tolerant Failsafe Design | <ul style="list-style-type: none"> - Safety design - Matches architecture - Traceability to safety requirements - Updated Fault Tree Analysis - Failure Mode Effects Analysis | Fail Safe Architecture & Design Analysis Document | Provided to the certification authority as soon as it is available and is refined during the project. |
| Design Implementation | <ul style="list-style-type: none"> - Safety Implementation - Matches design - Traceability to safety requirements - Updated Fault Tree Analysis - Failure Mode Effects Analysis | Implementation artifacts like software code and pre-production prototypes | Provided to the certification authority as soon as it is available. |
| Preliminary Safety Critical Testing, Verification, & Validation | <ul style="list-style-type: none"> - Safety critical testing | Preliminary safety critical test plan, procedures, and report | Provided to the certification authority as soon as it is available. |
| Production | <ul style="list-style-type: none"> - Proof that production matches design implementation | Production plan and final production system or product | Provided to the certification authority as soon as it is available. |
| Final Safety Critical Testing, Verification, & Validation | <ul style="list-style-type: none"> - Safety critical testing | Final safety critical test plan, procedures, and report | Provided to the certification authority as soon as it is available. |
| Tamper Proof Distribution | <ul style="list-style-type: none"> - Safety critical testing | Final safety critical test plan, procedures, and | Provided to the certification authority as |

| Activity | Formal Systems Practice | Artifact | Comment |
|--------------------------------------|---------------------------|---|---|
| | | report | soon as it is available. |
| Tamper Proof Operation & Maintenance | - Safety critical testing | Final safety critical test plan, procedures, and report | Provided to the certification authority as soon as it is available. |
| Certificate Issued | N/A | N/A | System or product can now be provided to the users. |

The technical activity begins with the identification of unsafe events and safety critical requirements.

The unsafe events are used to determine if the system will result in an unsafe condition. This is usually performed using a formal fault tree analysis. Words and logic cannot be used because the informal method does not provide the rigor to surface unintended consequences like a formal method such as fault tree analysis. The fault tree analysis begins with the architecture, is refined with the design, and is finally refined with the implementation. During implementation the formal top down fault tree analysis is augmented with a bottoms up formal Failure Mode Effects Analysis. FMEA is also a formal method that is based on extreme rigor.

The following is a list of possible unsafe events for a vaccine:

1. The vaccine does not work
2. The vaccine is not effective over a large enough population
3. The vaccine causes infection spread
4. The vaccine causes loss of long term health
5. The vaccine causes death
6. Vaccine contamination or spoilage is not detected

The possible safety critical requirements start by examining the list of unsafe events. The possible safety critical requirements for a vaccine based on the identified unsafe events are:

1. The vaccine shall establish antibodies that protect against infection from the contagion for a minimum of 60% of the vaccinated population.
2. The vaccine shall not cause active virus shedding.
3. The vaccine shall not damage internal organs, other body systems, or cause death within 30 days, 6 months, or 1 year.
4. A contaminated or spoiled vaccine shall not damage internal organs, other body systems, or cause death within 30 days, 6 months, or 1 year.
5. After 20 days all vaccinated patients shall be tested for the correct antibodies.
6. All vaccinated patients that fail to produce antibodies shall start an analysis of the batch production run to determine if there was a problem in production, distribution, or delivery.

The actual safety analysis should be significantly more complete than this simple example. The safety analysis also needs to be augmented with a security analysis to ensure the vaccine is not compromised by bad actors. There are also additional safety analysis areas that include distribution and delivery.

If we examine this simple example we see the importance of the test plan, procedures, and results. The tests include both animal and human tests. There are also extreme details which will affect the expected effectiveness of the vaccine. For example, humans were not consciously infected with the virus. Even though the effectiveness may be less than anticipated the tests should have determined if there are any bad side effects from the vaccine. The issue in this case is the test population subjected to the vaccine. For example pregnant women were not subjected to the vaccine.

In this type of setting with unknowns typically the system or product is rolled out slowly and closely observed for negative unintended consequences. With the vaccine this slow roll out is a natural artifact with the production and logistics limitations. The implications are that the true final certification will happen when the first group of people are vaccinated. This is typically called system validation for other mission critical systems. For example air traffic control systems and their updates are not validated until they appear at the first site and are subjected to live operations.

This entire process of certification is an evolving process of building confidence using our best uncompromised efforts.

Pfizer BioNTech Phase 1 2 3 Study Protocol

Pfizer / BioNTech disclosed their Phase 1/2/3 study. The study evaluates the Safety, Tolerability, Immunogenicity, and Efficacy of the SARS-CoV-2 RNA vaccine against COVID-19 In healthy individuals. This is a critical information product used to certify the vaccine [1] [2]. The study was performed on healthy individuals. It is unclear what the implications are for unhealthy individuals and that is something the Certification Authority must consider when addressing the entire system not just the vaccine. The system includes vaccine manufacturing, distribution, delivery and follow up. The Pfizer / BioNTech vaccine is only one part of the system. See section [Vaccine Systems Perspective](#).

The purpose of the study is to rapidly describe the safety, tolerability, and immunogenicity of 2 BNT162 RNA-based COVID-19 vaccine candidates against COVID-19, and the efficacy of 1 candidate, in healthy individuals. From the study [1]:

The development of an RNA-based vaccine encoding a viral antigen, which is then expressed by the vaccine recipient as a protein capable of eliciting protective immune responses, provides significant advantages over more traditional vaccine approaches. Unlike live attenuated vaccines, RNA vaccines do not carry the risks associated with infection and may be given to people who cannot be administered live virus (eg, pregnant women and immunocompromised persons). RNA-based vaccines are manufactured via a cell-free in vitro transcription process, which allows an easy and rapid production and the prospect of producing high numbers of vaccination doses within a shorter time period than achieved with PF-07302048 (BNT162 RNA-Based COVID-19 Vaccines) Protocol C4591001 traditional vaccine approaches. This capability is pivotal to enable the most effective response in outbreak scenarios.

The following are some of the key elements described in the study [1]:

- Evaluate the efficacy of confirmed COVID-19 in participants without evidence of infection before vaccination
- Evaluate the efficacy of confirmed COVID-19 in participants with and without evidence of infection before vaccination
- Evaluate the efficacy of confirmed severe COVID-19 in participants without evidence of infection before vaccination
- Evaluate the efficacy of confirmed severe COVID-19 in participants with and without evidence of infection before vaccination
- Local reactions for up to 7 days following each dose
- Systemic events for up to 7 days following each dose
- Local reactions are pain at the injection site, redness, and swelling
- Systemic events are fever, fatigue, headache, chills, vomiting, diarrhea, new or worsened muscle pain, and new or worsened joint pain
- Adverse events (AEs) from Dose 1 to 1 month after the last dose
- Serious AEs (SAEs) from Dose 1 to 6 months after the last dose
- AE and SAE Recording/Reporting are:
 - 1 - MILD Does not interfere with participant's usual function.
 - 2 - MODERATE Interferes to some extent with participant's usual function.
 - 3 - SEVERE Interferes significantly with participant's usual function.
 - 4 - LIFE-THREATENING Life-threatening consequences; urgent intervention indicated.
- Abnormal hematology and chemistry laboratory values 1 and 7 days after Dose 1; and 7 days after Dose 2
- Grading shifts in hematology and chemistry laboratory assessments between baseline and 1 and 7 days after Dose 1; and before Dose 2 and 7 days after Dose 2
- Various statistical analysis 7 and 21 days after Dose 1; 7 and 14 days and 1, 6, 12, and 24 months after Dose 2

Table 80 - Local Reaction Grading Scale [1]

| Symptom | Mild (Grade 1) | Moderate (Grade 2) | Severe (Grade 3) | Potentially Life Threatening (Grade 4) |
|-----------------------------------|---|---|--|---|
| Pain at the injection site | Does not interfere with activity | Interferes with activity | Prevents daily activity | Emergency room visit or hospitalization for severe pain |
| Redness | >2.0 cm to 5.0 cm (5 to 10 measuring device units) | >5.0 cm to 10.0 cm (11 to 20 measuring device units) | >10 cm ≥ 21 measuring device units) | Necrosis or exfoliative dermatitis |
| Swelling | >2.0 cm to 5.0 cm (5 to 10 | >5.0 cm to 10.0 cm (11 to 20 | >10 cm ≥ 21 measuring | Necrosis |

| Symptom | Mild (Grade 1) | Moderate (Grade 2) | Severe (Grade 3) | Potentially Life Threatening (Grade 4) |
|---------|-------------------------|-------------------------|------------------|--|
| | measuring device units) | measuring device units) | device units) | |

Table 81 - Systemic Event Grading Scale [1]

| Symptom | Mild (Grade 1) | Moderate (Grade 2) | Severe (Grade 3) | Potentially Life Threatening (Grade 4) |
|------------------------------------|----------------------------------|---------------------------------|------------------------------------|--|
| Vomiting | 1-2 times in 24 hours | >2 times in 24 hours | Requires IV hydration | Emergency room visit or hospitalization for hypotensive shock |
| Diarrhea | 2 to 3 loose stools in 24 hours | 4 to 5 loose stools in 24 hours | 6 or more loose stools in 24 hours | Emergency room visit or hospitalization for severe diarrhea |
| Headache | Does not interfere with activity | Some interference with activity | Prevents daily routine activity | Emergency room visit or hospitalization for severe headache |
| Fatigue/tiredness | Does not interfere with activity | Some interference with activity | Prevents daily routine activity | Emergency room visit or hospitalization for severe fatigue |
| Chills | Does not interfere with activity | Some interference with activity | Prevents daily routine activity | Emergency room visit or hospitalization for severe chills |
| New or worsened muscle pain | Does not interfere with activity | Some interference with activity | Prevents daily routine activity | Emergency room visit or hospitalization for severe new or worsened muscle pain |
| New or worsened joint pain | Does not interfere with activity | Some interference with activity | Prevents daily routine activity | Emergency room visit or hospitalization for severe new or worsened joint pain |

Table 82 - Scale of Fever [1]

| Fever | Action |
|-------------------------------|--------|
| >=38.0-38.4 C (100.4-101.1 F) | |

| Fever | Action |
|------------------------------|---|
| >38.4-38.9 C (101.2-102.0 F) | |
| >38.9-40.0 C (102.1-104.0 F) | Telephone contact should occur to gather more details and determine whether a site visit is clinically indicated. |
| >40.0 C (>104.0 F) | Notify the sponsor and, if it is determined to be related to the administration of the study intervention, further vaccinations will be discontinued in that participant. Only an investigator or medically qualified person is able to confirm a participant's fever as >40.0 C (>104.0 F) |

Pfizer BioNTech Phase 1 2 3 Study Protocol and study results are key information products used to certify the vaccine. However certifying the vaccine does not certify the Vaccination System which includes manufacturing, distribution, delivery, and follow up. Each of those system areas must be subjected to the same level of rigor to ensure that the Vaccination System is safe and effective.

References:

[1] A Phase 1/2/3, Placebo-Controlled, Randomized, Observer-Blind, Dose-Finding Study To Evaluate The Safety, Tolerability, Immunogenicity, And Efficacy Of SARS-CoV-2 RNA Vaccine Candidates Against COVID-19 In Healthy Individuals, webpage https://pfe-pfizercom-d8-prod.s3.amazonaws.com/2020-09/C4591001_Clinical_Protocol.pdf, December 2020. [PDF . local](#)

[2] Allergy warning for Pfizer/BioNTech vaccine after UK health workers with allergy history suffer reaction, CNN, December 9, 2020. webpage <https://www.cnn.com/2020/12/09/health/covid-vaccine-allergies-health-workers-uk-intl-gbr/index.html>, December 2020. [Allergy warning for Pfizer/BioNTech vaccine after UK health workers with allergy history suffer reaction](#)

Certification Failure

When there is a major failure of a certified system an examination of the certification process is performed. The root cause of the certification failure is always the same, the desire to get the system or product out as soon as possible. The techniques that are used to compromise the certification process are as follows:

- Bully Tactics: All the information is withheld until the last minute and then all the artifacts are dumped on the certification board for review. Pressure is then applied to provide immediately certification. A healthy certification authority will stop the activity as soon as it does not received preliminary information like plans, process descriptions, and safety critical requirement. They will issue a letter that the certification will not be granted and be silent. If the developer panics then sees the light they start to respond as expected. The certification authority having no confidence in the organization will put

them under an extreme microscope and examine everything multiple times. A compromised certification authority will ignore the communication failure and rubber stamp the certification when directed to provide the certification.

- **Inappropriate Certification Board:** The certification board is missing key stakeholders like engineers, scientists, test and validation specialists, and operational stakeholders that must use the system or product.
- **Fast Track Selection:** This is also called a delta certification. Many times a system or product is a slight modification of a previously certified system. However there are times when the system or product may appear to be a slight modification but actually is a major change. This typically happens when engineers are removed from this key decision and management is permitted to make this decision. In a delta certification there are significantly less analysis and testing activities, which is why the delta certification is requested. The system or product receives a delta certification goes operational and then disaster happens where people get sick and or die.
- **A Failure of Imagination:** This is where everyone is doing the best that they can. There are no compromises anywhere in the process and execution. The technology was just too complex and an unintended consequence surfaced and caused serious harm. An example of this is the Apollo I cabin fire February 21, 1967.
- **Flawed Certification Process:** The certification process is sabotaged and does not cover the entire life cycle of the system or product. For example manufacturing, distribution, operational use, and or maintenance are not examined and made part of the certification. This is basically gaming the system for success and happens when there is a complete collapse of the organization. Certification is a well-known and documented event with standards coming from the National Institute of Standards and existing within every US government agency that certifies systems and products.

FDA Certification Failure

In 2012, hip replacement manufacturer Stryker announced it was issuing a voluntary recall on the Rejuvenate ABG II modular neck stems [1]. The main problem was corrosion and release of cobalt and chromium into the blood stream. Stryker announced it would settle the lawsuits, paying upwards of \$1.4 billion to patients.

The root cause of the failure was the hip was fast tracked through the FDA by a new manager at Stryker. This manager had the same influence at Johnson and Johnson which also found itself with a defective hip that needed to be recalled. It is unclear why this manager was hired by Stryker and placed into the same type of position to force fast track certification. Stryker realized they had a problem and issued a self-recall and offered to pay for the costs of all hip replacements. The ABG II modular neck stem hip certification was based on a previously certified one piece hip system. The Rejuvenate ABG II system broke the hip into two pieces allowing surgeons to perform a better fit and perhaps more procedures per day.

The problem is that any engineer or machinist could immediately detect that the dissimilar metals between the two pieces would cause electrolysis and lead to breakdown and release of cobalt chromium into the blood stream. This is a classic case of extreme arrogance and ignoring key stakeholders.

The FDA 510(k) process allows manufacturers to forgo clinical testing in humans by claims that a device is similar to other products already on the market. The Stryker products approved under

the 510(k) pathway were likely never tested in research patients before being offered to the public. However, this is such an obvious engineering defect even the fast track process should have caught the problem. It suggests that the FDA was severely compromised and either ignored the engineers and other specialist on the certification board or consciously kept them out of the certification authority chain. Doctors and surgeons cannot provide guidance on what is an engineering, manufacturing, and use problem. For example, nine Philadelphia physicians invented or helped to develop a new joint replacement and received royalties and consulting fees. As the inventors and developers they would have provided information to the FDA certification board [2].

In 2019 a small start-up pharmacy with 14 employees found that Zantac and its generic form, ranitidine, contained a chemical thought to cause cancer. More than 40 countries have either stopped sales or launched investigations. In the US, the FDA confirmed unacceptable levels of N-nitrosodimethylamine (NDMA), in some ranitidine products including in syrups taken by babies [3].

The company checks the chemical makeup of drugs before shipment to consumers. It rejects more than 10 percent of the batches because tests detect contaminants, medicines that don't dissolve properly, pills that contain the wrong dose, and other problems. Occasionally they find a problem so urgent they play the role of watchdog.

This is a pharmacy company, buying drugs from wholesalers, and then selling to consumers. As of 2019 it is the only company that chemically tests the medicines it dispenses. The company was started when the founder refilled a prescription only to find that the new identical drug didn't work. The doctor suggested trying another pharmacy because it was probably a bad batch. The founder searched for a lab to verify the chemical contents of medications and could not find any.

[1] FLASH: Stryker recalls pair of metal hip implants, halts global production, MASS DEVICE July 6, 2012. webpage <https://www.massdevice.com/flash-stryker-recalls-pair-metal-hip-implants-halts-global-production>, [FLASH: Stryker recalls pair of metal hip implants, halts global production](#)

[2] The 10 Philly docs who got more than \$400K in medical-industry payouts, by Tom Avril, STAFF WRITER, Posted: March 16, 2017. webpage <https://www.inquirer.com/philly/health/rothman-payments-hip-knee-replacement-jefferson.html>, [The 10 Philly docs who got more than \\$400K in medical-industry payouts](#)

[3] A tiny pharmacy is identifying big problems with common drugs, including Zantac, The Washington Post, Carolyn Y. Johnson, November 8, 2019.

FAA Certification Failure

Boeing produced the B737 MAX and it became one of the worst engineering disasters in recent times. After two fatal crashes of the Boeing 737 MAX, regulatory authorities around the world grounded the 737 MAX until further notice. The accidents occurred with Lion Air Flight 610 on October 29, 2018 and Ethiopian Airlines Flight 302 on March 10, 2019. After the first crash, evidence was mounting in the public media that there was a problem with the B737 MAX and many were questioning why the FAA was not taking action that may have even included grounding the aircraft. The excuse was that not all the facts were available to ground the aircraft.

Even after the second aircraft crashed the FAA was referring to insufficient facts to warrant grounding of the aircraft. Meanwhile after the second crash on March 11, 2019 the rest of the world grounded the aircraft and would not allow it to enter their airspace. Eventually the FAA on March 13, 2019 also grounded the aircraft. This is the first time the FAA did not lead the world in such a critical situation.

After 2001, manufacturers complained to Congress about FAA delays in certification. The Republican-controlled Congress in 2003 ordered the FAA to delegate nuts-and-bolts compliance work to the manufacturers. In 2009, the FAA delegated authority to Boeing the first of what would become more than 80 aviation companies that were allowed to certify the safety of their own products. The approach called self-certification meant that developers certified their own products. This is basically a self-licking ice cream cone.

Having developers certify their own products is viewed as irresponsible and dangerous by seasoned engineering professionals and engineering managers. This is not a technology issue. It is a social issue that is not understood by financially educated and financially driven management. They don't know how people will compromise systems as the engineering challenges surface each day. Many have questioned how Boeing, a company renowned for engineering, made basic mistakes leading to a pair of deadly crashes and the grounding of the airplane for a problem that was described as a software problem. Boeing engineers say the effort was complicated by a push to outsource work to lower-paid contractors with no background in fault tolerant fail safe avionics. The official management talking point was that there was a software problem. That message is still being provided, however it is a lie. The avionics system in question had a non-fault tolerant non failsafe architecture that could never be certified. Further its design included algorithms that were not failsafe and could never be certified.

Because the FAA had insufficient staff and the developer was forced to self-certify the system it developed, there was no independent mechanism to determine if the certification process itself was compromised. Certification itself must be fault tolerant to ensure that any compromise will not lead to a false certification. Unfortunately Boeing management changed and they apparently had no basic engineering knowledge of how their product worked and what was needed to make it safe. The Boeing management then proceeded to subvert the engineers and force the certification.

This was happening during a period when the Transportation Department's Office of Inspector General (IG) was warning the FAA that its oversight of manufacturers' work was insufficient. Between the design in 2011 and the first plane in 2016, the IG criticized the FAA's handling of the self-certification system in three successive reports. The IG said in 2011 that the FAA's system for deciding which technologies carried the highest safety risks was not effective. Investigators also said the FAA did not adequately train company employees to spot noncompliance with safety requirements. The IG singled out the government's oversight of the Seattle-area FAA office that supervised Boeing's certifications. The IG reported the FAA does not know whether it has adequate staffing levels needed to meet workload requirements. Responding to the IG, the FAA agreed with much of the criticism and vowed to keep working to improve oversight of its self-certification programs. It defended the outsourcing of certification, writing to the IG in 2015 that the expanding magnitude of the US aerospace industry requires that the agency delegate an increasing number of oversight functions to the companies it regulates.

There was no desire to increase the FAA budget and rebuild FAA capability. Instead unstable contracts employing privatized workers with no longevity or deep career expertise were given this critical work. This is in a setting where public law establishes the FAA to ensure the safety of air transportation.

The bottom line is that Boeing and the FAA have management issues. They marginalized and pushed the engineers, technicians, operators, and all those competent to work in the area out of the decision authority loop. This is exactly what happened with the Space Shuttle Challenger disaster in 1987. The FAA should have protected Boeing from itself. They had final veto on the certification of the aircraft. Because of this failed oversight, Boeing as a business will suffer. The US aviation industrial base has been severely damaged.

What could the FAA have done? The FAA must respond to the political appointees and congress. The direction was clear, get out of the way. However, they could have formally communicated the dangers to congress and included line items in the budget to perform proper certification. They did not do that.

What could Boeing have done? They could have rejected the self-licking ice cream cone and lobbied for more money for the FAA to do its job correctly.

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[1] How a 50-year-old design came back to haunt Boeing with its troubled 737 Max jet, Los Angeles Times, Ralph Vartabedian, March 15, 2019.

[2] Flawed analysis, failed oversight: How Boeing, FAA certified the suspect 737 MAX flight control system, Seattle Times, Dominic Gates aerospace reporter, March 17, 2019.

[3] We now know this was coming from incompetent and dangerous management. The facts were that the mission critical system was not fault tolerant and fail-safe.

[4] Flying the Boeing 737 Max 8: A pilot's view from inside the cockpit, Washington Post, Todd C. Frankel, March 17, 2019.

[5] How the Boeing 737 Max safety system differs from others, USA TODAY, George Petras, March 11, 2019.

[6] Joint Authorities Technical Review Observations, Findings, and Recommendations, Submitted to the Associate Administrator for Aviation Safety, U.S. Federal Aviation Administration October 11, 2019.

[7] FAA's lax oversight played part in Boeing 737 Max crashes, but agency is pushing to become more industry-friendly, Washington Post, Michael Laris, Ian Duncan Lori Aratani, Oct. 28, 2019.

[8] Boeing Had Too Much Sway in Vetting Own Jets, FAA Was Told, Bloomberg, Peter Robison, and Alan Levin, March 17, 2019.

[9] Boeing's 737 Max Software Outsourced to \$9-an-Hour Engineers, Bloomberg, Peter Robison, June 28, 2019.

[10] How the FAA allows jetmakers to 'self certify' that planes meet U.S. safety requirements, Washington Post, Aaron C. Davis, Marina Lopes, March 15, 2019.

[11] On January 28, 1986, the NASA Space Shuttle broke apart killing all seven crew members: five NASA astronauts, one payload specialist, and a civilian schoolteacher.

Vaccines

As of August 2020 our approach to contain the virus has failed and the need for a vaccine is becoming more critical. The vaccine will require a systems approach for it to work, however as we have seen in the attempts to contain the virus we still continue to ignore the systems perspective. See section [Management Failure](#).

Key Vaccine Requirements and Reality

Some of the key system requirements for the vaccine to work are:

1. The vaccine must be effective for 2 years to fully remove the virus from the population, this may require multiple vaccination booster shots
2. The vaccine must include the whole world, because the world is fully connected
3. The vaccine must not cause harm, or people will begin to reject it
4. The vaccine must include a massive delivery system that will work, this is a massive production and logistics challenge
5. The people must be willing to take the vaccine, the people have lost confidence in the government and all authority

In an ideal world the vaccine product would be:

- Developed quickly
- Generate antibodies
 - to neutralize the virus before the first infection event
 - to target the virus for destruction before the first infection event
- Generate T cell responses
 - to support future robust antibody production
 - to kill infected cells after infection has happened
- 100% effective and 100% safe
- Easy to produce everywhere at any time
- Easy to deliver to everyone everywhere at any time
- Provide immunity for 2 or more years

History suggests the following:

- The first COVID-19 vaccine will not end the pandemic
- May be 20-60 percent effective at stimulating the correct antibodies to prevent infection
- Periodic vaccinations likely will be needed like the flu vaccine

- Periodic vaccines likely will be needed like the flu vaccine

Vaccine Approaches

There are many vaccines under various stages of development [1] [2]. The following table shows the vaccine approaches and the advantages disadvantages of each approach. .

Table 83 - Vaccine Approaches

| Vaccine Approach | Advantages | Disadvantage |
|--------------------------------|---|---|
| Live attenuated whole pathogen | Usually the best vaccine. Generates good antibodies response. Generates good T cell response. | Can revert to cause the disease to surface that it is intended to prevent. |
| Chemically inactivated | Generates good antibodies. | Weak T cell response. Because of this requires adjuvants and multiple doses. |
| Use recombinant protein | Generates good antibodies. | Weak T cell response. Because of this requires adjuvants and multiple doses. |
| Use peptides | Strong T cell response. Requires adjuvants and multiple doses. | Rely to T cell response to generate antibodies. |
| Genetic | Mimics live attenuated vaccine without risk of infection. Generates good antibodies response. Generates good T cell response. | Newest approach. Delivery mechanism, DNA and RNA do not efficiently enter cells like virus. Solutions include inserting DNA into vector, yeast, bacteria, and electroporation. |

The following table shows the COVID-19 vaccine platforms, manufacturing process, and organization developing the vaccine.

Table 84 - Vaccine Platforms

| Vaccine Types | Process | Process Details | Organization |
|---------------|------------|------------------------|--------------|
| Live | Attenuated | xenotropic, passage or | Sinovac |

| Vaccine Types | Process | Process Details | Organization |
|----------------|-------------|---|---|
| | | reassortment | |
| Inactivated | Killed | | |
| Inactivated | Subunit | disrupt, purify | |
| Inactivated | Conjugate | disrupt, purify, protein-polaccharide | |
| Genome Extract | Recombinant | insert yeast or bacteria, express antigen, purify | Novarax |
| Genome Extract | DNA or RNA | | Pfizer, BioNTech, Moderna, NIAID |
| Genome Extract | Vectored | insert DNA into vector | Oxford, AZ MERCK, Janssen, Vaxart (oral), Cansino (China) |

The following table shows the types of COVID-19 vaccines and the immunity response mechanism.

Table 85 - Vaccine Types and Immunity Responses

| Vaccine Types | Immunity Response Mechanism |
|---------------|--|
| Genetic | Use one or more of the coronavirus's own genes to provide immunity |
| Viral Vector | Use a virus to deliver coronavirus genes into cells and provide an immune response |
| Protein-Based | Use a coronavirus protein or a protein fragment to provide an immune response |

References:

[\[Library/Vaccines\]](#)

[1] Draft landscape of COVID-19 candidate vaccines, World Health Organization, July 15, 2020, August 28, 2020. webpage <https://www.who.int/publications/m/item/draft-landscape-of-covid-19-candidate-vaccines>, July 2020, August 2020. [Draft landscape of COVID-19 candidate vaccines](#) . [local lib](#)

[2] Webinar: COVID-19 Vaccine Development | COVID-19 Healthcare Coalition Response, c19hcc.org/insights August 5, 2020. webpage <https://c19hcc.org/insights>, August 2020. [Webinar: COVID-19 Vaccine Development | COVID-19 Healthcare Coalition Response](#)

21st Century Vaccine

Traditional vaccines contain either weakened viruses or purified signature proteins of the virus to trigger an immune response. A messenger RNA (mRNA) vaccine uses genetic material, the mRNA, that encodes the targeted viral protein. When these genetic instructions are injected into the upper arm, the muscle cells make the viral protein directly in the body that is then used to trigger the immune response.

To mimic what the SARS-CoV-2 virus does in nature, the vaccine mRNA codes only for a critical fragment of the viral protein. This gives the immune system a preview of what the real virus looks like without causing disease. The immune system forms antibodies that neutralizes the real virus if the individual is ever infected. [1]

While synthetic mRNA is genetic material, it cannot be transmitted to the next generation of cells. After an mRNA injection, this molecule guides the protein production inside the muscle cells, which reaches peak levels for 24 to 48 hours and can last for a few more days. It is quickly removed from the body. What remains are just the immune response artifacts.

Traditional vaccine development is very time consuming and cannot respond instantaneously against novel pandemics such as COVID-19. For seasonal flu it takes roughly six months from identification of the circulating influenza virus strain to produce a vaccine. The candidate flu vaccine virus is grown for about three weeks to produce a hybrid virus, which is less dangerous and better able to grow in hens' eggs. The hybrid virus is then injected into many fertilized eggs and incubated for several days to make more copies. Then the fluid containing virus is harvested from eggs, the vaccine viruses are killed, and the viral proteins are purified over several days.

The mRNA is manufactured by a chemical process rather than biological synthesis. This eliminates most of the time consuming manufacturing process of traditional vaccines. Rather than producing and having viral proteins injected, the human body uses the mRNA to manufacture the viral proteins. The mRNA molecules are far simpler than proteins. It is easier and faster to be redesigned, scale up and mass-produce than conventional vaccines. Within days of the genetic code of the SARS-CoV-2 virus becoming available, the mRNA code for a candidate vaccine testing was ready. What's most attractive is that once the mRNA vaccine tools become viable, mRNA can be quickly tailored for other future pandemics. A manufacturing process is summarized [A]:

1. An organic solvent containing dissolved lipids and an aqueous solution containing nucleic acids are injected into two inlet channels that merge into a single outlet channel.
2. Under laminar flow, the two solutions do not immediately mix, however microscopic features engineered into the channel cause the two fluids to intermingle in a controlled and reproducible way.
3. Within a millisecond, the two fluids are completely mixed, causing a change in solvent polarity that triggers the self-assembly of lipid nanoparticles loaded with nucleic acids.
4. Changing the speed and ratio of fluid injection controls the size of the lipid nanoparticles.

The mRNA technology is not new. It was shown that when synthetic mRNA is injected into an animal, the cells can produce a desired protein. However mRNA is unstable and easy to degrade into smaller components, and it is easily destroyed by the human body's immune defenses, which make delivering it to the target challenging. In 2005, researchers determined how to stabilize mRNA and package it into small particles to deliver it as a vaccine.

The biggest challenge for development of a mRNA vaccine is its instability because it starts to quickly break apart above freezing temperatures. Modification of the mRNA building blocks and development of the particles that can cocoon it relatively safely have helped the mRNA vaccine candidates. But they still require new freezer conditions for distribution and administration. The Pfizer-BioNTech mRNA vaccine will need to be stored at minus 94 degrees Fahrenheit and will degrade in approximately five days at normal refrigeration temperatures of slightly above freezing. Moderna claims its vaccine can be maintained at most home or medical freezer temperatures for up to six months for shipping and longer-term storage. Moderna also claims its vaccine can remain stable at standard refrigerated conditions, of 36 to 46 degrees Fahrenheit, for up to 30 days after thawing, within the six-month shelf life.

This is a 21st century technology approach to vaccination. It is only possible because of the ability to perform gene sequencing and the discovery of an approach that allows the genetic material that is the vaccine to be protected long enough for it to perform its function when injected into the body.

Pfizer/BioNTech Vaccine

The Pfizer/BioNTech vaccine is the first to be approved for use in Britain and the US.

The SARS-CoV-2 virus is studded with proteins that it uses to enter human cells. These spike proteins are the target for the vaccine and treatments. The Pfizer-BioNTech and Moderna vaccines are based on the virus's genetic instructions for building the spike protein. The vaccine uses mRNA genetic material that cells read to make these proteins. [2]

The mRNA is fragile and is destroyed by natural enzymes if it is injected directly into the body. To protect the mRNA, Pfizer/BioNTech wrap the mRNA in lipid nanoparticles. The mRNA molecules quickly fall apart at room temperature and need to be transported at -94 degrees Fahrenheit to stay viable until ready for delivery.

After injection, the vaccine particles bump into cells and fuse to them, releasing mRNA into the cells. The cell's molecules read the mRNA sequence and build spike proteins. The mRNA from the vaccine is eventually destroyed by the cell, leaving no permanent trace. Some of the proteins form spikes that migrate to the surface of the cell and stick out their tips. The vaccinated cells also break up some of the proteins into fragments, which appear on the cell surface. These protruding spikes and spike protein fragments are then recognized by the immune system. When the cell dies, the debris contains spike proteins and protein fragments. These are taken up by an immune cell called an antigen-presenting cell. The antigen-presenting cell has fragments of the spike protein on its surface. When other cells called helper T-cells detect these fragments they raise the alarm and help marshal other immune cells to fight the infection.

Immune cells, called B-cells, bump into the coronavirus like spikes and protein fragments on the surface of vaccinated cells. A few of the B-cells lock onto the spike proteins. If these B-cells are

then activated by helper T-cells, they will start to multiply and pour out antibodies that target the spike protein. The antibodies latch onto coronavirus spikes, mark the virus for destruction and prevent infection by blocking the spikes from attaching to other cells. The antigen-presenting cells also activate another type of immune cell called a killer T-cell to seek out and destroy any coronavirus infected cells that display the spike protein fragments on their surfaces.

The Pfizer-BioNTech vaccine requires two injections, given 21 days apart, to stimulate the immune system to fight off the coronavirus. Currently researchers don't know how long its protection might last. The Pfizer-BioNTech protocol study spans 24 months. As of December 2020, the study less than 12 months, but there has been sufficient time to determine that the vaccine is relatively safe. The current issue is the long term effectiveness of the vaccine (2+ years).

Why This Works

COVID-19 is an RNA virus and as it replicates it destroys cells. As the infection spreads it destroys more cells and the body is damaged until the immune response is established. There is also the excessive delayed immune response that also leads to more cell destruction. In that time the COVID-19 damage may be too great for recovery from permanent body damage or loss of life.

The mRNA vaccine does not replicate and it produces the same type of spike protein as COVID-19. After the spike protein is made, the cell breaks down the mRNA and disposes of it using enzymes in the cell. The mRNA never enters the cell's nucleus or affects genetic material so it does not alter or modify genetic makeup. The mRNA vaccine generated spike proteins cause the immune system to begin producing antibodies and activating T-cells to fight off what it thinks is an infection. It takes time in some people for the immune response to build when infected. Because the mRNA does not replicate, the body is not damaged during the time it takes for the immune response to be established as it would be with a COVID-19 virus infection [10].

Gene therapy is 21st century technology and is probably the next major breakthrough in medicine. Solid lipid nanoparticles are nanoparticles composed of lipids that are used to deliver RNA based therapies. The first use of a lipid nanoparticle delivery vehicle was approved in 2018 for the siRNA based drug Onpattro. The COVID-19 virus vaccines from BioNTech/Pfizer and Moderna use lipid nanoparticles [3] [4].

Allergic Reactions

As of December 2020, the Pfizer-BioNTech vaccine allergic reactions may be a result of the lipid nanoparticles [3] [4] used to stabilize the mRNA or the resulting protein after the mRNA enters the cells. The Moderna vaccine uses a different method to stabilize the mRNA as evidenced by the different refrigeration requirements. It also may use a different mRNA pattern. Both of these factors may affect the allergic reactions and levels.

The product description provided to the FDA in the Letter Of Authorization is [9]:

The Pfizer-BioNTech COVID-19 Vaccine is supplied as a frozen suspension in multiple dose vials; each vial must be diluted with 1.8 mL of sterile 0.9% Sodium Chloride Injection, USP prior to use to form the vaccine. After dilution, each vial contains 5 doses

of 0.3 mL per dose. The Pfizer-BioNTech COVID-19 Vaccine does not contain a preservative.

Each 0.3 mL dose of the Pfizer-BioNTech COVID-19 Vaccine contains 30 mcg of a nucleoside-modified messenger RNA (modRNA) encoding the viral spike (S) glycoprotein of SARS-CoV-2. Each dose of the Pfizer-BioNTech COVID-19 Vaccine also includes the following ingredients: lipids (0.43 mg (4-hydroxybutyl)azanediyl)bis(hexane-6,1-diyl)bis(2-hexyldecanoate), 0.05 mg phosphocholine, and 0.2 mg cholesterol), 0.01 mg potassium chloride, 0.01 mg monobasic potassium phosphate, 0.36 mg sodium chloride, 0.07 mg dibasic sodium phosphate dihydrate, and 6 mg sucrose. The diluent (0.9% Sodium Chloride Injection) contributes an additional 2.16 mg sodium chloride per dose.

The dosing regimen is two doses of 0.3 mL each, 3 weeks apart.

Unintended Consequences of RNA Therapy

RNA based therapy has been in development for years. There are studies and trials that have resulted in unintended consequences including death in both animals and humans [5] [6]. As always the challenges are in the details and each therapy presents unique challenges and potential unintended consequences. In a study from 2012 the following was a key finding: These SARS-CoV vaccines all induced antibody and protection against infection with SARS-CoV. However, challenge of mice given any of the vaccines led to occurrence of Th2-type immunopathology suggesting hypersensitivity to SARS-CoV components was induced. Caution in proceeding to application of a SARS-CoV vaccine in humans is indicated [14].

The COVID-19 mRNA based therapies have passed the extreme consequences of death based on the relatively large Phase 3 population levels. Although not perfect, these are promising early indications. The logistics of vaccine manufacturing, distribution, and delivery will translate into a relatively slow introduction of the therapy into the population so that any short term outwardly visible negative unintended consequences spread should be contained if it should surface. The largest issue is the ability to maintain high quality manufacturing, distribution, and delivery to ensure that the vaccine is not contaminated or becomes ineffective. This suggest that everyone should be tested for the presence of antibodies after being vaccinated until the pandemic and then local US epidemic subsides.

Healthcare Worker Assessment

If you think COVID is overblown and/or are upset about mask mandates and economic shutdowns, remember that the way to end all of this is to achieve herd immunity through vaccination. We need the majority of the population to be vaccinated to achieve that. Even if you're young and healthy with a low risk of having a serious infection, If you want life to go back to normal, the best way to contribute is to get vaccinated.

The following is an extract that was posted by a fellow ER doc in the ER doctor's FB group. (Dr. Ken Lavelle) It's a good summary of the Pfizer document the FDA reviewed.

The FDA issued an emergency authorization for the first COVID-19 vaccine earlier this week. But wait, is that good news? I mean, do we even know what's in it? Or how safe it is? Or if it

really works? This all happened very fast. The FDA released a comprehensive report earlier this week of the data it reviewed before authorizing it, and it has an abundance of information about the ingredients, the side effect data, and the efficacy data. [7] [8]

Summary

It's an mRNA vaccine containing no part of an actual virus, so it's impossible to get COVID-19 from the vaccine. The vaccine reduced the incidence of COVID-19 by 95% in the clinical trial. A high percentage of participants had mild side effects like a sore arm, mild headache, or fatigue, but most did not find those side effects significant enough to report if they weren't asked specifically about them. There was no increase in deaths or serious medical issues in the vaccinated group compared to those who weren't vaccinated.

When comparing alternatives, it appears the risks of having serious complications from a COVID-19 infection are much higher than the risk of having a serious complication from the vaccine. Getting vaccinated does not mean you can stop wearing masks and social distancing right away, we'll have to wait until a majority of people are vaccinated. Achieving herd immunity through vaccination is likely the only way to put an end to social distancing mandates and government enforced shutdowns.

Longer Summary

I'll start by noting children under 12 and pregnant women were not included in the trial. Because we don't yet have safety or efficacy data for these populations, the FDA has not made recommendations for these groups. The American College of Obstetricians and Gynecologists, however, has recommended that the vaccine not be withheld from pregnant or lactating women if they otherwise qualify.

How does it work?

It's an mRNA vaccine. If you think back to biology class, you'll remember that mRNA molecules are the ones that tells our cells what proteins to make. For this vaccine, it contains the code for a protein found on the surface of the virus, called a spike protein. Once injected, our cells take it in and start making the spike protein the mRNA codes for, then our immune system recognizes it as foreign and creates an immune response against it. Then, when actual virus enters our bodies, our immune system recognizes the protein and attacks the virus.

This is a new way to make vaccines, but people have been working on it and studying delivery methods for mRNA vaccines for many years. It's much easier to make and mass produce than more traditional vaccines, which is part of the reason the clinical trials were able to get up and running so quickly. With the method already perfected, all that was required was to determine the gene sequence for the protein of interest, then start producing it. mRNA vaccines were of particular interest before COVID-19 partly because they could be produced much quicker than other methods in the event of a pandemic.

It's important to remember that you cannot get COVID-19 from this vaccine. There was no actual virus used in making it. You can get symptoms which you may confuse for a mild infection, but that is actually just your immune system creating immunity (see the safety effects section for more details).

What's in it?

Ingredients: the mRNA molecules, lipid carriers (fat molecules that help it get inside our cells), and a few other things like saline, potassium chloride, potassium phosphate, and sucrose (sugar) that are naturally found in high quantities in our bodies. That's it. No aluminum, no thimerosal, no heavy metals, no preservatives. None of the ingredients that some people have been concerned about for other vaccines (the validity of those concerns are outside the scope of this post).

How well does it work?

Essentially there were about 18,000 people that received the vaccine, and 18,000 that received a saline placebo. In the vaccinated group, 8 people were diagnosed with COVID-19 during the study, compared to 162 people in the placebo group for an efficacy of 95%. These numbers will obviously vary a bit when more people get vaccinated, but a statistical analysis determined that there's a 97.5% chance the vaccine is at least 90% effective [7] [8].

What about side effects, is it safe? The trials collected side effects through two different methods. One subset of participants was asked specifically whether they had particular symptoms (solicited), while everyone else could report any symptoms they wanted but weren't asked specifically whether they had particular symptoms (unsolicited).

From the actual study executive summary [7] [8]:

- Injection site reactions (84.1%),
- Fatigue (62.9%),
- Headache (55.1%),
- Muscle pain (38.3%),
- Chills (31.9%),
- Joint pain (23.6%),
- Fever (14.2%);
- Severe adverse reactions
 - Occurred in 0.0% to 4.6% of participants,
 - Were more frequent after Dose 2 than after Dose 1,
 - Were generally less frequent in participants 55 years of age (.2.8%) as compared to younger participants (.4.6%)
- About 20-30% of people receiving the placebo also reported headache or fatigue, so it's likely many of those symptoms in the treatment group were not actually caused by the vaccine.

Solicited data (from Dr. Ken Lavelle review):

- Most people (70-80%) receiving the vaccine reported mild to moderate pain at the injection site, with 1% reporting severe pain
- About 5% reported redness or swelling at injection site
- 10-15% reported fever
- About 50-60% reported fatigue, with only 2-5% being reported as severe
- About 50% reported headache, with 0-3% being severe.

Unsolicited data (from Dr. Ken Lavelle review):

- 11% reported injection site pain,
- 5% fatigue,
- 6% fever,
- 7% muscle or joint pain, and
- 5% headache.

There's obviously a big difference between the solicited and unsolicited group, which likely means that the majority of symptoms were minor enough that participants didn't think they were significant enough to report unless asked specifically about them.

Serious adverse events (any serious medical event that happened during the trial, no matter whether it was caused by the vaccine or not) occurred in <0.5% of participants, with a similar incidence in the placebo group. Serious adverse events which investigators thought could potentially be related to the vaccine, out of the 18,000 participants: 1 case of ventricular arrhythmia, 1 case of enlarged lymph nodes (there were more cases of this, but only one case designated as serious), and 1 shoulder injury. There were a handful of other serious adverse events that happened during the trial such as appendicitis, heart attacks, and strokes that were extremely rare and occurred no more often than they do in the general population, and therefore were not thought to be related to the vaccine. There were 4 cases of Bell's palsy in the vaccine group compared to 0 in the placebo group. It did not occur any more than the would be expected in the general population, but because there were no cases in the placebo group it will continue to be monitored by the FDA going forward.

There were no deaths thought to be due to the vaccine, and actually more deaths in the placebo group (4 to 2). The trial included elderly people and was conducted over many months, so a few deaths from natural causes out of almost 40,000 people is completely expected. Some have theorized that mRNA vaccines could trigger flare-ups of autoimmune diseases, but participants with autoimmune diseases were included in the trial and this was not observed.

In summary, it is likely that you will have some mild side effects like sore arm and mild fatigue or headache which are short lived. It is very unlikely, but not impossible, that you will have more serious soreness, headache, or fatigue, and there is no evidence of any life threatening or long lasting side effects. The risks of serious side effect seem to be much lower than the risk of having a serious problem related to a COVID-19 infection. So far we only have about 2 months of safety data. It's possible that given more time and a larger number of vaccinated people that other rare side effects will be discovered. Historically, however, almost all vaccine side effects manifest themselves during the first 2 months (which is why the FDA required 2 months of safety data before reviewing any vaccine). By the time most people have access to the vaccine there will be many more months of data, and any additional side effects that were rare enough not to be caught in the trial should manifest themselves by then.

Lastly, can I stop wearing a mask and social distancing once I'm vaccinated?

The short answer is probably not yet. While the vaccine prevents you from getting sick, it does not prevent the virus from entering your body. It is possible you could contract the virus and be contagious even though you don't get sick or have symptoms, thanks to the vaccine. This has not been studied yet, but there are studies being planned to answer this question. Until then, the best

practice would be to continue to wear masks and social distance when around other people (unless you don't care about other people, or they have all been vaccinated too) until enough people in the community have been vaccinated to achieve herd immunity. This will probably take until well into next year, assuming enough people get vaccinated. If you think COVID is overblown and/or are upset about mask mandates and economic shutdowns, remember that the way to end all of this is to achieve herd immunity through vaccination. We need the majority of the population to be vaccinated to achieve that. Even if you're young and healthy with a low risk of having a serious infection, If you want life to go back to normal, the best way to contribute is to get vaccinated.

Moderna Vaccine

The Moderna COVID-19 vaccine is an mRNA based vaccine like the Pfizer/BioNTech vaccine [11]. The Moderna COVID-19 Vaccine is administered as a 2-dose series, 1 month apart, into the muscle. As of December 2020 The FDA has authorized the emergency use of the Moderna COVID-19 Vaccine to prevent COVID-19 in individuals 18 years of age and older under an Emergency Use Authorization (EUA).

The available safety data to support the EUA include an analysis of 30,351 participants enrolled in an ongoing randomized, placebo-controlled study conducted in the U.S. These participants, 15,185 of whom received the vaccine and 15,166 of whom received saline placebo, were followed for a median of more than two months after receiving the second dose. The most commonly reported side effects, which typically lasted several days, were pain at the injection site, tiredness, headache, muscle pain, chills, joint pain, swollen lymph nodes in the same arm as the injection, nausea and vomiting, and fever. Of note, more people experienced these side effects after the second dose than after the first dose, so it is important for vaccination providers and recipients to expect that there may be some side effects after either dose, but even more so after the second dose. [13]

The effectiveness data to support the EUA include an analysis of 28,207 participants in the ongoing randomized, placebo-controlled U.S. study who did not have evidence of SARS-CoV-2 infection prior to the first dose of vaccine. Among these participants, 14,134 received the vaccine and 14,073 received placebo. The vaccine was 94.1% effective in preventing COVID-19 disease among these clinical trial participants with 11 cases of COVID-19 in the vaccine group and 185 in the placebo group. At the time of the analysis of these 196 COVID-19 cases, none in the vaccine group and 30 in the placebo group were classified as severe. After the analysis of these 196 cases was completed, one severe case in the vaccine group was identified and is awaiting confirmation. At this time, data are not available to determine how long the vaccine will provide protection, nor is there evidence that the vaccine prevents transmission of SARS-CoV-2 from person to person. [13]

In clinical trials, approximately 15,400 individuals 18 years of age and older have received at least 1 dose of the Moderna COVID-19 Vaccine [12].

Side effects that have been reported with the Moderna COVID-19 Vaccine include:

- Injection site reactions: pain
- Tenderness and swelling of the lymph nodes in the same arm of the injection
- Swelling (hardness), and redness

- General side effects: fatigue, headache, muscle pain, joint pain, chills, nausea and vomiting, and fever

There is a remote chance that the Moderna COVID-19 Vaccine could cause a severe allergic reaction. A severe allergic reaction would usually occur within a few minutes to one hour after getting a dose of the Moderna COVID-19 Vaccine. Signs of a severe allergic reaction can include:

- Difficulty breathing
- Swelling of your face and throat
- A fast heartbeat
- A bad rash all over your body
- Dizziness and weakness

These may not be all the possible side effects of the Moderna COVID-19 Vaccine. Serious and unexpected side effects may occur. The Moderna COVID-19 Vaccine is still being studied in clinical trials. The Moderna COVID-19 Vaccine contains the following ingredients: messenger ribonucleic acid (mRNA), lipids (SM-102, polyethylene glycol [PEG] 2000 dimyristoyl glycerol [DMG], cholesterol, and 1,2-distearoyl-sn-glycero-3-phosphocholine [DSP C]), tromethamine, tromethamine hydrochloride, acetic acid, sodium acetate, and sucrose.

mRNA Vaccine Ingredients

The following table compares the ingredients of the mRNA vaccines [11] [12].

Table 86 - mRNA Vaccine Ingredients

| Pfizer/BioNTech | Moderna |
|--|---|
| mRNA | mRNA |
| lipids ((4-hydroxybutyl)azanediyl) bis(hexane-6, 1-diyl)bis(2-hexyldecanoate), 2 [(polyethylene glycol)-2000]-N, N-ditetradecylacetamide, 1,2-Distearoyl-sn-glycero-3-phosphocholine, and cholesterol) | lipids (SM-102, polyethylene glycol [PEG] 2000 dimyristoyl glycerol [DMG], cholesterol, and 1,2-distearoyl-sn-glycero-3-phosphocholine [DSP C]) |
| potassium chloride, monobasic potassium phosphate, sodium chloride, dibasic sodium phosphate dihydrate, and <u>sucrose</u> | tromethamine, tromethamine hydrochloride, acetic acid, sodium acetate, and <u>sucrose</u> |
| 18,198 received vaccine 18,325 received placebo COVID-19 cases: 8 in the vaccine group and 162 in the | 14,134 received vaccine and 14,073 received placebo COVID-19 cases: 11 in the vaccine |

| Pfizer/BioNTech | Moderna |
|---------------------------------------|--|
| placebo group Effectiveness: 95% | group and 185 in the placebo group Effectiveness: 94.1% |
| 200 million US doses by July 31, 2021 | 200 million US doses by June 2021 |

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US Government Actions to Develop Vaccine

The US Federal Government took action to develop a vaccine in record time. Operation Warp Speed is a public private partnership to facilitate and accelerate the development, manufacturing, and distribution of COVID-19 vaccines, therapeutics, and diagnostics. Operation Warp Speed was introduced in early April 2020, after a round-table meeting with President Trump, Vice President Pence and industry executives at the White House on March 2, 2020. After it was first revealed in the press on April 29, 2020 President Trump officially announced the public private partnership on May 15, 2020. [3]

It will promote mass production of multiple vaccines based on preliminary evidence allowing for faster distribution if clinical trials confirm one of the vaccines is safe and effective. The plan anticipates that some of these vaccines will not prove safe or effective, making the program more costly than typical vaccine development, but potentially leading to the availability of a viable vaccine several months earlier than typical timelines. Congress allocated on March 27, 2020 nearly \$10 billion for Operation Warp Speed through the Coronavirus Aid, Relief, and Economic Security (CARES) Act, with \$6.5 billion designated by Congress for countermeasure development through Biomedical Advanced Research and Development Authority (BARDA), along with \$3 billion for National Institutes of Health (NIH) research.

Operation Warp Speed is an interagency program that includes components of the Department of Health and Human Services, including the Centers for Disease Control and Prevention (CDC), Food and Drug Administration (FDA), the National Institutes of Health (NIH), and the Biomedical Advanced Research and Development Authority (BARDA); the Department of Defense (DOD); private firms; and other federal agencies, including the Department of Agriculture, the Department of Energy, and the Department of Veterans Affairs.

As of July 2020, multiple companies were funded to develop and prepare for manufacturing their vaccine candidates. The company vaccine candidates are:

Table 87 - Operation Warp Speed Companies

| Vaccine / Company | US Funding | Funding Date | Study | Claim | Doses | Storage | Information [2] [3] [4] | Approval |
|---|--------------------------------|-----------------------|-------|-------|-------|---------|--|------------------------------------|
| Johnson & Johnson + Janssen Pharmaceutical | none | none | 43K | 67% | 1 | 2-8°C | Announced a separate trial with two doses in November 2020. | Feb 27, 2021 US |
| <p>The effectiveness data to support the EUA include an analysis of 39,321 participants in the ongoing randomized, placebo-controlled study being conducted in South Africa, certain countries in South America, Mexico, and the U.S. who did not have evidence of SARS-CoV-2 infection prior to receiving the vaccine. Among these participants, 19,630 received the vaccine and 19,691 received saline placebo. Overall, the vaccine was approximately 67% effective in preventing moderate to severe/critical COVID-19 occurring at least 14 days after vaccination and 66% effective in preventing moderate to severe/critical COVID-19 occurring at least 28 days after vaccination.</p> <p>Additionally, the vaccine was approximately 77% effective in preventing severe/critical COVID-19 occurring at least 14 days after vaccination and 85% effective in preventing severe/critical COVID-19 occurring at least 28 days after vaccination.</p> <p>There were 116 cases of COVID-19 in the vaccine group that occurred at least 14 days after vaccination, and 348 cases of COVID-19 in the placebo group during this time period. There were 66 cases of COVID-19 in the vaccine group that occurred at least 28 days after vaccination and 193 cases of COVID-19 in the placebo group during this time period. Starting 14 days after vaccination, there were 14 severe/critical cases in the vaccinated group versus 60 in the placebo group, and starting 28 days after vaccination, there were 5 severe/critical in the vaccine group versus 34 cases in the placebo group.</p> <p>At this time, data are not available to determine how long the vaccine will provide protection, nor is there evidence that the vaccine prevents transmission of SARS-CoV-2 from person to person. [7]</p> | | | | | | | | |
| AstraZeneca + Vaccitech | \$1.0 billion \$1.2 billion | May 2020 June 2020 | 65K | 70% | 2 | 2-8°C | AstraZeneca - University of Oxford. May 2020 funding to receive 300 million doses for American use. Orders for 3 billion doses even before any late-stage study results. That's more than twice as many as any other candidate. Initial clinical results were mixed. | Dec 30, 2020 UK |
| Pfizer + BioNTech | \$2.0 billion | July 2020 | 44K | 95% | 2 | -70°C | New vaccine approach mRNA. Manufacture 100 million vaccine doses for US when it is | Dec 02, 2020 UK Dec 11, 2020 US |

| Vaccine / Company | US Funding | Funding Date | Study | Claim | Doses | Storage | Information [2] [3] [4] | Approval |
|---|---------------|--------------|-------|-------|-------|---------|--|-----------------|
| | | | | | | | shown to be safe and effective, and is licensed. The first company to report positive phase 3 clinical data. Plans to produce 50M doses in 2020 and 1.3B in 2021. | |
| <p>The effectiveness data to support the EUA include an analysis of 36,523 participants in the ongoing randomized, placebo-controlled international study, the majority of whom are U.S. participants, who did not have evidence of SARS-CoV-2 infection through seven days after the second dose. Among these participants, 18,198 received the vaccine and 18,325 received placebo. The vaccine was 95% effective in preventing COVID-19 disease among these clinical trial participants with eight COVID-19 cases in the vaccine group and 162 in the placebo group. Of these 170 COVID-19 cases, one in the vaccine group and three in the placebo group were classified as severe.</p> <p>At this time, data are not available to make a determination about how long the vaccine will provide protection, nor is there evidence that the vaccine prevents transmission of SARS-CoV-2 from person to person. [5]</p> | | | | | | | | |
| Moderna | \$483 million | June 2020 | 30K | 95% | 2 | 2-8°C | New vaccine approach mRNA. Expects to have 20M doses for the U.S. in December and 100M globally in Q1 2021. | Dec 18, 2020 US |
| <p>The effectiveness data to support the EUA include an analysis of 28,207 participants in the ongoing randomized, placebo-controlled U.S. study who did not have evidence of SARS-CoV-2 infection prior to the first dose of vaccine. Among these participants, 14,134 received the vaccine and 14,073 received placebo. The vaccine was 94.1% effective in preventing COVID-19 disease among these clinical trial participants with 11 cases of COVID-19 in the vaccine group and 185 in the placebo group. At the time of the analysis of these 196 COVID-19 cases, none in the vaccine group and 30 in the placebo group were classified as severe. After the analysis of these 196 cases was completed, one severe case in the vaccine group was identified and is awaiting confirmation.</p> <p>At this time, data are not available to determine how long the vaccine will provide protection, nor is there evidence that the vaccine prevents transmission of SARS-CoV-2 from person to person. [6]</p> | | | | | | | | |
| Merck + IAVI | none | none | | | | | | |
| Vaxart | none | none | | | | | | |
| Inovio | none | none | | | | | | |

| Vaccine / Company | US Funding | Funding Date | Study | Claim | Doses | Storage | Information [2] [3] [4] | Approval |
|----------------------------|---------------|--------------|-------|-------|-------|---------|--|--|
| Novavax | \$1.6 billion | July 2020 | 45K | | 2 | 2-8°C | Novavax to produce 100 million doses of its candidate vaccine. Novavax is a company with no history of marketed products. Small biotech firm has never brought a product to market. Received \$1.6 billion from U.S. and \$399 million from Coalition for Epidemic Preparedness. Stock rose 3,000% in nine months. | |
| Sanofi + Glaxo Smith Kline | \$2.1 billion | July 2020 | | | | | | |
| . | | | | | | | | |
| | | | | | | | Russia and China allowed vaccine distribution before conducting large-scale clinical trials. | |
| . | | | | | | | | |
| Sinovac Biotech | none | none | 26K | 78% | 2 | 2-8°C | Vaccine platform is a chemically inactivated Covid-19 virus. | Aug 28, 2020 China |
| CanSino Biologics | none | none | 40K | | 1 | 2-8°C | Uses a harmless cold virus to deliver its genetic payload. Approved for the Chinese military even before late-stage tests began. | Jun 29, 2020 China |
| Sinopharm | none | none | 50K | 79% | 2 | 2-8°C | Administered hundreds of thousands of doses before vaccine was fully tested. | Aug 28, 2020 China |
| Sputnik V | none | none | | | | | Russian vaccine. Based on two adenovirus vectors. Developed by the Gamaleya National Center of Epidemiology and Microbiology (Moscow, Russia). Aug 11, 2020 for schools and the health service, and social workers. [2] Dec 28, | Aug 11, 2020 Russia Dec 28, 2020 Russia |

| Vaccine / Company | US Funding | Funding Date | Study | Claim | Doses | Storage | Information [2] [3] [4] | Approval |
|--------------------------|-------------------|---------------------|--------------|--------------|--------------|----------------|--|------------------------------|
| | | | | | | | 2020 for everyone over the age of 18 including those over 60. [3] | |
| Gamaleya | none | none | 40K | 91% | 2 | -18°C | Variation of the Russian vaccine, Sputnik V. Can be stored using standard refrigeration temperatures of 2-8°C. It's currently available in limited quantities. | Aug 11, 2020 Russia |

Author Comment: These small US Federal Government funding levels for a disaster of this scale are completely inappropriate. The US Federal Government did nothing other than place an order to buy some stuff. See section [Government Failure](#). Fortunately there was sufficient previous US Federal Government funding and industrial capacity to allow for the vaccines to be developed. We need to thank our parents and grandparents for saving us and our children in this massive disaster.

President Elect Biden stated that the current administration has no plan for vaccine delivery [1]. President-elect Joe Biden said Friday that the Trump administration had shared information with his transition team about distributing a vaccine to various states, but Biden said his team had not seen a detailed plan. There is no detailed plan that we've seen, anyway, as to how you get the vaccine out of a container, into an injection syringe, into somebody's arm. It's going to be very difficult for that to be done and it's a very expensive proposition, Biden said. He noted, There's a lot more that has to be done.

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Operation Warp Speed

The following is from the press release and follow on information provided by the US Government.

What is the goal?

Operation Warp Speed's goal is to produce and deliver 300 million doses of safe and effective vaccines with the initial doses available by January 2021, as part of a broader strategy to accelerate the development, manufacturing, and distribution of COVID-19 vaccines, therapeutics, and diagnostics (collectively known as countermeasures). [1] [2] [3]

How will the goal be accomplished?

By investing in and coordinating countermeasure development, OWS will allow countermeasures such as a vaccine to be delivered to patients more rapidly while adhering to standards for safety and efficacy.

Who's working on it?

OWS is a partnership among components of the Department of Health and Human Services (HHS), including the Centers for Disease Control and Prevention (CDC), the Food and Drug Administration (FDA), the National Institutes of Health (NIH), and the Biomedical Advanced Research and Development Authority (BARDA), and the Department of Defense (DoD). OWS engages with private firms and other federal agencies, including the Department of Agriculture, the Department of Energy, and the Department of Veterans Affairs. It will coordinate existing HHS-wide efforts, including the NIH's Accelerating COVID-19 Therapeutic Interventions and Vaccines (ACTIV) partnership, NIH's Rapid Acceleration of Diagnostics (RADx) initiative, and work by BARDA.

What's the plan and what's happened so far?

Development: To accelerate development while maintaining standards for safety and efficacy, OWS has been selecting the most promising countermeasure candidates and providing coordinated government support.

Protocols for the demonstration of safety and efficacy are being aligned, which will allow the trials to proceed more quickly, and the protocols for the trials will be overseen by the federal government, as opposed to traditional public-private partnerships, in which pharmaceutical companies decide on their own protocols. Rather than eliminating steps from traditional development timelines, steps will proceed simultaneously, such as starting manufacturing of the vaccine at industrial scale well before the demonstration of vaccine efficacy and safety as happens normally. This increases the financial risk, but not the product risk.

Select actions to support OWS vaccine development so far include:

March 30: HHS announced \$456 million in funds for Johnson & Johnson's (Janssen) candidate vaccine. Phase 1 clinical trials began in Belgium on July 24th and in the U.S on July 27th.

April 16: HHS made exit disclaimer icon up to \$483 million in support available for Moderna's candidate vaccine, which began Phase 1 trials on March 16 and received a fast-track designation from FDA. This agreement was expanded exit disclaimer icon on July 26 to include an additional \$472 million to support late-stage clinical development, including the expanded Phase 3 study of the company's mRNA vaccine, which began on July 27th.

May 21: HHS announced up to \$1.2 billion in support for AstraZeneca's candidate vaccine, developed in conjunction with the University of Oxford. The agreement is to make available at least 300 million doses of the vaccine for the United States, with the first doses delivered as early as October 2020, if the product successfully receives FDA EUA or licensure. AstraZeneca's large-scale Phase 3 clinical trial began on August 31, 2020.

July 7: HHS announced \$450 million in funds to support the large-scale manufacturing of Regeneron's COVID-19 investigational anti-viral antibody treatment, REGN-COV2. This agreement is the first of a number of OWS awards to support potential therapeutics all the way through to manufacturing. As part of the manufacturing demonstration project, doses of the medicine will be packaged and ready to ship immediately if clinical trials are successful and FDA grants EUA or licensure.

July 7: HHS announced \$1.6 billion in funds to support the large-scale manufacturing of Novavax's vaccine candidate. By funding Novavax's manufacturing effort, the federal government will own the 100 million doses expected to result from the demonstration project.

July 22: HHS announced up to \$1.95 billion in funds to Pfizer for the large-scale manufacturing and nationwide distribution of 100 million doses of their vaccine candidate. The federal government will own the 100 million doses of vaccine initially produced as a result of this agreement, and Pfizer will deliver the doses in the United States if the product successfully receives FDA EUA or licensure, as outlined in FDA guidance, after completing demonstration of safety and efficacy in a large Phase 3 clinical trial, which began July 27th.

July 31: HHS announced approximately \$2 billion in funds to support the advanced development, including clinical trials and large scale manufacturing, of Sanofi and GlaxoSmithKline's (GSK) investigational adjuvanted vaccine. By funding the manufacturing effort, the federal government will own the approximately 100 million doses expected to result from the demonstration project. The adjuvanted vaccine doses could be used in clinical trials or, if the FDA authorizes use, as outlined in agency guidance, the doses would be distributed as part of a COVID-19 vaccination campaign.

August 5: HHS announced approximately \$1 billion in funds to support the large-scale manufacturing and delivery of Johnson & Johnson's (Janssen) investigational vaccine candidate. Under the terms of the agreement, the U.S. Government will own the resulting 100 million doses of vaccine, and will have the option to acquire more. The company's investigational vaccine relies on Janssen's recombinant adenovirus technology, AdVac, a technology used to develop and manufacture Janssen's Ebola vaccine with BARDA support; that vaccine received European Commission approval and was used in the Democratic Republic of the Congo (DRC) and Rwanda during the 2018-2020 Ebola outbreak that began in the DRC.

August 11: HHS announced up to \$1.5 billion in funds to support the large-scale manufacturing and delivery of Moderna's investigational vaccine candidate. Under the terms of the agreement, the U.S. Government will own the resulting 100 million doses of vaccine, and will have the option to acquire more. The vaccine, called mRNA-1273, has been co-developed by Moderna and scientists from the National Institute of Allergy and Infectious Diseases (NIAID), part of the National Institutes of Health. NIAID has continued to support the vaccine's development including nonclinical studies and clinical trials. Additionally, BARDA has supported phase 2/3 clinical trials, vaccine manufacturing scale up and other development activities for this vaccine. The Phase 3 clinical trial, which began July 27, is the first government-funded Phase 3 clinical trial for a COVID-19 vaccine in the United States.

August 23: As part of the agency's efforts to combat COVID-19, the FDA issued an emergency use authorization (EUA) for investigational convalescent plasma. Based on available scientific evidence, the FDA determined convalescent plasma may be effective in lessening the severity or shortening the length of COVID-19 illness in hospitalized patients, and that the known and potential benefits of the product outweigh the known and potential risks. The EUA authorizes the distribution of convalescent plasma in the U.S. as well as its administration by health care providers, as appropriate, to treat suspected or confirmed cases of COVID-19. Learn more about EUAs.

As announced on May 15, the vaccine development plan is as follows, subject to change as work proceeds:

- Fourteen promising candidates have been chosen from the 100+ vaccine candidates currently in development—some of them already in clinical trials with U.S. government support.
- The 14 vaccine candidates are being narrowed down to about seven candidates, representing the most promising candidates from a range of technology options (nucleic acid, viral vector, protein subunit), which will go through further testing in early-stage clinical trials.
- Large-scale randomized trials for the demonstration of safety and efficacy will proceed for the most promising candidates.

Manufacturing: The federal government is making investments in the necessary manufacturing capacity at its own risk, giving firms confidence that they can invest aggressively in development and allowing faster distribution of an eventual vaccine. Manufacturing capacity for selected candidates will be advanced while they are still in development, rather than scaled up after approval or authorization. Manufacturing capacity developed will be used for whatever vaccine is eventually successful, if possible given the nature of the successful product, regardless of which firms have developed the capacity.

Select actions to support OWS manufacturing efforts so far include:

The May 21, April 16, and March 30 HHS agreements with AstraZeneca, Moderna, and Johnson & Johnson respectively include investments in manufacturing capabilities.

June 1: HHS announced a task order with Emergent BioSolutions to advance domestic manufacturing capabilities and capacity for a potential COVID-19 vaccine as well as therapeutics, worth approximately \$628 million, using Emergent's BARDA-supported Center for Innovation in Advanced Department and Manufacturing.

July 27: HHS announced a task order with Texas A&M University and FUJIFILM to advance domestic manufacturing capabilities and capacity for a potential COVID-19 vaccine, worth approximately \$265 million, using another BARDA-supported CIADM.

August 4: Grand River Aseptic Manufacturing Inc., (GRAM) Grand Rapids, Michigan, was awarded a \$160 million firm-fixed-price contract for domestic aseptic fill and finish manufacturing capacity for critical vaccines and therapeutics in response to the COVID-19 pandemic.

Distribution: Before the countermeasures are approved or authorized, the program will build the necessary plans and infrastructure for distribution.

HHS plans for a tiered approach to vaccine and therapeutic distribution, which will build on allocation methodology developed as part of pandemic flu planning and be adjusted based on experience from the COVID-19 response so far, data on the virus and its impact on populations and the performance of a given countermeasure, and the needs of the essential workforce. OWS will expand domestic manufacturing and supplies of specialized materials and resources, such as

glass vials, that can be necessary for distribution. DoD's involvement will enable faster distribution and administration than would have otherwise been possible.

Select actions to support OWS distribution efforts include:

May 12: DoD and HHS announced a \$138 million contract with ApiJect for more than 100 million prefilled syringes for distribution across the United States by year-end 2020, as well as the development of manufacturing capacity for the ultimate production goal of over 500 million prefilled syringes in 2021.

June 9: HHS and DoD announced a joint effort to increase domestic manufacturing capacity for vials that may be needed for vaccines and treatments: June 11: HHS announced \$204 million in funds to Corning to expand the domestic manufacturing capacity to produce approximately 164 million Valor Glass vials per year if needed. Valor Glass provides chemical durability to minimize particulate contamination. The specialized glass allows for rapid filling and capping methods that can increase manufacturing throughput by as much as 50 percent compared with conventional filling lines, which in turn can reduce the overall manufacturing time for vaccines and therapies.

June 11: HHS announced \$143 million to SiO₂ Materials Science to ramp up capacity to produce the company's glass-coated plastic container, which can be used for drugs and vaccines. The new lines provide the capacity to produce an additional 120 million vials per year if needed.

August 14: HHS and DoD announced that McKesson Corporation will be a central distributor of future COVID-19 vaccines and related supplies needed to administer the pandemic vaccinations. The CDC is executing an existing contract option with McKesson to support vaccine distribution. The company also distributed the H1N1 vaccine during the H1N1 pandemic in 2009-2010. The current contract with McKesson, awarded as part of a competitive bidding process in 2016, includes an option for the distribution of vaccines in the event of a pandemic. Detailed planning is underway to ensure rapid distribution as soon as the FDA authorizes one or more vaccines. Once these decisions are made, McKesson will work under CDC's guidance to ship COVID-19 vaccines to administration sites.

Who's leading OWS?

HHS Secretary Alex Azar and Defense Secretary Mark Esper oversee OWS, with Dr. Moncef Slaoui designated as chief advisor and General Gustave F. Perna confirmed as the chief operating officer. To allow these OWS leaders to focus on operational work, in the near future the program will be announcing separate points of contact, with deep expertise and involvement in the program, for communication with Congress and the public.

What are you doing to make these products affordable for Americans?

The Administration is committed to providing free or low-cost COVID-19 countermeasures to the American people as fast as possible. Any vaccine or therapeutic doses purchased with US taxpayer dollars will be given to the American people at no cost.

How is this being funded?

Congress has directed almost \$10 billion to this effort through supplemental funding, including the CARES Act. Congress has also appropriated other flexible funding. The almost \$10 billion specifically directed includes more than \$6.5 billion designated for countermeasure development through BARDA and \$3 billion for NIH research.

Single Privatized Contract Approach Implications

As of September 29, 2020, NPR and other entities have been have been unsuccessful at receiving copies of procurement contracts through public records requests. They requested contracts between the Federal Government and the pharmaceutical companies not the contracted intermediary, Advanced Technologies International - ATI. The Health and Human Services (HHS) response was that it had no records for the \$1.6 billion contract with Novavax, indicating that the department leading Operation Warp Speed doesn't have a copy of the contract. NPR made the same request of the Department of Defense and is awaiting the response. It is unclear what the implications may be with the Department of Defense role [6].

Operation Warp Speed to develop a COVID-19 vaccine has been compared to the Manhattan Project, however that is incorrect and a serious misrepresentation of the US Government response. Instead of using US Government resources to marshal massive national and international resources to establish and run a massive program to solve a very complex problem the US Government handed off contracting and oversight to a single company Advanced Technologies International, Inc. (ATI). Unlike the Manhattan Project where secrecy was needed to protect the US from nation state enemies, the secrecy that is established using this approach is based on civil law associated with intellectual property and trade secrets. The details of Operation Warp Speed will take years to surface and most of it will be held as private data not releasable to anyone other than those under civil contract agreements including non-disclosure agreements. Operation Warp Speed issuing billions of dollars' of tax payer money to companies through ATI also bypasses the regulatory oversight and transparency of traditional federal contracting mechanisms [4].

As a reference point the Manhattan project developed the atomic bomb, employed approximately 130,000 people, and cost approximately \$1.89 billion in 1944 dollars or \$28 billion in 2020 dollars. The Semi-Automatic Ground Environment (SAGE) project was developed to defend against the nuclear threat was more than twice as large and cost approximately \$83 billion in 2020 dollars. The defense problem was more than twice as difficult.

The US Government established a mechanism in the 1950's called an Other Transaction Authority, or OTA. The OT authority started with the National Aeronautics and Space Administration (NASA) when the National Aeronautics and Space Act of 1958 was passed. Seven other specific agencies have been given OT authority: the Department of Defense (DOD), Federal Aviation Administration (FAA), Department of Transportation (DOT), Department of Homeland Security (DHS), Transportation Security Administration, Department of Health and Human Services, and Department of Energy.

The purpose of the OTA was to allow small companies with little resources but important new technology to be funded without subjecting them to normal government contracting. Normal government contracting is captured in the Federal Acquisition Rules (FARS). The OTA was never intended to be used to hide information and bypass oversight and transparency. The OTA was meant to protect the 1-5 person company with little management capability (e.g. contracts,

legal, administrative) from having their work taken by massive companies working in the same area for the US Government. The claim is that these kinds of agreements allow the government to be more nimble is irresponsible and a perversion of the original intent of the OTA.

It appears that many of the ATI OTAs weakened or excluded contract language. For example language that allows the government to take control of a drug or vaccine if a manufacturer that received federal funding engages in price gouging [4]. These are some of the negative system consequences of using the OTA approach on large entities that clearly have the capability to enter into US government contracts:

- Contracts between the pharmaceutical companies and ATI may not be available through public records requests
- Additional documents are exempt from public disclosure for five years, others may never be disclosed, it is private data
- Exemption from laws and regulations designed to protect government and taxpayer interests
- The technical work is the technical work and an OTA will not speed up the technical work so OTAs are NOT faster than traditional government contracts
- The only purpose of an OTA is to protect intellectual property of small entities unable to protect themselves, not hide taxpayer owned property

Using the Freedom of Information Act (FOIA), citizens are not able to access agreements that are maintained by a private entity. The implications are that we don't know what traditional taxpayer protections were omitted by the ATI contracts. We also will not have access to all the technical documents. The only access that will be provided to the citizens of the US and the people of the world is what the companies decide to disclose. It is obvious that any negative technical information will not be disclosed.

This is the system approach that was selected and the system will behave based on its requirements not someone's after the fact thoughts, expectations, dreams, or desires. It appears the key stakeholders, the people, were removed from the table. Some refer to the concept of trust but verify. Systems practitioners that work on serious mission critical systems where loss of life is possible rely on the concept of - never trust anyone or anything - instead they establish systems that always verify and assume that trust has been compromised and the system must be able to detect that compromise and safely deal with the compromise (failsafe architectures / systems). If one starts with a compromised system, no one should be surprised if there are massive negative consequences. This is separate and distinct from massive **unintended** negative consequences where everyone did their best but the problem was beyond our current capabilities. Starting with a compromised system is called gaming the system. It is done to favor a hidden stakeholder, usually for financial benefit but there are other reasons that systems are gamed with the result being a compromised system.

The key question: **Is this US approach to vaccine development a reasonable system approach and has very effort been made to ensure that all negative consequences have been addressed?** Now show me the documented evidence.

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FDA Approval Pfizer-BioNTech Vaccine

FDA News Release

FDA Takes Key Action in Fight Against COVID-19 By Issuing Emergency Use Authorization for First COVID-19 Vaccine [1]

Action Follows Thorough Evaluation of Available Safety, Effectiveness, and Manufacturing Quality Information by FDA Career Scientists, Input from Independent Experts

For Immediate Release:

December 11, 2020

Today, the U.S. Food and Drug Administration issued the first emergency use authorization (EUA) for a vaccine for the prevention of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in individuals 16 years of age and older. The emergency use authorization allows the Pfizer-BioNTech COVID-19 Vaccine to be distributed in the U.S.

“The FDA’s authorization for emergency use of the first COVID-19 vaccine is a significant milestone in battling this devastating pandemic that has affected so many families in the United States and around the world,” said FDA Commissioner Stephen M. Hahn, M.D. “Today’s action follows an open and transparent review process that included input from independent scientific and public health experts and a thorough evaluation by the agency’s career scientists to ensure this vaccine met FDA’s rigorous, scientific standards for safety, effectiveness, and manufacturing quality needed to support emergency use authorization. The tireless work to develop a new vaccine to prevent this novel, serious, and life-threatening disease in an expedited timeframe after its emergence is a true testament to scientific innovation and public-private collaboration worldwide.”

The FDA has determined that Pfizer-BioNTech COVID-19 Vaccine has met the statutory criteria for issuance of an EUA. The totality of the available data provides clear evidence that Pfizer-BioNTech COVID-19 Vaccine may be effective in preventing COVID-19. The data also support that the known and potential benefits outweigh the known and potential risks, supporting the vaccine’s use in millions of people 16 years of age and older, including healthy individuals. In making this determination, the FDA can assure the public and medical community that it has conducted a thorough evaluation of the available safety, effectiveness and manufacturing quality information.

The Pfizer-BioNTech COVID-19 Vaccine contains messenger RNA (mRNA), which is genetic material. The vaccine contains a small piece of the SARS-CoV-2 virus’s mRNA that instructs cells in the body to make the virus’s distinctive “spike” protein. When a person receives this vaccine, their body produces copies of the spike protein, which does not cause disease, but triggers the immune system to learn to react defensively, producing an immune response against SARS-CoV-2.

“While not an FDA approval, today’s emergency use authorization of the Pfizer-BioNTech COVID-19 Vaccine holds the promise to alter the course of this pandemic in the United States,” said Peter Marks, M.D., Ph.D., Director of the FDA’s Center for Biologics Evaluation and Research. “With science guiding our decision-making, the available safety and effectiveness data support the authorization of the Pfizer-BioNTech COVID-19 Vaccine because the vaccine’s known and potential benefits clearly outweigh its known and potential risks. The data provided by the sponsor have met the FDA’s expectations as conveyed in our June and October guidance documents. Efforts to speed vaccine development have not sacrificed scientific standards or the integrity of our vaccine evaluation process. The FDA’s review process also included public and independent review from members of the agency’s Vaccines and Related Biological Products Advisory Committee. Today’s achievement is ultimately a testament to the commitment of our career scientists and physicians, who worked tirelessly to thoroughly evaluate the data and information for this vaccine.”

FDA Evaluation of Available Safety Data

Pfizer BioNTech COVID-19 Vaccine is administered as a series of two doses, three weeks apart. The available safety data to support the EUA include 37,586 of the participants enrolled in an ongoing randomized, placebo-controlled international study, the majority of whom are U.S. participants. These participants, 18,801 of whom received the vaccine and 18,785 of whom received saline placebo, were followed for a median of two months after receiving the second dose. The most commonly reported side effects, which typically lasted several days, were pain at the injection site, tiredness, headache, muscle pain, chills, joint pain, and fever. Of note, more people experienced these side effects after the second dose than after the first dose, so it is important for vaccination providers and recipients to expect that there may be some side effects after either dose, but even more so after the second dose.

It is mandatory for Pfizer Inc. and vaccination providers to report the following to the Vaccine Adverse Event Reporting System (VAERS) for Pfizer-BioNTech COVID-19 Vaccine: all vaccine administration errors, serious adverse events, cases of Multisystem Inflammatory Syndrome (MIS), and cases of COVID-19 that result in hospitalization or death.

FDA Evaluation of Available Effectiveness Data

The effectiveness data to support the EUA include an analysis of 36,523 participants in the ongoing randomized, placebo-controlled international study, the majority of whom are U.S. participants, who did not have evidence of SARS-CoV-2 infection through seven days after the second dose. Among these participants, 18,198 received the vaccine and 18,325 received placebo. The vaccine was 95% effective in preventing COVID-19 disease among these clinical trial participants with eight COVID-19 cases in the vaccine group and 162 in the placebo group. Of these 170 COVID-19 cases, one in the vaccine group and three in the placebo group were classified as severe. At this time, data are not available to make a determination about how long the vaccine will provide protection, nor is there evidence that the vaccine prevents transmission of SARS-CoV-2 from person to person.

The EUA Process

On the basis of the determination by the Secretary of the Department of Health and Human Services on February 4, 2020, that there is a public health emergency that has a significant potential to affect national security or the health and security of United States citizens living abroad, and then issued declarations that circumstances exist justifying the authorization of emergency use of unapproved products, the FDA may issue an EUA to allow unapproved medical products or unapproved uses of approved medical products to be used in an emergency to diagnose, treat, or prevent COVID-19 when there are no adequate, approved, and available alternatives.

The issuance of an EUA is different than an FDA approval (licensure) of a vaccine. In determining whether to issue an EUA for a product, the FDA evaluates the available evidence and assesses any known or potential risks and any known or potential benefits, and if the benefit-risk assessment is favorable, the product is made available during the emergency. Once a manufacturer submits an EUA request for a COVID-19 vaccine to the FDA, the agency then evaluates the request and determines whether the relevant statutory criteria are met, taking into account the totality of the scientific evidence about the vaccine that is available to the FDA.

The EUA also requires that fact sheets that provide important information, including dosing instructions, and information about the benefits and risks of the Pfizer-BioNTech COVID-19 Vaccine, be made available to vaccination providers and vaccine recipients.

The company has submitted a pharmacovigilance plan to FDA to monitor the safety of Pfizer-BioNTech COVID-19 Vaccine. The pharmacovigilance plan includes a plan to complete longer-term safety follow-up for participants enrolled in ongoing clinical trials. The pharmacovigilance plan also includes other activities aimed at monitoring the safety profile of the Pfizer-BioNTech COVID-19 vaccine and ensuring that any safety concerns are identified and evaluated in a timely manner.

The FDA also expects manufacturers whose COVID-19 vaccines are authorized under an EUA to continue their clinical trials to obtain additional safety and effectiveness information and pursue approval (licensure).

The EUA for the Pfizer-BioNTech COVID-19 Vaccine was issued to Pfizer Inc. The EUA will be effective until the declaration that circumstances exist justifying the authorization of the emergency use of drugs and biologics for prevention and treatment of COVID-19 is terminated,

and may be revised or revoked if it is determined the EUA no longer meets the statutory criteria for issuance.

The FDA, an agency within the U.S. Department of Health and Human Services, protects the public health by assuring the safety, effectiveness, and security of human and veterinary drugs, vaccines and other biological products for human use, and medical devices. The agency also is responsible for the safety and security of our nation's food supply, cosmetics, dietary supplements, products that give off electronic radiation, and for regulating tobacco products.

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[1] FDA News Release, FDA Takes Key Action in Fight Against COVID-19 By Issuing Emergency Use Authorization for First COVID-19 Vaccine, FDA Approval Pfizer-BioNTech Vaccine, US Government, December 11, 2020. [local vaccine lib](#)

FDA Approval Moderna Vaccine

FDA News Release

FDA Takes Additional Action in Fight Against COVID-19 By Issuing Emergency Use Authorization for Second COVID-19 Vaccine [1]

Action Follows Thorough Evaluation of Available Safety, Effectiveness, and Manufacturing Quality Information by FDA Career Scientists, Input from Independent Experts

For Immediate Release:

December 18, 2020

Today, the U.S. Food and Drug Administration issued an emergency use authorization (EUA) for the second vaccine for the prevention of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The emergency use authorization allows the Moderna COVID-19 Vaccine to be distributed in the U.S. for use in individuals 18 years of age and older.

“With the availability of two vaccines now for the prevention of COVID-19, the FDA has taken another crucial step in the fight against this global pandemic that is causing vast numbers of hospitalizations and deaths in the United States each day,” said FDA Commissioner Stephen M. Hahn, M.D. “Through the FDA’s open and transparent scientific review process, two COVID-19 vaccines have been authorized in an expedited timeframe while adhering to the rigorous standards for safety, effectiveness, and manufacturing quality needed to support emergency use authorization that the American people have come to expect from the FDA. These standards and our review process, which are the same we have used in reviewing the first COVID-19 vaccine and intend to use for any other COVID-19 vaccines, included input from independent scientific and public health experts as well as a thorough analysis of the data by the agency’s career staff.”

The FDA has determined that the Moderna COVID-19 Vaccine has met the statutory criteria for issuance of an EUA. The totality of the available data provides clear evidence that the Moderna COVID-19 Vaccine may be effective in preventing COVID-19. The data also show that the known and potential benefits outweigh the known and potential risks—supporting the company’s request for the vaccine’s use in people 18 years of age and older. In making this determination, the FDA can assure the public and medical community that it has conducted a thorough evaluation of the available safety, effectiveness, and manufacturing quality information.

The Moderna COVID-19 Vaccine contains messenger RNA (mRNA), which is genetic material. The vaccine contains a small piece of the SARS-CoV-2 virus’s mRNA that instructs cells in the body to make the virus’s distinctive “spike” protein. After a person receives this vaccine, their body produces copies of the spike protein, which does not cause disease, but triggers the immune system to learn to react defensively, producing an immune response against SARS-CoV-2.

“Guided by science and data, the agency’s career staff determined that the vaccine’s known and potential benefits clearly outweigh its known and potential risks, and although not an FDA approval, the FDA’s expectations described in our June and October guidance documents have been met,” said Peter Marks, M.D., Ph.D., Director of the FDA’s Center for Biologics Evaluation and Research. “Today’s authorization demonstrates our steadfast commitment to the health of the American people, with the assurance that our scientific standards and the integrity of our review process have been maintained. This achievement is yet another testament to the dedication of FDA’s career scientists and physicians, who have been working urgently to conduct comprehensive and rigorous evaluations of the data submitted for vaccines to prevent COVID-19.”

FDA Evaluation of Available Safety Data

Moderna COVID-19 Vaccine is administered as a series of two doses, one month apart. The available safety data to support the EUA include an analysis of 30,351 participants enrolled in an ongoing randomized, placebo-controlled study conducted in the U.S. These participants, 15,185 of whom received the vaccine and 15,166 of whom received saline placebo, were followed for a median of more than two months after receiving the second dose. The most commonly reported side effects, which typically lasted several days, were pain at the injection site, tiredness, headache, muscle pain, chills, joint pain, swollen lymph nodes in the same arm as the injection, nausea and vomiting, and fever. Of note, more people experienced these side effects after the second dose than after the first dose, so it is important for vaccination providers and recipients to expect that there may be some side effects after either dose, but even more so after the second dose.

It is mandatory for ModernaTX, Inc. and vaccination providers to report the following to the Vaccine Adverse Event Reporting System (VAERS) for Moderna COVID-19 Vaccine: all vaccine administration errors, serious adverse events, cases of Multisystem Inflammatory Syndrome (MIS), and cases of COVID-19 that result in hospitalization or death.

FDA Evaluation of Available Effectiveness Data

The effectiveness data to support the EUA include an analysis of 28,207 participants in the ongoing randomized, placebo-controlled U.S. study who did not have evidence of SARS-CoV-2 infection prior to the first dose of vaccine. Among these participants, 14,134 received the vaccine

and 14,073 received placebo. The vaccine was 94.1% effective in preventing COVID-19 disease among these clinical trial participants with 11 cases of COVID-19 in the vaccine group and 185 in the placebo group. At the time of the analysis of these 196 COVID-19 cases, none in the vaccine group and 30 in the placebo group were classified as severe. After the analysis of these 196 cases was completed, one severe case in the vaccine group was identified and is awaiting confirmation. At this time, data are not available to determine how long the vaccine will provide protection, nor is there evidence that the vaccine prevents transmission of SARS-CoV-2 from person to person.

The EUA Process

On the basis of the determination by the Secretary of the Department of Health and Human Services on Feb. 4, 2020, that there is a public health emergency that has a significant potential to affect national security or the health and security of United States citizens living abroad, and issued declarations that circumstances exist justifying the authorization of emergency use of unapproved products, the FDA may issue an EUA to allow unapproved medical products or unapproved uses of approved medical products to be used in an emergency to diagnose, treat, or prevent COVID-19 when there are no adequate, approved, and available alternatives.

The issuance of an EUA is different than an FDA approval (licensure) of a vaccine, in that a vaccine available under an EUA is not approved. In determining whether to issue an EUA for a product, the FDA evaluates the available evidence to determine whether the product may be effective and also assesses any known or potential risks and any known or potential benefits. If the product meets the effectiveness standard and the benefit-risk assessment is favorable, the product is made available during the emergency. Once a manufacturer submits an EUA request for a COVID-19 vaccine to the FDA, the agency then evaluates the request and determines whether the relevant statutory criteria are met, taking into account the totality of the scientific evidence about the vaccine that is available to the FDA.

The EUA also requires that fact sheets that provide important information, including dosing instructions, and information about the benefits and risks of the Moderna COVID-19 Vaccine, be made available to vaccination providers and vaccine recipients.

ModernaTX, Inc. has submitted a pharmacovigilance plan to the FDA to monitor the safety of Moderna COVID-19 Vaccine. The pharmacovigilance plan includes a plan to complete longer-term safety follow-up for participants enrolled in ongoing clinical trials. The pharmacovigilance plan also includes other activities aimed at monitoring the safety profile of the Moderna COVID-19 vaccine and ensuring that any safety concerns are identified and evaluated in a timely manner.

The FDA also expects manufacturers whose COVID-19 vaccines are authorized under an EUA to continue their clinical trials to obtain additional safety and effectiveness information and pursue approval (licensure).

The EUA for the Moderna COVID-19 Vaccine was issued to ModernaTX, Inc. The authorization will be effective until the declaration that circumstances exist justifying the authorization of the emergency use of drugs and biologics for prevention and treatment of COVID-19 is terminated. The EUA for Moderna COVID-19 Vaccine may be revised or revoked if it is determined the EUA no longer meets the statutory criteria for issuance.

The FDA, an agency within the U.S. Department of Health and Human Services, protects the public health by assuring the safety, effectiveness, and security of human and veterinary drugs, vaccines and other biological products for human use, and medical devices. The agency also is responsible for the safety and security of our nation's food supply, cosmetics, dietary supplements, products that give off electronic radiation, and for regulating tobacco products.

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[1] FDA News Release, FDA Takes Additional Action in Fight Against COVID-19 By Issuing Emergency Use Authorization for Second COVID-19 Vaccine, FDA Approval Moderna Vaccine, US Government, December 18, 2020. [local vaccine lib](#)

FDA Approval Janssen Vaccine

FDA News Release

FDA Issues Emergency Use Authorization for Third COVID-19 Vaccine

Action Advances Fight Against COVID-19, Follows Comprehensive Evaluation of Available Safety, Effectiveness and Manufacturing Quality Information by FDA Career Scientists, Input from External Experts

For Immediate Release:

February 27, 2021

Today, the U.S. Food and Drug Administration issued an emergency use authorization (EUA) for the third vaccine for the prevention of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The EUA allows the Janssen COVID-19 Vaccine to be distributed in the U.S for use in individuals 18 years of age and older.

"The authorization of this vaccine expands the availability of vaccines, the best medical prevention method for COVID-19, to help us in the fight against this pandemic, which has claimed over half a million lives in the United States" said Acting FDA Commissioner Janet Woodcock, M.D. "The FDA, through our open and transparent scientific review process, has now authorized three COVID-19 vaccines with the urgency called for during this pandemic, using the agency's rigorous standards for safety, effectiveness and manufacturing quality needed to support emergency use authorization."

The FDA has determined that the Janssen COVID-19 Vaccine has met the statutory criteria for issuance of an EUA. The totality of the available data provides clear evidence that the Janssen COVID-19 Vaccine may be effective in preventing COVID-19. The data also show that the vaccine's known and potential benefits outweigh its known and potential risks, supporting the company's request for the vaccine's use in people 18 years of age and older. In making this determination, the FDA can assure the public and medical community that it has conducted a thorough evaluation of the available safety, effectiveness and manufacturing quality information.

The Janssen COVID-19 Vaccine is manufactured using a specific type of virus called adenovirus type 26 (Ad26). The vaccine uses Ad26 to deliver a piece of the DNA, or genetic material, that is used to make the distinctive "spike" protein of the SARS-CoV-2 virus. While adenoviruses are a group of viruses that are relatively common, Ad26, which can cause cold symptoms and pink eye, has been modified for the vaccine so that it cannot replicate in the human body to cause illness. After a person receives this vaccine, the body can temporarily make the spike protein, which does not cause disease, but triggers the immune system to learn to react defensively, producing an immune response against SARS-CoV-2.

"After a thorough analysis of the data, the FDA's scientists and physicians have determined that the vaccine meets the FDA's expectations for safety and effectiveness appropriate for the authorization of a vaccine for emergency use," said Peter Marks, M.D., Ph.D., director of the FDA's Center for Biologics Evaluation and Research. "With today's authorization, we are adding another vaccine in our medical toolbox to fight this virus. At the same time, the American people can be assured of the FDA's unwavering commitment to public health through our comprehensive and rigorous evaluation of the data submitted for vaccines to prevent COVID-19."

FDA Evaluation of Available Safety Data

The Janssen COVID-19 Vaccine is administered as a single dose. The available safety data to support the EUA include an analysis of 43,783 participants enrolled in an ongoing randomized, placebo-controlled study being conducted in South Africa, certain countries in South America, Mexico, and the U.S. The participants, 21,895 of whom received the vaccine and 21,888 of whom received saline placebo, were followed for a median of eight weeks after vaccination. The most commonly reported side effects were pain at the injection site, headache, fatigue, muscle aches and nausea. Most of these side effects were mild to moderate in severity and lasted 1-2 days.

As part of the authorization, the FDA notes that it is mandatory for Janssen Biotech Inc. and vaccination providers to report the following to the Vaccine Adverse Event Reporting System (VAERS) for Janssen COVID-19 Vaccine: serious adverse events, cases of Multisystem Inflammatory Syndrome and cases of COVID-19 that result in hospitalization or death.

It is also mandatory for vaccination providers to report all vaccine administration errors to VAERS for which they become aware and for Janssen Biotech Inc. to include a summary and analysis of all identified vaccine administration errors in monthly safety reports submitted to the FDA.

FDA Evaluation of Available Effectiveness Data

The effectiveness data to support the EUA include an analysis of 39,321 participants in the ongoing randomized, placebo-controlled study being conducted in South Africa, certain countries in South America, Mexico, and the U.S. who did not have evidence of SARS-CoV-2 infection prior to receiving the vaccine. Among these participants, 19,630 received the vaccine and 19,691 received saline placebo. Overall, the vaccine was approximately 67% effective in preventing moderate to severe/critical COVID-19 occurring at least 14 days after vaccination and 66% effective in preventing moderate to severe/critical COVID-19 occurring at least 28 days after vaccination.

Additionally, the vaccine was approximately 77% effective in preventing severe/critical COVID-19 occurring at least 14 days after vaccination and 85% effective in preventing severe/critical COVID-19 occurring at least 28 days after vaccination.

There were 116 cases of COVID-19 in the vaccine group that occurred at least 14 days after vaccination, and 348 cases of COVID-19 in the placebo group during this time period. There were 66 cases of COVID-19 in the vaccine group that occurred at least 28 days after vaccination and 193 cases of COVID-19 in the placebo group during this time period. Starting 14 days after vaccination, there were 14 severe/critical cases in the vaccinated group versus 60 in the placebo group, and starting 28 days after vaccination, there were 5 severe/critical in the vaccine group versus 34 cases in the placebo group.

At this time, data are not available to determine how long the vaccine will provide protection, nor is there evidence that the vaccine prevents transmission of SARS-CoV-2 from person to person.

The EUA Process

On the basis of the determination by the Secretary of the Department of Health and Human Services on Feb. 4, 2020, that there is a public health emergency that has a significant potential to affect national security or the health and security of United States citizens living abroad, and issued declarations that circumstances exist justifying the authorization of emergency use of unapproved products, the FDA may issue an EUA to allow unapproved medical products or unapproved uses of approved medical products to be used in an emergency to diagnose, treat, or prevent COVID-19 when there are no adequate, approved, and available alternatives.

The issuance of an EUA is different than an FDA approval (licensure) of a vaccine, in that a vaccine available under an EUA is not approved. In determining whether to issue an EUA for a product, the FDA evaluates the available evidence to determine whether the product may be effective and also assesses any known or potential risks and any known or potential benefits. If the product meets the effectiveness standard and the benefit-risk assessment is favorable, the product is made available during the emergency. Once a manufacturer submits an EUA request for a COVID-19 vaccine to the FDA, the agency then evaluates the request and determines whether the relevant statutory criteria are met, taking into account the totality of the scientific evidence about the vaccine that is available to the FDA.

The EUA also requires that fact sheets that provide important information, including dosing instructions, and information about the benefits and risks of the Janssen COVID-19 Vaccine, be made available to vaccination providers and vaccine recipients.

Janssen Biotech Inc. has submitted a pharmacovigilance plan to the FDA describing its commitment to monitor the safety of Janssen COVID-19 Vaccine. The pharmacovigilance plan includes a plan to complete longer-term safety follow-up for participants enrolled in ongoing clinical trials. The pharmacovigilance plan also includes other activities aimed at monitoring the safety profile of the Janssen COVID-19 Vaccine and ensuring that any safety concerns are identified and evaluated in a timely manner.

The FDA also expects manufacturers whose COVID-19 vaccines are authorized under an EUA to continue their clinical trials to obtain additional safety and effectiveness information and pursue approval (licensure).

The EUA for the Janssen COVID-19 Vaccine was issued to Janssen Biotech Inc., a Janssen Pharmaceutical Company of Johnson & Johnson. The authorization will be effective until the declaration that circumstances exist justifying the authorization of the emergency use of drugs and biologics for prevention and treatment of COVID-19 is terminated. The EUA for Janssen COVID-19 Vaccine may be revised or revoked if it is determined the EUA no longer meets the statutory criteria for issuance.

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References:

[1] FDA News Release, FDA Issues Emergency Use Authorization for Third COVID-19 Vaccine, FDA Approval Janssen Vaccine, US Government, February 27, 2021. [local vaccine lib](#)

Vaccine Systems Perspective

Even though massive resources are being applied to develop a successful vaccine, it is clear from a systems perspective that the vaccine will not immediately stop the pandemic. In the best case scenario there is a successful vaccine but it will take 2 or more years for the virus to be removed. In the worst case no vaccine is found. In the middle case there is a vaccine but it will not be 100% effective. This will lengthen the time for the virus to be removed from 2 years to perhaps decades matching what occurred with other efforts to eradicate diseases via vaccination.

If there is a vaccine these are the possible results [[spreadsheet](#) Vaccine].

Table 88 - Vaccine Systems Perspective

| Population | Naturally Immune % | Vaccine Effectiveness % | Vaccinated % | Exposed Population | Deaths @ 2% | Deaths @ 3% | Deaths @ 3.5% | UV-C or FAR UV-222 Kill / Inactivate [9] [10] | Deaths @ 3.5% (With UV) | Ventilation Effectiveness 4 AUC [11] | Deaths @ 3.5% (With UV + Ventilation) | Comment |
|-------------|--------------------|-------------------------|--------------|--------------------|------------------|-------------|-------------------|---|-------------------------|--------------------------------------|---------------------------------------|--|
| 328,000,000 | 10% | 70% | 70% | 150,552,000 | 3,011,040 | 4,516,560 | 5,269,320 | 90% | 526,932 | 28% | 379,391 | Likely vaccine result with some natural immunity |
| 328,000,000 | 10% | 90% | 90% | 56,088,000 | 1,121,760 | 1,682,640 | 1,963,080 | 90% | 196,308 | 28% | 141,342 | Unlikely vaccine result with some natural immunity |
| 328,000,000 | 0% | 70% | 70% | 167,280,000 | 3,345,600 | 5,018,400 | 5,854,800 | 90% | 585,480 | 28% | 421,546 | Likely vaccine result with no natural immunity |
| 328,000,000 | 0% | 90% | 90% | 62,320,000 | 1,246,400 | 1,869,600 | 2,181,200 | 90% | 218,120 | 28% | 157,046 | Unlikely vaccine result with no natural immunity |
| | | | | | | | | | | | | |
| 328,000,000 | 0% | 0% | 0% | 328,000,000 | 6,560,000 | 9,840,000 | 11,480,000 | 90% | 1,148,000 | 28% | 826,560 | No vaccine, natural herd immunity |
| 328,000,000 | 10% | 0% | 0% | 295,200,000 | 5,904,000 | 8,856,000 | 10,332,000 | 90% | 1,033,200 | 28% | 743,904 | No vaccine, natural herd immunity |

Note: Ventilation works only when it is turned on. The HVAC fan(s) must run 1 hour before and 1 hour after the facility opens to the public.

As of November 16, 2020 interim results from phase 3 clinical trials of the vaccine from Moderna (US company) demonstrated an efficacy rate of 94.5% in a trial of more than 30,000 patients. In the previous week Pfizer (Germany based) and BioNTech announced an efficacy of more than 90% in a trial of 44,000 patients. AstraZeneca could release interim data on its COVID-19 vaccine in December, according to the University of Oxford, who partnered with AstraZeneca to develop a vaccine. [1] [2]

It is unclear what the population characteristics are for those where the vaccine did not work. In systems engineering analysis when things are scaled from tens of thousands to million and then hundreds of million there are unintended consequences. Things may shift where the vaccine may be less effective than suggested by this promising result. Time will tell. There is still the system problem of vaccinating a sufficiently large population in a short enough time to stop the pandemic in a reasonable time. This also does not change the fact that our modern buildings and airplanes are a source of infection spread.

The vaccine analysis has been augmented to show the effects of UV and ventilation infrastructure modifications. Unlike the vaccine this assumes that all the infrastructure modifications that are needed are performed. A key observation is the effect of UV introduction. The UV solution is a constant 90% cleaning of the air from an infection that is continuously being emitted into the environment [3] [4]. Although better ventilation effects may be provided, it is unlikely that it would approach the effectiveness of UV in real world settings. Only open ventilation where windows are open and fans are running provide 88% effectiveness but only for 1 hour [5]. This suggests that the solution must include:

1. Proper indoor and outside ventilation guidance so that people can enjoy life and not become infected
2. The performance numbers must be disclosed and understood by the people (vaccines, UV, ventilation)
3. The technologies and their effectiveness must be understood by the people (vaccines, UV, ventilation)
4. No more vague guidance like provide ventilation - state how much for each living scenario, or people will continue to be infected
5. Decontamination protocols must be followed
6. Disease treatment to increase survivability and quality of life must be pursued
7. Multiple vaccines that may need to be administered over several years will be needed

▼ The United Kingdom begins vaccinating with the Pfizer/BioNTech vaccine. The first to receive the initial dose of the two dose vaccine was 90 year old Margaret Keenan at 6:31 AM local time on Tuesday December 8, 2020 at University Hospital in Coventry. This was less than a week after the UK became the first to approve the Pfizer/BioNTech vaccine. [6] [7]

▼ After two people reported adverse reactions on the first day of vaccination, Britain's medicine regulator advised people with a history of significant allergies to not get Pfizer-BioNTech's COVID-19 vaccine. Britain's NHS workers reported anaphylactoid reactions associated with receiving the vaccine. People with a significant history of allergic reactions should not receive this vaccination. Allergic reactions were not a feature in the clinical trials. Pfizer said people with a history of severe adverse allergic reactions to vaccines or the candidate's ingredients were excluded from their late stage trials, which is reflected in the MHRA's emergency approval protocol. The new MHRA guidance is that any person with a

history of a significant allergic reaction to a vaccine, medicine or food (such as previous history of anaphylactoid reaction or those who have been advised to carry an adrenaline autoinjector) should not receive the Pfizer BioNtech vaccine and that resuscitation facilities should be available for all vaccinations. [8]

Pfizer's trial protocol [9] shows that people with a history of severe allergic reaction (e.g., anaphylaxis) to any component of the study intervention were not able to take part [10].

It is unknown why people sensitive to allergic reactions were permitted to take the vaccine, because they were not part of the study. The guidance should have been clearly provided that those with severe allergic reactions should disclose the information and the facilities administering the vaccine should be prepared. No new guidance should have been needed if the system safety analysis was fully addressed. The new guidance is evidence of missing this critical safety element. The Pfizer / BioNTech vaccine is only one element of the system that includes manufacturing, distribution, delivery, and follow up. See section [System or Product Certification](#).

References:

[1] Moderna vaccine trial's results bode well for Oxford/AstraZeneca, The Guardian, November 16, 2020. webpage <https://www.theguardian.com/society/2020/nov/16/moderna-vaccines-effectiveness-bodes-well-for-oxfordastrazeneca-jab>, November 2020. [Moderna vaccine trial's results bode well for Oxford/AstraZeneca](#)

[2] Pfizer and AstraZeneca slide as Moderna's rival COVID-19 vaccine shows strong efficacy, Business Insider, November 16, 2020. webpage <https://markets.businessinsider.com/news/stocks/pfizer-astrazeneca-stock-price-moderna-covid19-vaccine-shows-strong-efficacy-2020-11-1029806658>, November 2020. [Pfizer and AstraZeneca slide as Moderna's rival COVID-19 vaccine shows strong efficacy](#)

[3] Effect of Ultra-violet Irradiation of Classrooms on Spread of Measles in Large Rural Central Schools, May 1947. New York State Department of Health, Albany, N.Y. webpage <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1623610/pdf/amjphnation01116-0034.pdf>, November 2020. [Effect of Ultra-violet Irradiation of Classrooms on Spread of Measles in Large Rural Central Schools . local](#)

[4] Basic Upper-Room Ultraviolet Germicidal Irradiation Guidelines for Healthcare Settings, Department of Health and Human Services Centers for Disease Control and Prevention National Institute for Occupational Safety and Health, DHHS (NIOSH), Publication No. 2009-105 March 2009. webpage <https://www.cdc.gov/niosh/docs/2009-105/pdfs/2009-105.pdf>, November 2020. [Basic Upper-Room Ultraviolet Germicidal Irradiation Guidelines for Healthcare Settings . local](#)

[5] See section [Wells-Riley Summary](#), 1 hour, No Mask, 10,800 cu-ft scenario.

[6] Covid-19 vaccine: First person receives Pfizer jab in UK, BBC, December 8, 2020. webpage <https://www.bbc.com/news/uk-55227325>, December 2020. [Covid-19 vaccine: First person receives Pfizer jab in UK](#)

[7] First Britons receive Covid-19 vaccine, a landmark moment in the pandemic, CNN, December 8, 2020. webpage <https://www.cnn.com/2020/12/08/europe/uk-pfizer-biontech-covid->

vaccination-intl/index.html, December 2020. [First Britons receive Covid-19 vaccine, a landmark moment in the pandemic](#)

[8] UK warns people with serious allergies to avoid Pfizer vaccine after two adverse reactions, REUTERS, December 9, 2020. webpage <https://www.reuters.com/article/health-coronavirus-britain-vaccine/uk-warns-people-with-serious-allergies-to-avoid-pfizer-vaccine-idUSKBN28J1DX>, December 2020. [UK warns people with serious allergies to avoid Pfizer vaccine after two adverse reactions](#)

[9] A Phase 1/2/3, Placebo-Controlled, Randomized, Observer-Blind, Dose-Finding Study To Evaluate The Safety, Tolerability, Immunogenicity, And Efficacy Of SARS-CoV-2 RNA Vaccine Candidates Against COVID-19 In Healthy Individuals, webpage https://pfe-pfizercom-d8-prod.s3.amazonaws.com/2020-09/C4591001_Clinical_Protocol.pdf, December 2020. [PDF . local](#)

[10] Allergy warning for Pfizer/BioNTech vaccine after UK health workers with allergy history suffer reaction, CNN, December 9, 2020. webpage <https://www.cnn.com/2020/12/09/health/covid-vaccine-allergies-health-workers-uk-intl-gbr/index.html>, December 2020. [Allergy warning for Pfizer/BioNTech vaccine after UK health workers with allergy history suffer reaction](#)

Vaccine Distribution

Vaccine distribution is based on the ability to manufacture and deliver the vaccine to the patient. As of December 28, 2020 there is some empirical data to determine the vaccine delivery rate. The rate is expected to start slow and then increase with time. The question then becomes, assuming infinite capacity to manufacture, what is the possible delivery rate.

The following figure shows the Operation Warp Speed distribution process. Notice that it does not show what happens once the vaccine arrives at the final destination [4].

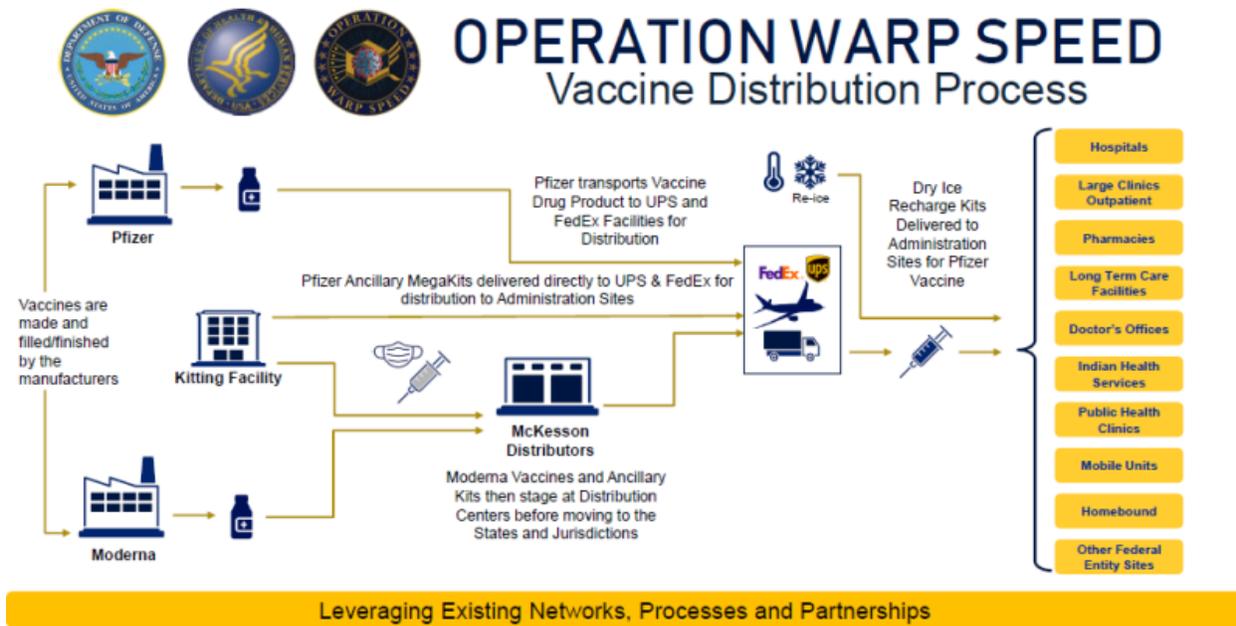


Figure 44 - Operation Warp Speed Distribution Process

The following table shows empirical data on the vaccine delivery rate. The 300,000,000 vaccinated number was selected because it is an easy factor to quickly extrapolate other results and it is within the expected herd immunity range. This first batch was destined to healthcare providers. Some healthcare providers were queried by survey if they were interested in receiving the vaccine. It is unclear if those surveys affected the vaccination delivery rate.

Table 89 - Initial Vaccine Delivery Rate

| Date | Vaccinated | Daily Rate | Days to reach 300 M | Years | Comment |
|------------|------------|------------|---------------------|-------|---|
| 12/14/2020 | 0 | - | - | - | Vaccination starts [1] |
| 12/28/2020 | 2,100,000 | 150,000 | 2,000 | 5 | More was manufactured and more doses confirmed received than vaccinated [2] |
| 01/01/2021 | 2,800,000 | 155,556 | 1,929 | 5 | [14] |

The following table is a model of what may be possible for vaccine delivery given certain assumptions.

Table 90 - Vaccine Delivery Rate Model

| Item | Number | Comments |
|------|--------|----------|
| | | |

| Item | Number | Comments |
|--------------------------------------|-------------|--|
| Minutes to Vaccinate | 30 | Assumption, wait for side effects |
| To be vaccinated | 300,000,000 | Assumption |
| Person Hours | 150,000,000 | |
| Person Years @ 2,000 hrs / yr | 75,000 | |
| # of persons to complete in 1 year | 75,000 | |
| # of persons to complete in 6 months | 150,000 | There are more than 2,500,000 nurses and more than 800,000 doctors in the US |
| . | | |
| Daily rate to complete in 1 year | 821,918 | |
| Daily rate to complete in 6 months | 1,643,836 | |

The following table shows the doses received and shots given between December 16 and 23, 2020 [3]. Geographically isolated areas such as Alaska, American Samoa, Guam and the Northern Mariana Islands can place orders for multiple weeks at once.

Table 91 - Doses Received and Vaccinations Given

| Destinations | Doses Allocated | Doses Confirmed Received | Vaccinations Shots Given |
|--------------------------------|-----------------|--------------------------|--------------------------|
| California | 1,762,900 | 437,900 | 70,258 |
| Texas | 1,207,525 | 262,800 | 83,967 |
| Florida | 964,950 | 184,275 | 68,133 |
| New York | 909,425 | 630,000 | 89,000 |
| Federal agencies | 785,275 | 158,000 | 3,100 |
| Department of Veterans Affairs | - | 73,000 | - |
| Indian Health Service | - | 85,000 | 3,100 |
| Other agencies | - | - | - |

| Destinations | Doses Allocated | Doses Confirmed Received | Vaccinations Shots Given |
|---------------------|------------------------|---------------------------------|---------------------------------|
| Pennsylvania | 596,125 | 141,405 | 50,466 |
| Illinois | 583,575 | 109,000 | 100,991 |
| Ohio | 529,975 | 98,475 | 11,700 |
| North Carolina | 461,925 | - | 24,500 |
| Georgia | 456,900 | 284,275 | 26,010 |
| Michigan | 455,900 | 231,075 | 37,660 |
| New Jersey | 405,825 | 208,000 | 27,730 |
| Virginia | 385,175 | 227,425 | 19,943 |
| Washington | 337,075 | 107,250 | 30,000 |
| Massachusetts | 320,975 | 59,639 | 34,953 |
| Arizona | 314,750 | 58,500 | 12,338 |
| Tennessee | 303,200 | 96,000 | 24,236 |
| Indiana | 298,750 | 94,000 | 33,000 |
| Missouri | 277,225 | 51,675 | 23,000 |
| Maryland | 273,875 | 50,700 | 10,497 |
| Wisconsin | 265,575 | 49,725 | 10,358 |
| Colorado | 251,450 | 56,160 | 43,749 |
| Minnesota | 250,650 | 174,750 | 2,999 |
| South Carolina | 228,425 | 42,900 | 19,644 |
| Alabama | 221,625 | 42,950 | 15,286 |
| Louisiana | 210,350 | 118,500 | 22,108 |
| Kentucky | 202,650 | 87,625 | 11,192 |
| Oregon | 189,725 | 47,200 | 10,407 |

| Destinations | Doses Allocated | Doses Confirmed Received | Vaccinations Shots Given |
|---------------------|------------------------|---------------------------------|---------------------------------|
| Oklahoma | 174,900 | 33,150 | 21,000 |
| Connecticut | 167,100 | 31,200 | 16,487 |
| Puerto Rico | 160,275 | 77,725 | 28,500 |
| Iowa | 142,600 | 26,000 | 8,400 |
| Arkansas | 136,075 | 25,350 | 12,969 |
| Mississippi | 133,725 | 62,600 | 4,500 |
| Nevada | 133,025 | 40,350 | 10,000 |
| Kansas | 130,450 | 24,000 | 600 |
| Utah | 125,825 | 68,800 | 11,380 |
| New Mexico | 95,400 | 17,550 | 14,000 |
| West Virginia | 86,800 | 60,875 | 18,488 |
| Nebraska | 86,500 | 15,600 | 15,462 |
| Idaho | 73,775 | 51,400 | 6,538 |
| Hawaii | 66,850 | 33,450 | 5 |
| Maine | 64,775 | 8,001 | 8,001 |
| New Hampshire | 64,775 | 45,650 | 3,819 |
| Alaska | 61,900 | 61,100 | 8,918 |
| Rhode Island | 50,950 | 9,750 | 7,072 |
| Montana | 50,050 | - | 7,407 |
| Delaware | 44,925 | 8,775 | 3,872 |
| South Dakota | 40,175 | 22,400 | 8,398 |
| North Dakota | 35,350 | 21,244 | 11,903 |
| Washington, D.C. | 34,550 | 6,825 | 4,500 |

| Destinations | Doses Allocated | Doses Confirmed Received | Vaccinations Shots Given |
|--------------------------|------------------------|---------------------------------|---------------------------------|
| Vermont | 31,975 | 17,200 | 4,374 |
| Wyoming | 27,150 | 4,975 | 2,352 |
| Guam | 19,300 | 11,700 | 1,931 |
| Northern Mariana Islands | 8,450 | - | - |
| American Samoa | 8,250 | 5,850 | 139 |
| U.S. Virgin Islands | 5,525 | 975 | 260 |
| Totals | 15,713,175 | 5,060,699 | 1,161,600 |

When the Food and Drug Administration (FDA) authorized the COVID-19 vaccine, the Advisory Committee on Immunization Practices (ACIP) held a public meeting to review all available data about the vaccine before making recommendations. The ACIP reviewed all available clinical trial information, including descriptions of who will be receiving each vaccine (age, race, ethnicity, underlying medical conditions), how different groups respond to the vaccine, and the side effects of each vaccine. The ACIP voted on whether to recommend the vaccine. The ACIP also voted on recommendations for vaccination priorities when supplies are limited. The ACIP recommendations were as follow [5]:

1. Dec. 01, 2020: ACIP recommended that health care personnel and long-term care facility residents be offered COVID-19 vaccination first (Phase 1a)
2. Dec. 11, 2020: FDA issued an Emergency Use Authorization (EUA) for use of the Pfizer-BioNTech COVID-19 vaccine in persons aged 16 years and older
3. Dec. 13, 2020: ACIP issued recommendations for the use of Pfizer-BioNTech’s COVID-19 vaccine for the prevention of COVID-19
4. Dec. 18, 2020: FDA issued an EUA for the use of the Moderna COVID-19 vaccine for use in individuals 18 years of age and older
5. Dec. 20, 2020: ACIP issued recommendations for the use of Moderna COVID-19 vaccine for the prevention of COVID-19
6. Dec. 20, 2020: ACIP updated interim vaccine allocation recommendations:
 1. In Phase 1b, COVID-19 vaccine should be offered to people aged 75 years and older and non-health care frontline essential workers,
 2. In Phase 1c, to people aged 65–74 years, people aged 16–64 years with high-risk medical conditions, and essential workers not included in Phase 1b

The ACIP identified four ethical principles to guide their decision making process when supply is limited [5]:

1. **Maximize benefits and minimize harms** - Respect and care for people using the best available data to promote public health and minimize death and severe illness.

2. **Mitigate health inequities** - Reduce health disparities in the burden of COVID-19 disease and death, and make sure everyone has the opportunity to be as healthy as possible.
3. **Promote justice** - Treat affected groups, populations, and communities fairly. Remove unfair, unjust, and avoidable barriers to COVID-19 vaccination.
4. **Promote transparency** - Make a decision that is clear, understandable, and open for review. Allow and seek public participation in the creation and review of the decision processes.

The ACIP vaccine priority is clearly provided as follows:

1. Phase 1a: Health care personnel and long-term care facility residents
2. Phase 1b: Aged 75 years and older and non-health care frontline essential workers
3. Phase 1c: Aged 65-74 years, people aged 16-64 years with high-risk medical conditions, and essential workers not included in Phase 1b

As of January 1, 2021 Texas, Florida and other Republican led states are not following the ACIP recommendations on who should get the vaccine when the supplies are limited. They are offering the vaccine to a broader segment of their elderly populations and asking front-line workers to wait. Federal recommendations give priority in the second tier to grocery store employees, transit staffers and other front-line workers, along with people 75 and older. But in Florida and Texas they are offering the vaccine to a broader segment of their elderly populations and asking front-line workers to wait [6]. The problem with this approach is that there are significantly more elderly than front line workers and there is an insufficient quantity of vaccine. This is clearly a system based on access and privilege rather than a system based on common sense and ethics. If you are privileged and or have access you will be the first to be vaccinated as the epidemic continues to ravage the population.

Abuses based on access and privilege are occurring in other states. Medical professionals at hospitals in Massachusetts, New York, Arizona, California and elsewhere claim that those who have little or no contact with COVID-19 patients have received vaccinations (management, executives, etc.) and those with the most exposure to COVID-19 patients are not always the first to get vaccinated [7].

In New Jersey any facility caught not following the recommendations is shut down by local authorities [8] [9].

Successful Massive Vaccination Program Example

On March 5, 1947 a smallpox outbreak started in New York City and ended on April 24, 1947.

On April 4, 1947 the U.S. Army Medical School Laboratory in Washington confirmed three cases of smallpox.

On April 4, 1947, the New York City Mayor and Commissioner of Health informed the public about the smallpox outbreak and announced plans to vaccinate everybody in the city. Within three weeks of the discovery of the outbreak, the U.S. Public Health Service, in conjunction with New York City health officials, had **procured vaccine and inoculated over 6,350,000 adults and children**. In the **first two weeks 5,000,000 had been vaccinated**. This was the largest mass

vaccination effort ever conducted for smallpox in America. It is the last outbreak of smallpox in America.

At the time, the New York City Health Department had 250,000 individual doses of vaccine and 400,000 doses in bulk. The Mayor of New York called an emergency meeting with the heads of the seven American pharmaceutical companies involved in vaccine production and asked them for a commitment to provide 6 million doses of vaccine. The pharmaceutical companies accomplished the task by putting the vaccine into round-the-clock production. Additional vaccine doses were obtained from the Army and Navy.

Vaccination clinics were set up around the city at hospitals, health department clinics, police and fire stations, and schools. Volunteers drawn from the American Red Cross, the City Health Department, off-duty police and firefighters, and the disbanded World War II Air Raid Warden networks located in all of New York's coastal towns, went door-to-door to urge residents to get vaccinated. A radio and print ad campaign called, "Be sure, be safe, get vaccinated!" advertised the vaccination clinic locations and emphasized that vaccination was free. Within days, long lines formed outside the clinics. More than 600,000 New Yorkers were vaccinated in the first week. The vaccination clinics began closing April 26, 1947 with the last closing May 3, 1947. [10] [11]

This system was not based on bullshit, lies, or money as a motivation [12].

Other Countries

As of January 2021 the following vaccines are being administered in the following countries.

Pfizer/BioNTech: Austria Bulgaria Canada Chile Costa Rica Croatia Denmark England Estonia Finland France Germany Greece Hungary Iceland Ireland Israel Italy Kuwait Latvia Lithuania Luxembourg Mexico Northern Ireland Oman Poland Portugal Romania Scotland United Kingdom United States Wales

Moderna: United States

CNBG, Sinovac: China

Sinopharm: Bahrain

Sputnik V: Argentina Russia

As of January 2021 the following countries have administered the following number of vaccinations per 100 people. This is the vaccinations distribution system performance [14].

Table 92 - Vaccination Distribution Systems Performance Jan 2021

| Perf Level 1 Vaccinations % | Perf Level 2 Vaccinations % | Perf Level 3 Vaccinations % | Perf Level 4 Vaccinations % |
|--|--|--|--|
| Israel 11.55 | United States 0.84 | Lithuania 0.08 | Costa Rica 0 |

| Perf Level 1 Vaccinations % | Perf Level 2 Vaccinations % | Perf Level 3 Vaccinations % | Perf Level 4 Vaccinations % |
|--|--|--|--|
| Bahrain 3.49 | Denmark 0.51 | Italy 0.08 | France 0 |
| Scotland 1.69 | China 0.31 | Argentina 0.07 | |
| Northern Ireland 1.64 | Canada 0.29 | Bulgaria 0.07 | |
| United Kingdom 1.47 | Germany 0.2 | Austria 0.07 | |
| Iceland 1.43 | Estonia 0.19 | Romania 0.06 | |
| England 1.4 | Croatia 0.19 | Kuwait 0.06 | |
| Wales 1.12 | Luxembourg 0.19 | Chile 0.05 | |
| | Portugal 0.16 | Hungary 0.05 | |
| | World 0.13 | Russia 0.04 | |
| | Poland 0.13 | Ireland 0.04 | |
| | Oman 0.13 | Latvia 0.03 | |
| | | Finland 0.03 | |
| | | Mexico 0.02 | |
| | | Greece 0.02 | |

As of January 01, 2021 Israel has the highest vaccination rate of 11.55% of the population. More than 420,000 Israelis have been infected and 3,325 have died. Israel's began vaccination on December 20, 2020. Some of the elements that contributed to fast vaccination rate are [13]:

1. Heavily digitized, community-based health system
2. All citizens by law must register with one of the country's four H.M.O.s
3. The government was proactive in a national inoculation campaign, according to Israeli health experts
4. Small size population of 9 million, however its percentage of national resources dedicated to the effort were obviously higher
5. An aggressive procurement effort
6. Companies were interested in supplying Israel because of its H.M.O.s' reputation for efficiency and gathering reliable data
7. Early preparations as a strategy

Officials have not released the number of vaccine doses that it has received so far, or how much it paid for them, saying the agreements are confidential. Israel prioritized health workers and

citizens 60 and older. A majority of the high-risk population should receive the second of two doses of the Pfizer-BioNTech vaccine by late January.

About 150,000 Israelis are being vaccinated per day. This is the same number of vaccinations given in the US with a population of over 328 million. Based on these numbers the performance of the vaccination delivery system in Israel is 36 times more than the US. This is like an automobile from Israel using a 219 HP engine and an automobile from the US using a 6 HP lawn mower engine.

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Virus Decontamination

Decontamination Background and Solutions

Viruses, bacteria, and fungi decontamination tends to be viewed from the perspective of an after the fact event. For example, a contamination event occurs, and the response is to perform decontamination. However, decontamination can be a continuous activity and, in this approach, it is used to prevent the establishment of viruses, bacteria, and fungi. Some of the tools that can be used for continuous decontamination are physical structure materials, the use of UV-C lights, and hydrogen peroxide vapor. [1] Decontamination . [2] Infection prevention and control . [3] Bioburden

Materials

Antimicrobial materials can be used on touch surfaces where viruses, bacteria, and fungi colonize and live on doorknobs, push plates, railings, tray tables, water faucet handles, hospital IV poles, HVAC systems, and other equipment. Materials like copper and its alloys, like brass and bronze, are antimicrobial. [4]

UV-C Lights

The use of UV lights is another example of continuous decontamination. The UV needs to be in the UV-C band, which is harmful, so the UV light exposure needs to be properly managed. The lights can be placed at the ceiling level to prevent UV exposure to the people in a room setting. Air circulation will continuously expose contaminated air to the UV lights. This technology is 70

years old and was common as late as the 1970's in all public spaces including small businesses. Today it is uncommon and is viewed as an industrial application with no general consumer products. The UV lights also can be placed in HVAC system ducts. In large commercial settings the long runs of ducts will provide massive exposure to UV-C as the air takes relatively long times to pass through long duct runs. Companies - UV: Xenex [5] . American Ultraviolet [6] . International Ultra Violet Association [7] . UV Solutions Buyers Guide [8] . UV Solutions [9]

Hydrogen Peroxide Vapor

One of the issues associated with decontamination is the ability to access all surfaces with the decontaminating agent. Hydrogen peroxide can be sprayed to reach the hard to clean surface areas. This includes lab settings where there are cables hoses and other structures that are difficult to clean. Getting reliable and repeatable results of reaching the pre-determined hydrogen peroxide level and getting exact results even in high humidity conditions is important. The Engineering of hydrogen peroxide decontamination systems is an exiting capability [10]. Certification of vapor phase hydrogen peroxide sterilization process for spacecraft applications is just another source that can be used to help develop these systems [11].

The companies include - Hydrogen Peroxide: Bioquell [12] . Hangzhou Meizhuo Biotechnology Co [13] . Small Containers: Steris [14] . Hydrogen Peroxide Generators [15] . Validating Hydrogen Peroxide Bio-Decontamination [16]. Vaisala developed the HPP270 [17] . Designed especially for environments containing hydrogen peroxide vapor. It measures hydrogen peroxide content in ppm, temperature, and humidity - referring to both relative humidity and relative saturation.

Hospitals, Clean Room, and Military Technologies

It's not that we don't have the technology to support decontamination and prevent the spread of bacteria, and fungi. It readily exists in various places in the society. The issue is to identify the technology and then determine what needs to be moved into other settings in the society. For example, there is massive technology associated with hospitals, clean rooms, and military operations in biohazard settings. Companies [18], [19]. Other Information [20], [21]. Big Picture: Spanish Flu [22], COVID-19 Pandemic [23].

FAR-UV 222 Lights

Health [24]

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Disinfectants and Inactivating Agents

An analysis of chemical disinfectants and inactivating agents was performed by the CDC [1]. There is also an analysis of ozone disinfection from the EPA [2]. Chemical disinfectants, inactivating agents, and ozone disinfection appear to be the available tools. Of note within the chemical disinfectants category is the potential use of hydrogen peroxide and ultraviolet radiation (UV).

Table 93 - Disinfectants and Inactivating Agents

| <u>Chemical Disinfectants</u> | <u>Miscellaneous Inactivating Agents</u> | Not in CDC Study |
|---|--|---|
| <ul style="list-style-type: none"> • Alcohol • Chlorine and chlorine compounds • Formaldehyde • Glutaraldehyde • Hydrogen peroxide • Iodophors • Ortho-phthalaldehyde (OPA) • Peracetic acid • Peracetic acid and hydrogen peroxide • Phenolics • Quaternary ammonium compounds | <ul style="list-style-type: none"> • Other Germicides • Metals as Microbicides • Ultraviolet Radiation (UV) • Pasteurization • Flushing- and Washer-Disinfectors | <ul style="list-style-type: none"> • <u>Ozone Disinfection</u> |

Executive Summary

The Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008, presents evidence-based recommendations on the preferred methods for cleaning, disinfection and sterilization of patient-care medical devices and for cleaning and disinfecting the healthcare environment. This document supercedes the relevant sections contained in the 1985 Centers for Disease Control (CDC) Guideline for Handwashing and Environmental Control. 1 Because

maximum effectiveness from disinfection and sterilization results from first cleaning and removing organic and inorganic materials, this document also reviews cleaning methods. The chemical disinfectants discussed for patient-care equipment include alcohols, glutaraldehyde, formaldehyde, hydrogen peroxide, iodophors, ortho-phthalaldehyde, peracetic acid, phenolics, quaternary ammonium compounds, and chlorine. The choice of disinfectant, concentration, and exposure time is based on the risk for infection associated with use of the equipment and other factors discussed in this guideline. The sterilization methods discussed include steam sterilization, ethylene oxide (ETO), hydrogen peroxide gas plasma, and liquid peracetic acid. When properly used, these cleaning, disinfection, and sterilization processes can reduce the risk for infection associated with use of invasive and noninvasive medical and surgical devices. However, for these processes to be effective, health-care workers should adhere strictly to the cleaning, disinfection, and sterilization recommendations in this document and to instructions on product labels. [3]

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Potential System Solutions - Decontamination Architectures

There are a few different alternatives for a Return to Life system. They are as follows:

1. **Approach 1 Do Nothing:** This architecture is based on letting the disease to run its course with not mitigations. This approach will probably infect most of the US within a few months. The stats are clear. 60% infection rate, 3.5% death rate. This translates to 10 million people dead in a few months. This will destroy the country as all systems will collapse. In this scenario other diseases will surface and hunger will spread. This will translate into more deaths and probably a revolution.
2. **Approach 2 Periodically Close Down the Country:** This is the shutting down of all activities except for the most essential. This will slow the spread of the disease and may preserve many of the existing systems. It also provides time to search for a cure and medications to reduce the death rate.
3. **Approach 3 Modify Social Behavior:** This is coupled with periodically closing the country (approach 2). As people return to life their behavior is modified to minimize the spread of disease. This pushes all responsibility on the people and removes all

responsibility from the industrial base and the government. Although the new management styles that surfaced in the late 1980's of pushing everything down to the lowest level person for responsibility may have worked in the past, it will now lead to serious problems because this is an ultimate life threatening event. This approach is totally unacceptable, and it will lead to social unrest.

4. **Approach 4 Modify the Infrastructure and Social Behavior:** This is coupled with periodically closing down the country and modifying social behavior (approaches 2 and 3). As people return back to life not only is behavior modified but the infrastructure is modified to minimize the spread of disease. This approach has the greatest potential to minimize the spread of the disease. It will require the industrial base to get involved to produce various system elements.

Architecture 4 is the selected approach for obvious reasons. Everyone has a stake and responsibility in dealing with the COVID-19 disaster. The next step is to determine the various approaches to implementing Approach 4.

The following offers conceptual architectures for different Return to Life systems. The various conceptual architectures need to be fully identified, validated, matured to physical architectures and then designed with appropriate products. The resulting systems then need to be validated for effectiveness. This is a huge task because there is no industrial base to develop all the systems that are needed. There are products and narrow point solutions in specific areas. These systems once in place may last for decades.

System Settings

No single solution will fit all needs, but the potential solutions can fall into different categories:

- A. Schools
- B. Malls Airports: Spread Span office buildings, enclosed malls, airports
- C. Small Office: Small office buildings with compartmented office spaces
- D. Restaurants: Enclosed public gathering spaces like restaurants, movie theaters, department stores, grocery stores, big box stores, retail stores
- E. Shared Living: Apartment buildings, hotels, dorms, and other shared spaces
- F. Houses: No shared walls, separate lots, townhouses, shared walls
- G. Computer Labs: Data Centers, Command and Control Centers
- H. Public Transit: Airplanes, Trains, Buses, Ships, Rental Cars
- I. City: high density, massive crowds, concrete walks, massive structures
- J. Hospitals: This is a baseline to consider for the remaining infrastructure
- K. Military Bio Hazard Facilities: This is a baseline to consider for the civilian infrastructure

Decontamination Architecture Approaches and System Settings

Table 94 - Decontamination Architecture Approaches

| No | Architecture Elements (slang term is bag of tricks taken from safety and security communities) | A Schools | B Malls Airports | C Small Office | D Restaurants Stores | E Shared Living | F Houses | G Computer Labs | H Public Transit | I City | J Hospitals | K Military |
|----|---|--------------|------------------------|----------------------|----------------------------|-----------------------|-------------|-----------------------|------------------------|-----------|----------------|---------------|
| | Physical Containment Approaches | | | | | | | | | | | |
| 1 | Physical separation (e.g. 6 foot) | X | X | X | X | X | | X | X | X | X | X |
| 2 | Group people together to minimize cross contamination | X | | X | | X | | X | | | X | X |
| 3 | Personal space physical barriers (plexiglass) | X | X | X | X | | | X | X | | X | X |
| 4 | Masks | X | X | X | X | | | X | X | X | X | X |
| 5 | Smocks | teacher | | | | | | X | driver | | X | X |
| 6 | Full body personal protection equipment (PPE) | | | | | | | | | | X | X |
| 7 | Hazmat suits | | | | | | | | | | X | X |
| 8 | Emergency stretcher patient containment structure | | | | | | | | | | X | X |
| | Decontamination Approaches | | | | | | | | | | | |
| 1 | Personal Commercial Disinfectant Wipes (event driven) | | | | | | X | X | | | exists | exists |
| 2 | Personal Commercial Disinfectant Spray (event | | | | | | X | X | | | exists | exists |

| No | Architecture Elements (slang term is bag of tricks taken from safety and security communities) | A Schools | B Malls Airports | C Small Office | D Restaurants Stores | E Shared Living | F Houses | G Computer Labs | H Public Transit | I City | J Hospitals | K Military |
|----|---|--------------|------------------------|----------------------|----------------------------|-----------------------|-------------|-----------------------|------------------------|-----------|----------------|---------------|
| | driven) | | | | | | | | | | | |
| 3 | Janitorial Cleaning of Office Spaces using commercial disinfectants (cyclic) | X | X | X | X | | | X | X | | exists | exists |
| 4 | Janitorial Cleaning of High Touch surfaces multiple times per day (handrails, elevator buttons, seating, equipment) | X | X | X | X | X | | X | X | | exists | exists |
| 5 | Special Cleaning of COVID- 19 suspected or tested positive | X | X | X | X | X | | X | X | | exists | exists |
| | - | | | | | | | | | | | |
| 1 | Shoe disinfecting mats at building entrances | X | goal | goal | X | | X | | | | goal | unknown |
| 2 | Fresh water disinfecting sinks at building entries | X | goal | goal | goal | | | | | | goal | unknown |
| 3 | Elevator foot controls | X | X | X | X | X | | X | X | | goal | unknown |
| 4 | Disposable wipes at key locations | X | X | X | X | X | X | X | X | X | exists | exists |
| 5 | Hand sanitizers at key locations | X | X | X | X | X | X | X | X | X | exists | exists |
| 6 | Touch surface cleaned after each use | X | goal | goal | X | | | X | goal | | exists | exists |
| | - | | | | | | | | | | | |
| 4 | Event Driven Hydrogen | X | X | X | X | X | | X new | X | | exists | unknown |

| No | Architecture Elements (slang term is bag of tricks taken from safety and security communities) | A Schools | B Malls Airports | C Small Office | D Restaurants Stores | E Shared Living | F Houses | G Computer Labs | H Public Transit | I City | J Hospitals | K Military |
|----|---|--------------|------------------------|----------------------|----------------------------|-----------------------|-------------|-----------------------|------------------------|-----------|----------------|---------------|
| | Peroxide spot spraying | | | | | | | | | | | |
| 5 | Cyclic Hydrogen Peroxide total space spraying | X | X | X | X | X | | X new | X | X | exists | unknown |
| 6 | Event Driven UV-C spot space exposure | X | X | X | X | X | | X new | X | | exists | exists |
| 7 | Cyclic UV-C total space exposure | X | X | X | X | | | X new | X | | exists | exists |
| | - | | | | | | | | | | | |
| 8 | Hydrogen Peroxide building entry spraying as people enter | X | X | X | | | | X new | | X | - | unknown |
| 9 | UV building entry when people are not present | X | X | | | | | X new | | | - | unknown |
| 10 | UV upper room placement (in restrooms, etc) | X | X | X | X | X | | X new | | | exists | exists |
| | - | | | | | | | | | | | |
| 11 | HVAC Systems Hydrogen Peroxide Distribution | X | X | X | X | X | | X new | X | | - | unknown |
| 12 | HVAC Systems Massive Internal UV-C Exposure | X | X | X | | | | X new | X | | exists | exists |
| 13 | HVAC Systems copper / nickel air distribution placements | X | X | X | | | | X new | X | | - | unknown |
| 14 | HVAC Positive and or Negative Pressure Delivery | X | X | X | X | X | | X | X | | exists | exists |
| 15 | HVAC Total Air Exchange | X | X | X | X | X | | X | X | | exists | exists |

| No | Architecture Elements (slang term is bag of tricks taken from safety and security communities) | A Schools | B Malls Airports | C Small Office | D Restaurants Stores | E Shared Living | F Houses | G Computer Labs | H Public Transit | I City | J Hospitals | K Military |
|----|---|--------------|------------------------|----------------------|----------------------------|-----------------------|-------------|-----------------------|------------------------|-----------|----------------|---------------|
| | every X minutes | | | | | | | | | | | |
| 16 | HVAC Virus Filters and Frequent Replacement | X | X | X | X | X | X | X | X | | exists | exists |
| 17 | Massive Natural Air Ventilation | X | X | X | X | X | X | X | X | X | exists | exists |
| | Hydrogen Peroxide Delivery Systems | | | | | | | | | | | |
| 1 | Personal Room Vaporizers (uncontrolled levels) | | | | | | maybe | | | | - | unknown |
| 2 | Room Dehumidifiers (uncontrolled levels) | | | | | | maybe | | | | - | unknown |
| 3 | Cold Foggers Handheld | X | X | X | X | X | maybe | X | X | X | - | unknown |
| 4 | Commercial Hydrogen Generators (monitored & controlled levels) | X | X | X | X | X | | X new | | | - | unknown |
| | Measurement Systems | | | | | | | | | | | |
| 1 | Hydrogen Peroxide Passive measurement | X | X | X | X | X | maybe | X new | X | | exists | exists |
| 2 | Hydrogen Peroxide Closed loop measurement and control system | X | X | X | X | X | | X new | | | - | unknown |
| 3 | UV-C Passive measurement | X | X | X | X | X | maybe | X new | X | | - | unknown |
| 4 | UV-C Closed loop measurement and control system | X | X | X | X | X | | X new | | | - | unknown |

| No | Architecture Elements (slang term is bag of tricks taken from safety and security communities) | A Schools | B Malls Airports | C Small Office | D Restaurants Stores | E Shared Living | F Houses | G Computer Labs | H Public Transit | I City | J Hospitals | K Military |
|----|---|---------------------|------------------------|----------------------|----------------------------|-----------------------|-------------|-----------------------|------------------------|-----------|----------------|---------------|
| | Reporting | | | | | | | | | | | |
| 1 | Internal Users Based | X | X | X | X | X | | X new | X | | exists | exists |
| 2 | External Third Party | X | X | X | | | | X new | X | | exists | exists |
| | Screening | | | | | | | | | | | |
| 1 | COVID-19 Testing and Isolation | X | X | X | X | X | X | X | X | X | exists | exists |
| 2 | Temperature Check | no too traumatic | | | | | | X | | | exists | exists |
| 3 | Oxygen Level Check | no too traumatic | | | | | | X | | | exists | exists |
| 4 | Cell Phone Contact Tracing and Crowd History (China) | | | | | | | X new | | X new | - | unknown |
| | Home Protocol | | | | | | | | | | | |
| 1 | COVID-19 Health care worker | | | | | | X | | | | exists | exists |
| 2 | Non-COVID-19 Health care worker | | | | | | X | | | | exists | exists |
| 3 | Retail worker | | | | | | X | | | | N/A | N/A |
| 4 | Office worker | | | | | | X | | | | N/A | N/A |
| 5 | Outdoor worker city | | | | | | X | | | | N/A | N/A |
| 6 | Outdoor worker non-city | | | | | | X | | | | N/A | N/A |
| 7 | Retail shopper | | | | | | X | | | | N/A | N/A |
| 8 | Mail order shopper | | | | | | X | | | | N/A | N/A |

Note 1: The UV approach requires failsafe management because it will destroy material and harm people. Used within an HVAC system it is within a safe boundary. EPA Test Results: Biological Inactivation Efficiency By HVAC In-Duct Ultraviolet Light Systems (EPA 600/R-06/054) local [1]. This is a viable technology that every commercial building can immediately adopt. Its advantage over sophisticated filtration systems are simple maintenance with no operator maintenance issues. Sophisticated filtration systems only work when properly maintained.

Note 2: Air Ventilation - Ventilating. Adequate ventilation shall be assured by introducing fresh air into any personnel enclosure. If the enclosure volume is 4.25 m³ (150 ft³) or less per-person, a minimum of 0.85 m³ (30 ft³) of ventilation air per minute shall be introduced into the enclosure; approximately two-thirds should be outdoor air. For larger enclosures, the air supply per-person may be in accordance with the curves in Figure 35. Air shall be moved past personnel at a velocity not more than 60 m (200 ft) per minute. Ventilation or other protective measures shall be provided to keep gases, vapors, dust, and fumes within the Permissible Exposure Limits specified by 29 CFR 1910 and the limits specified in the American Conference of Governmental Industrial Hygienists Threshold Limit Values. Intakes for ventilation systems shall be located to minimize the introduction of contaminated air from such sources as exhaust pipes. (See 5.12.6.2 for vehicle ventilation provisions.) - MIL-STD-1472 [2]. There are also OSHA regulations [3].

Note 3: Total Air Exchange every X minutes. Later in this report there is analysis to suggest how often the air should be exchanged in a building to mitigate the risk of infection. Air Flow Rates And Natural Ventilation [4] . HVAC and Open Ventilation Design Solutions [5]. Suggest to keep reading rather than jump ahead and risk missing some content.

Note 4: Massive natural ventilation. This is explained further in this report. Air Flow Rates And Natural Ventilation [6] [7] [8]. Suggest to keep reading rather than jump ahead and risk missing some content.

Each of the columns represent a conceptual architecture. Notice the services provided by each of these architectures are different and they range from minimal to massive. Ideally a single scalable architecture could be developed but that is unlikely. The architectures are driven by the environment. The physical architecture is realized when actual products are found for the conceptual architecture and the system is sized. The size of the system determines the size and number of subsystems (the X marks the subsystem for each architecture) needed for a particular solution.

If we examine the proposed conceptual architecture for Computer Labs and Command and Control Centers we see that a large number of different subsystems are needed. This will be a large capital investment and a new system will need to be stood up to ensure that it operates properly and is as effective as possible. It is unclear if it makes sense to mature this conceptual architecture first and then scale it down or if each conceptual architecture needs to take its own path.

These **Decontamination Architectures are based on safety and security architectures.** In each case there is a bag of tricks that are learned from previous experience. Each of them represent a level of protection. Some provide more protection than others. The architecture solutions start with the easiest level of protection and then move to the more difficult levels of

protection to make the architecture more immune to compromise from a safety, security or in this case virus exposure perspective. As more layers are added the architecture costs increase and complexity is introduced with more unintended consequences.

The **Decontamination Architectures are risk reduction architectures** and will not completely remove the virus except perhaps in the most extreme cases of massive layers of protection as may be found in a bio hazard lab setting. Instead they will reduce the concentration of the virus which will reduce the potential for infection.

These architectures are based on the massive use of hydrogen peroxide and other disinfectants. It is unclear what the unintended consequences may be with the massive production and distribution (into the environment) that these disinfectant practices may have on our other systems.

Except for Reporting and Screening these architectures are a view of the past. It is clear that forgotten knowledge needs to be resurrected. Something happened on the way to the 21st century and we need to understand that journey or the next pandemic may be an extinction level event.

The danger moving forward is that there is no desire to investigate our existing systems because of arguments that COVID-19 is so infectious and it acts so slowly before people get really sick. So they are engaging in life, while infected and spreading the virus, therefore there is nothing wrong with our systems. The problem with this argument is that we know the virus is able to survive for a long period of time on our standard materials used in all our systems. We also see that our HVAC systems and janitorial practices allow the virus to accumulate on our structures. This appears to be in part an engineering issue. Again what changed as we moved from the 20th into the 21st century?

References:

[1] Biological Inactivation Efficiency by HVAC In-Duct Ultraviolet Light Systems, U.S. Environmental Protection Agency, American Ultraviolet Corporation ACP-24/HO-4, EPA 600/R-06/054, May 2006. webpage https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=459522, April 2020. [Biological Inactivation Efficiency By HVAC In-Duct Ultraviolet Light Systems](#) . [local](#)

[2] Human Engineering, MIL-STD-1472F, Department of Defense, 23 August 1999, MIL-STD-1472D, 14 March 1989. [MIL-STD-1472F](#) . [MIL-STD-1472D](#) . [local](#)

[3] webpage <https://www.osha.gov/SLTC/ventilation>, April 2020. [OSHA Ventilation](#)

[4] See section [Air Flow Rates And Natural Ventilation](#)

[5] See section [HVAC and Open Ventilation Design Solutions](#)

[6] See section [Air Flow Rates And Natural Ventilation](#)

[7] See section [Proposed Legislation](#)

[8] See section [Virus Diffusion Classroom Design](#)

Vendors and Hard to Find Industrial Vendors

The following is a list of vendors and hard to find industrial vendors to implement the proposed conceptual architectures.

Table 95 - Products Vendors and Associations

| Products | Vendors and Associations |
|-----------------------------------|--|
| UV Decontamination | American Air and Water [1] . American Ultraviolet [2] . International Ultra Violet Association [3] . UV Solutions Buyers Guide [4] . UV Solutions [5] . Healthe [6] |
| Hydrogen Peroxide Decontamination | Bioquell [7] . Hangzhou Meizhuo Biotechnology Co [8] |
| Hydrogen Peroxide Measurement | Vaisala [9] . Validating Hydrogen Peroxide Bio-Decontamination [10] |
| Cold Foggers for Decontamination | see Internet |
| Thermometers - no contact | local stores, Internet |
| Oxygen Meters - finger | local stores, Internet |
| Cell phone contact tracing | US privacy and validation issues - see Internet |
| HVAC virus filters - home | home supply stores |
| HVAC systems | local HVAC companies, Internet |
| HVAC systems - heavy industrial | see Internet |
| Home protocol | no industrial base, being developed realtime by the people |
| Total System Solution | Unable to find total system solutions. The industrial base is companies offering point solutions based on their products and or technologies. The user must develop their system and integrate the various products into a total system solution. |

Note 1: As of May 2020, the US industrial base is unable to meet the new demand because of the COVID-19 disaster. Products are on backorder.

References:

[1] [American Air and Water](https://www.americanairandwater.com), webpage <https://www.americanairandwater.com>, April 2020.

[2] [American Ultraviolet](https://www.americanultraviolet.com), webpage <https://www.americanultraviolet.com>, April 2020.

[3] [International Ultra Violet Association](http://www.iuva.org), webpage <http://www.iuva.org>, April 2020.

[4] [UV Solutions Buyers Guide](https://uvsolutionsmag.com/buyersguide/services/MAIN_COVID19), webpage https://uvsolutionsmag.com/buyersguide/services/MAIN_COVID19, April 2020.

[5] [UV Solutions](https://www.uvsolutionsmag.com), webpage <https://www.uvsolutionsmag.com>, April 2020.

[6] [Healthe](https://healthelighting.com) webpage <https://healthelighting.com>, September 2020.

[7] [Bioquell](https://www.bioquell.com) webpage <https://www.bioquell.com>, April 2020.

[8] [Hangzhou Meizhuo Biotechnology Co](https://e.hzmeizhuo.com/about), webpage <https://e.hzmeizhuo.com/about>, April 2020.

[9] [Vaisala](http://www.vaisala.com), webpage <http://www.vaisala.com>, April 2020.

[10] [Validating Hydrogen Peroxide Bio-Decontamination](https://www.youtube.com/watch?v=McGI3z4WvXQ), webpage <https://www.youtube.com/watch?v=McGI3z4WvXQ>, April 2020.

Home Protocols

Before a set of home protocols are developed a risk analysis of different scenarios should be considered. Once the scenarios are in place then a reasonable allocation of mitigation approaches can be offered as part of the Home Protocols subsystem architectures.

Table 96 - Scenarios and Exposure Risk

| Scenario | Exposure Risk |
|--|---------------|
| Healthcare worker ICU procedure COVID-19 | Very High |
| Healthcare worker ER COVID-19 | Very High |
| Healthcare worker ICU procedure non-COVID-19 | Low |
| Healthcare worker ER non-COVID-19 | Low |
| EMT worker in COVID-19 hot spot | Very High |
| Police in COVID-19 hot spot | High |
| Hospital staff COVID-19 | High |
| Hospital staff non-COVID-19 | Med |
| - | |
| Retail store worker | Med |
| Warehouse worker | Low-High |
| Office worker | Med |
| Outdoor worker non-city | Low |
| Outdoor worker city | Med |
| Public Transit worker | High |
| - | |
| Group Walking city | High |
| Group Walking city 6 feet apart | Med |
| Group Walking non-city 6 feet apart | Low |
| Walking no people in sight | None |
| Retail customer | Med |
| Restaurant customer | Med |
| Movie / Theater customer | Med |
| - | |
| Opening door used by others | Med |
| Hugging shaking hands | High |
| Receiving mail or package | Med |
| - | |
| Living in house with COVID-19 person | High |
| | |

Note: This table uses a qualitative analysis approach rather than a quantitative approach. As the years click by and others analyze the actual data this table will be validated. Currently it is only one reasonable assessment that represents a mental model of those that populated this table.

COVID-19 exposure risks based on scenario analysis Workers and people tend to fall into categories

- | | |
|--------------|------------------------------------|
| A. Very High | A. COVID-19 Health care worker |
| B. High | B. Non-COVID-19 Health care worker |
| C. Med | C. Retail worker |
| D. Low | D. Office worker |
| E. None | E. Outdoor worker city |
| | F. Outdoor worker non-city |
| | G. Retail shopper |
| | H. Mail order shopper |

So the question is how should the protocols be allocated. Should they be allocated to the exposure risks or to the categories of workers and people. The following table allocates the protocols to the workers and people. It is the most direct communication of the stakeholder needs, even if it may change significantly over time.

Table 97 - Home Protocols

| Protocol Item | A. COVID-19 Health Care Worker | B. Non-COVID- 19 Health Care Worker | C. Retail Worker | D. Office Worker | E. Outdoor Worker City | F. Outdoor Worker Non-City | G. Retail Shopper | H. Mail Order Shopper |
|--|---|--|---------------------------------|---------------------------------|---|---|----------------------------------|--------------------------------------|
| Live outside the physical home | X China | | | | | | | |
| - | | | | | | | | |
| Disinfect vehicle upon home arrival | X | X | X | X | X | X | X | |
| Disinfect shoes and leave in space outside living area | X | X | X | X | X | X | maybe | |
| Remove all clothes, place in washer | X | X | X | X | X | | maybe | |
| Remove gloves, masks, dispose | X | X | X | X | X | X | maybe | |
| Immediately go take shower | X | X | X | X | X | X | maybe | |
| - | | | | | | | | |
| Place boxes outside in daylight for 24 hours | | | | | | | maybe still need to open | maybe still need to open |
| Disinfect hands prior to handling | | | | | | | X | X |
| Disinfect all bags and boxes | | | | | | | X | X |
| Disinfect all items | | | | | | | X | X |
| Isolate all disinfected bags and boxes to throw away | | | | | | | X | X |
| Remove gloves and mask | | | | | | | X | X |
| - | | | | | | | | |
| Disinfect hands after handling | | | | | | | X | X |

| Protocol Item | A. COVID-19 Health Care Worker | B. Non-COVID- 19 Health Care Worker | C. Retail Worker | D. Office Worker | E. Outdoor Worker City | F. Outdoor Worker Non-City | G. Retail Shopper | H. Mail Order Shopper |
|---------------------------|---|--|---------------------------------|---------------------------------|---|---|----------------------------------|--------------------------------------|
| Wash hands after handling | | | | | | | X | X |

Healthcare Based Perspective

Healthcare stakeholders provide important information about a Return to Life system. There are many healthcare stakeholders providing information. [1]. The following are considerations from the healthcare stakeholders' perspectives.

Simple guidelines for day-to-day living in this new COVID world.

- Wear a mask when you are in places with other people
- Treat your home, car, and yard as safe places, no mask or gloves
- Be on high alert on what you are doing with your hands when you are in danger zones, this is when you must not touch your face
- Consider wearing gloves (even winter gloves or work gloves) but only for short periods of time and only when in touch exposure danger zones
- Remove your gloves and mask when you return to your safe place
- Wash your hands every single time you take off your gloves or mask, or move from a danger zone back to a safe zone
- When you are at home and after washing up, you can relax, scratch your nose, rub your eyes and floss your teeth

Protections work together. All protections or countermeasures individually are only partially effective. This concept is well understood and practiced by engineers developing safe and secure systems.

- Wearing a car seat belt reduces the likelihood of dying by about 50%
- Independently, air bags reduce the risk of dying by about 30-40%
- Together they reduce risk by 65-70%.
- Licensing, speed limits, anti-lock brakes, police enforcement achieve very good risk reduction (well into the upper 90s).
- Protecting yourself and society from COVID works exactly the same way

Getting Infected is not black and white.

- A tiny number of viruses placed in a person's throat one time is not likely to lead to the average person getting sick with COVID.
- A tiny number of live viruses placed in the throats of 1,000 people, less than half might get sick
- 1,000 or 1,000,000 viral organisms, the average person will probably get sick.
- A tiny number of organisms 10 or 100 times in a week, the average person also will likely get sick because of the multiple exposures

- Your body has protective countermeasures such as mucus and cilia and your blood and other fluids likewise have generic immune and other protections
- Your nose reduces the risk of viral particles getting to your throat
- A mask reduces the risk of the viral particles getting to your nose
- Social distancing reduces the risk of them getting to your mask
- These countermeasures work together
- The power of each individual countermeasure is much less important than their collective power in protection

So how does a mask really work?

- It hasn't been measured for COVID
- Masks that are FDA cleared have been tested against a benchmark and have a rating
- N95 masks have been shown to reduce 95% of passage of a certain size particle over a certain time period in specific laboratory conditions
- In a pre-COVID ER, masks change 6-12 times in a shift
- Wearing the same mask (N95 or not) for a 12-hour ER shift is definitely not as strong as using a fresh one, but it is far stronger than not wearing any mask

N95s have benefits over simple dust masks used during construction work.

- Are more comfortable to wear
- Air is more likely to go through the mask than around it
- Exhaled air is less likely to fog your glasses
- Inhaled air is a bit less restricted

Any mask has protective properties.

- Make it hard to touch the nose and mouth, providing protection from hand to face transmission
- Reduce exposure of the nose and mouth to viruses in the air by directly breathing in viral spray or viral fog
- Reduce the chance that others will get infected from you when you are sick and don't know it

Great masks and poor masks can both stop water droplets. Most coughs and sneezes are composed of a fine spray of water droplets soaked with virus. Stopping the droplets also stops the virus. A dry virus dies quicker so even though individual virus particles are extremely tiny and can enter in the air around a mask, or even go through the mask, they are less likely to infect than a droplet teeming with viruses being kept alive by the droplet. The most likely way a dose of virus will get in your nose or mouth is:

- Via touch of your own hand (most likely)
- Via water droplet-laden virus (cough, sneeze or even breathing)
- Via dry virus particles (least worrisome)

The issues behind mask testing.

- Proving that virus-sized particles go right through old bandannas is irrelevant
- The most likely way of getting sick is by hand-face touching, where a bandanna might be effective
- The most likely way of getting sick is also by virus-laden water droplets where a bandanna might be effective
- Even though bandannas are relatively poor at blocking dry individual viruses, that is the least likely to get sick

Retail store or warehouse workers.

- Wear a mask
- Wear glasses instead of contacts
- Wear something over your shirt or blouse that you can take off in the garage or other staging area before entering your safe zone car or home
- Wear gloves or not (your employer has a requirement)
- Wash your hands when you take your mask off and gloves
- When you finish work, wash before you get to your car
- Take your outer layer off and gloves off before fully entering your car
- Sanitize your hands on entering your car
- Do it all over again in your garage or mudroom before getting inside your house
- Put your clothes and mask in the wash and take a shower when you get home

Key Takeaways.

- Social distance, stay six feet from people, ten feet is better
- Your safe zone is your house
- For you, and for family living with you, your yard is likely a safe zone
- When outside, and with no other people nearby, you are in a safe zone
- For most people, your car should be a safe zone

Masks.

- The easiest most reliable precaution to take when out of your safe zone

- If you work with the public, you should absolutely be wearing a mask on the job
- If you are in a safe place, a mask has low value, because the risk is already low
- If you are going to put the same mask on and off, then treat the outside as contaminated and the inside as safe
- If you handle the outside of your mask, then consider your hands as contaminated, and wash them
- Don't touch the inside of your mask with your hands or anything else dirty
- Put the cloth mask in the laundry at least daily or wash with warm water and soap
- Have at least two masks so one can be in the wash and the other clean when needed
- Don't bother boiling masks before you wear them, the detergent in your washing machine is easier, stronger, and more likely to succeed in cleaning the mask

Table 98 - Risk of Infection with Masks and Quarantine

| Scenario | Risk of Infection | Infected Person | Uninfected Person |
|-----------------|--------------------------|--------------------------------------|---|
| 1 | Highest | No Mask | No Mask |
| 2 | Less than Scenario 1 | No Mask | Mask |
| 3 | Less than Scenario 2 | Mask | No Mask |
| 4 | Less than Scenario 3 | Mask | Mask |
| 5 | Less than Scenario 4 | Mask More than 6 feet apart | Mask More than 6 feet apart |
| 6 | None | Quarantine No contact with others | Stay at home with no other infected person |

References:

[1] Saving Your Health, One Mask at a Time, Peter S. Tippett, MD, PhD, April 7, 2020. webpage <https://caremesh.com/blog/2020/4/8/saving-your-health-one-mask-at-a-time>, May 2020. [Saving Your Health, One Mask at a Time](#)

Engineering Based Perspective

There are many stakeholder views that have been offered to society on the COVID-19 disaster as of May 2020 except for the Engineering Stakeholder. This analysis adds the engineering perspective to the current set of stakeholders. Stakeholders not offered in this analysis are those in denial and those focused strictly on making money by returning to the days before the disaster. They are an example of stakeholders that must be removed from the discussion because it is impossible to develop a solution with them at the stakeholder table.

The engineering perspective on the COVID-19 disaster begins with examining the current system space. The stakeholder needs of the people are reasonable and must be met. Healthcare stakeholders are using a 14th century approach to deal with the crisis when they focus on masks

and social distancing. Healthcare stakeholders are also relying on a cure or disease management both of which are years away. The Engineering stakeholders are not even at the table as of May 2020 except in support of the healthcare stakeholders.

Today we rely on our physical structures to live. This means that the physical structures must somehow reduce the concentration or eliminate viruses. During the energy crisis of the 1970's all HVAC systems were modified to reduce the amount of external air to reduce the amount of fuel consumption. This eventually translated to dollars and today there is a heavy emphasis to reduce HVAC airflow because of costs. This must change immediately. The airflow in all public buildings must be massively increased. As the air moves through the ductwork it must be subjected to massive amounts of UV and materials that will destroy viruses and bacteria. High humidity environments must have the humidity in the buildings drastically reduced. Once these measures are attempted, they need to be tested in lab settings to see if they work and then tuned to get the maximum benefit without compromise. Specifications then need to be developed for HVAC systems for every type of public building setting. The same applies to all the engineering solutions offered in all the proposed Decontamination Architectures.

All aircraft and cruise ships must have their HVAC systems tested for virus containment. The assumption is that these HVAC systems are safe but that may not be the case. This system engineering analysis suggests that the initial virus spread was because of the poor HVAC systems in both cruise ships and airplanes. The materials used in these transportation systems also might be suspect. If that is the case, changing these materials will be problematic and similar to what the healthcare stakeholders are doing as they pursue a cure. It is years away. There may be a protocol based on decontamination that may help to reduce the concentration or eliminate the virus. Once again tests need to be performed under controlled lab conditions and then specifications developed for proper system management.

Risk and Confidence Levels Analysis

On June 8, 2020, the New York Times released the results of a survey of 511 Epidemiologists. Surveys are typically used by management to perform damage control and change the dialog usually to force a certain agenda by a small set of hidden stakeholders. However, a survey can be converted to meaningful systems analysis such as risk and confidence level assessments. [1]

Periodically in a systems activity, experts are called in and asked to weigh in on key system issues. Questions are framed around the key system issues and votes are requested. The votes are gathered and then converted to a risk and confidence levels analysis. The New York Times did call in experts, input on key system issues were asked in terms of questions, and votes were gathered. This raw data was used to determine the following system risk and confidence levels analysis results. [[spreadsheet](#)]

To convert a time based survey to Risk and Confidence Levels over time the following equations are used:

Risk Level = 100 - sum of the votes over time
Confidence Level = sum of the votes over time
Comfort Level = Confidence Level

In this case Confidence Level is equivalent to Comfort Level. The fundamental question being how comfortable the Epidemiologists are engaging in the Event as time moves forward.

Table 99 - Engaging in Life Events Risk and Confidence Levels 1 of 2

| Event 511 Epidemiologists June 2020 | Summer risk | Fall Winter risk | 1+ yr risk | | Summer confidence | Fall Winter confidence | 1+ yr confidence |
|--|--------------------|-------------------------|-------------------|--|--------------------------|-------------------------------|-------------------------|
| Bring in mail without precautions | 39 | 23 | 6 | | 61 | 77 | 94 |
| See a doctor for a nonurgent appointment | 40 | 11 | 0 | | 60 | 89 | 100 |
| Vacation overnight within driving distance | 44 | 18 | 0 | | 56 | 82 | 100 |
| Get a haircut at a salon or barber shop | 60 | 21 | 2 | | 40 | 79 | 98 |
| Attend a small dinner party | 68 | 22 | 1 | | 32 | 78 | 99 |
| Hike or picnic outdoors with friends | 69 | 28 | 1 | | 31 | 72 | 99 |
| Send kids to school, camp or day care | 70 | 15 | 0 | | 30 | 85 | 100 |
| Work in a shared office | 74 | 20 | 2 | | 26 | 80 | 98 |
| Send children on play dates | 78 | 31 | 2 | | 22 | 69 | 98 |
| Ride a subway or a bus | 81 | 41 | 2 | | 19 | 59 | 98 |
| Visit elderly relative or friend in their home | 80 | 39 | 0 | | 20 | 61 | 100 |
| Travel by airplane | 80 | 36 | -1 | | 20 | 64 | 101 |
| Eat at a dine-in restaurant | 84 | 28 | 0 | | 16 | 72 | 100 |
| Exercise at a gym or fitness studio | 90 | 48 | 8 | | 10 | 52 | 92 |
| Attend a wedding or a funeral | 83 | 42 | 0 | | 17 | 58 | 100 |
| Hug or shake hands when greeting a friend | 92 | 53 | 11 | | 8 | 47 | 89 |
| Go out with someone you don't know well | 88 | 46 | 4 | | 12 | 54 | 96 |
| Attend a church or other religious service | 89 | 46 | 3 | | 11 | 54 | 97 |
| Stop routinely wearing a face covering | 94 | 54 | 2 | | 6 | 46 | 98 |
| Attend a sporting event, concert or play | 98 | 66 | 2 | | 2 | 34 | 98 |

Table 100 - Engaging in Life Events Risk and Confidence Levels 2 of 2

| Event | Spring risk | Summer risk | Fall risk | Winter risk | Spring 21 risk | +1 year risk | Spring confidence | Summer confidence | Fall confidence | Winter confidence | Spring 21 confidence | +1 year confidence |
|-------------------------------------|--------------------|--------------------|------------------|--------------------|-----------------------|---------------------|--------------------------|--------------------------|------------------------|--------------------------|-----------------------------|---------------------------|
| School, camp and day care | 93 | 73 | 64 | 49 | 9 | -1 | 7 | 27 | 36 | 51 | 91 | 101 |
| Sporting events, concerts and plays | 92 | 90 | 74 | 10 | 2 | 1 | 8 | 10 | 26 | 90 | 98 | 99 |
| Hugs and handshakes | 93 | 86 | 70 | 28 | 17 | 11 | 7 | 14 | 30 | 72 | 83 | 89 |
| Weddings and funerals | 98 | 90 | 71 | 29 | 18 | 18 | 2 | 10 | 29 | 71 | 82 | 82 |
| Airplanes | 85 | 73 | 57 | 20 | 7 | 0 | 15 | 27 | 43 | 80 | 93 | 100 |
| Meetings with new people | 96 | 88 | 72 | 30 | 14 | 12 | 4 | 12 | 28 | 70 | 86 | 88 |
| Stop wearing masks | 93 | 90 | 69 | 17 | 10 | 9 | 7 | 10 | 31 | 83 | 90 | 91 |
| Visiting the elderly | 97 | 86 | 71 | 32 | 19 | 19 | 3 | 14 | 29 | 68 | 81 | 81 |

In all systems activities these results are constantly revisited as more is learned about the system. The raw responses for the data used to prepare this analysis were collected the last week of May 2020. They are not based on hard numbers. This is what is referred to as a qualitative analysis. Ideally others would develop models and attempt to put hard numbers against these key system events. Unfortunately, many times the systems analysis must rely on qualitative analysis findings and the system architects must work with those results to develop an effective system solution. The solution includes other quantitative and qualitative analysis findings.

There was no analysis to cross correlate the findings and look for consistencies or inconsistencies.

My takeaway from this analysis is that there is fear and it will take a long time for the fear to subside. This only adds to the case that there should be massive engineering efforts to try and mitigate the effects of this terrible worldwide disaster.

References:

[1] When 511 Epidemiologists Expect to Fly, Hug and Do 18 Other Everyday Activities Again, New York Times, June 8, 2020. webpage <https://www.nytimes.com/interactive/2020/06/08/upshot/when-epidemiologists-will-do-everyday-things-coronavirus.html>, June 2020. [When 511 Epidemiologists Expect to Fly, Hug and Do 18 Other Everyday Activities Again](https://www.nytimes.com/interactive/2020/06/08/upshot/when-epidemiologists-will-do-everyday-things-coronavirus.html)

Dream and Horror Architectures

In every systems engineering effort trying to solve problems that no one will touch with a ten foot pole there is always the Dream Architecture or Ideal Architecture. This is the system solution that most acknowledge will probably work perfectly. The issue is that the dream architecture may be impossible to implement. However, keeping the dream architecture alive in the team makes them try to move each potential solution to a new level of perfection. Then there is always the potential miracle and the dream architecture may become reality.

So, what is the COVID-19 dream architecture solution?

Dream Architecture

This architecture is based on our best science and engineering.

Architecture 1 - Engineering

Herd immunity is different than susceptibility to infection. I don't know the current susceptibility to infection data. Because this thing is so nasty it may be 100%. The herd number is based on what happens as the virus moves within the population. After about 60% the virus starts to get eliminated from the environment because more of it goes into the organisms that can destroy it. It is a depopulation mechanism. You can run a model on this and assume different herd immunity percentages to see how quickly the virus will disappear. [[Wiki-Ref](#) SARS Airborne droplet 50-80%]

The herd concept is important because one of the ideas is to consider using machines to increase the herd count. For example, what if all our major buildings are retrofitted to do the breathing of 7 billion people and those machines as they are "breathing" kill the virus via UV. So, people go back to work in safe buildings that also act to suck up and kill the virus as it spreads across the herd. This is what is called a Dream Architecture. Great systems teams always track the dream architecture in grave situations with the possibility of massive death.

The requirements for the dream architecture are:

1. No one dies, ever
2. It is the quickest to be deployed because people are dying every day
3. All resources in the civilization have been accessed
4. The analysis is not cut short by external forces
5. Every aspect has been investigated
6. All alternatives have been considered
7. A point of analysis diminishing returns has been reached regardless of the numbers and types of people examining the architecture
8. Everyone acknowledges that the unintended consequences are minimized
9. Everyone knows this is the right thing to do

The reality is that something may be missed and people will die. However, this is because the problem is beyond our existing capabilities, we gave it our best shot without compromise. We can sleep at night knowing that we minimized death.

Architecture 2 - Social (not ideal, we know the limitations)

This architecture is based on quarantine. We think that after 14 days the virus does not spread. In this architecture everyone is quarantined for 14 or more days. Social distancing is a compromise. If we had perfect social distancing that would be equivalent to quarantine. However, we know that we don't have perfect social distancing because the virus is still killing people. The workplaces were shut down in mid-March 2020 and now it is mid May 2020 and the virus is still killing people 2 months later.

The problem with this architecture is that it cannot be implemented effectively because it relies on people. People are not dependable like machines. It is called being human. This is why most system solutions attempt to remove people from the system for it to work. People are always the weakest link in any system.

Architecture 3 - Medicine (not ideal, we know the limitations)

Find a cure and or find ways to treat the disease to stop death and or health damage. Since this did not happen immediately with our current arsenal of cures and treatments, this will take a long time. The optimistic estimates for a cure are 2 years away and treatment also appears to be problematic and may take years to stop most death scenarios. So, this must be coupled with Architecture 2 Social Distancing and Quarantine.

Others will have Dream Architectures - what are they?

Horror Architecture

This architecture is based on human sacrifice and ignores science and engineering.

The horror architecture always surfaces when the dream architecture is being investigated. It needs to be fully understood so that it cannot get traction and potentially become the solution.

The horror architecture uses the same herd immunity concept to eventually eliminate the virus however instead of using machines, people are used in place of the machines. This approach examines the death rates by age and identifies the most reasonable point to draw a line and allow those with the lower death rates to go back to work. As they mix in the herd the virus population is consumed by the herd and eventually eliminated from the environment. The other people go into quarantine mode for 14 or more days. They re-emerge when there are no more deaths or there is 100% testing of those that acted as the cleaning agent in the system.

The characteristics of the Horror Architecture are:

1. Consciously allow some people to die
2. It's an experiment that may go wrong with massive unintended consequences
 1. We find that it doesn't work and precious time is lost
 2. The virus mutates to a more virulent strain killing even more people
 3. There are massive long term health effects for those that were infected
3. As the virus spreads and kills people, there may be social unrest
4. Everyone knows this is the wrong thing to do

It is based on ignoring the key requirements of the Dream Architecture. Instead those requirements are converted to anti-good or evil as in Horror requirements in this grave disaster as follows:

1. The analysis is cut short by external forces
2. Not all resources in the civilization have been accessed
3. Not all avenues have been investigated
4. Not all alternatives have been considered
5. Various aspects about the problem have been ignored
6. A point of analysis diminishing returns has not been reached
7. Everyone acknowledges that the unintended consequences are not minimized

▼ In a grave situation like war, people have no choices, however they are **not tricked or fooled** into putting their lives on the line for the greater good.

- ▼ Each individual makes the choice to potentially sacrifice their life.
- ▼ It is their lives, they own it, not someone else's.

This architecture is being called the herd immunity approach in the popular media. This was adopted early in the disaster by Sweden. The US policy clearly shifted on August 31, 2020 to use a non-vaccine herd immunity approach [1]. On September 16, 2020 it penetrated the popular media and death estimates were offered if this policy is permitted to proceed and they were between 6,385,500 and 2,150,000 as the best case just assuming 3X better [2] [3].

References:

[1] New Trump pandemic adviser pushes controversial ‘herd immunity’ strategy, worrying public health officials, The Washington Post, August 31, 2020. webpage https://www.washingtonpost.com/politics/trump-coronavirus-scott-atlas-herd-immunity/2020/08/30/925e68fe-e93b-11ea-970a-64c73a1c2392_story.html, [New Trump pandemic adviser pushes controversial ‘herd immunity’ strategy, worrying public health officials](#)

[2] Math On Trump COVID Strategy Has Millions Dying Before It Works, The Rachel Maddow Show, MSNBC, September 16, 2020. webpage <https://www.msnbc.com/rachel-maddow-show>, September 2020.

[3] Math On Trump Covid Strategy Has Millions Dying Before It Works | Rachel Maddow | MSNBC, www.youtube.com, September 16, 2020. webpage <https://www.youtube.com/watch?v=UVfxjS1DnBc>, September 2020. [Math On Trump Covid Strategy Has Millions Dying Before It Works | Rachel Maddow | MSNBC](#)

Facilities

After all of this analysis the elephant in the room is facilities and facility engineering. In a typical design review that is systems driven the content includes many topics. In the past the ground based facilities were always viewed as low risk. This means that it would be offered usually towards the end of a design review session.

The following table shows a typical Pre-COVID-19 Systems Engineering Design Review.

Table 101 - Pre-COVID-19 Systems Engineering Design Review

| | |
|--|--|
| <ul style="list-style-type: none"> • Needs • Boundary & External Interfaces • Key Requirements • Key Functions • Functional Allocations • Performance Analysis • Reliability Maintainability Availability (RMA) • Internal External Communications • Architecture Alternatives • Architecture Tradeoff and Selection | <ul style="list-style-type: none"> • Transition Analysis • Detailed Functional Analysis • Detailed Operational Analysis • Human Factors • Testing Concept • Maintenance (ILS) • Training (ILS) • Logistics (ILS) • Facilities • Installation & Operation • Decommissioning |
|--|--|

This analysis suggests that to mitigate or remove the COVID-19 virus and future deadly viruses the architecture solution must include the Vaccine + UV + HVAC as major subsystems that must be rolled out into the infrastructure. This is based on the findings in the following table. [1]

Table 102 – Safe Facilities and Vaccine

| Naturally Immune % | Vaccine Effectiveness % | Vaccinated % | Exposed Population | Deaths @ 3.5% | UV-C or FAR UV-222 Kill / Inactivate | Deaths @ 3.5% (With UV) | Ventilation Effectiveness 4 AUC | Deaths @ 3.5% (With UV + Ventilation) |
|---------------------------|--------------------------------|---------------------|---------------------------|----------------------|---|--------------------------------|--|--|
| 10% | 70% | 70% | 150,552,000 | 5,269,320 | 90% | 526,932 | 28% | 379,391 |
| 10% | 90% | 90% | 56,088,000 | 1,963,080 | 90% | 196,308 | 28% | 141,342 |
| 0% | 70% | 70% | 167,280,000 | 5,854,800 | 90% | 585,480 | 28% | 421,546 |
| 0% | 90% | 90% | 62,320,000 | 2,181,200 | 90% | 218,120 | 28% | 157,046 |
| . | | | | | | | | |
| 0% | 0% | 0% | 328,000,000 | 11,480,000 | 90% | 1,148,000 | 28% | 826,560 |
| 10% | 0% | 0% | 295,200,000 | 10,332,000 | 90% | 1,033,200 | 28% | 743,904 |

Notes: Population = 328,000,000. Ventilation works only when it is turned on. The HVAC fan(s) must run 1 hour before and 1 hour after the facility opens to the public. UV is a form of ventilation.

The table above can be viewed from two perspectives. The first is from the perspective of herd immunity. Herd immunity is a function of the risk of infection. If the risk of infection is reduced using technology like UV and HVAC systems then the herd immunity number will be significantly lower. Lowering the herd immunity number will lead to a shorter time for the virus to be under control. The second perspective is from the number of lives saved. Using the UV and HVAC technologies that were introduced in the last century will save lives. This analysis shows that this simple moral ethical choice is also the most effective and lowest cost choice because of the massive costs associated with loss of life, loss of health, and shut downs. [2]

Because of this key finding the priority of Facilities in all design reviews moving forward should be number one. The following table shows a typical Design Review now that there is COVID-19 and future mutations.

Table 103 - Post COVID-19 Systems Engineering Design Review

| | |
|--|---|
| <ul style="list-style-type: none"> • <u>Facilities</u> • Needs • Boundary & External Interfaces • Key Requirements • Key Functions • Functional Allocations • Performance Analysis • Reliability Maintainability Availability (RMA) • Internal External Communications • Architecture Alternatives • Architecture Tradeoff and Selection | <ul style="list-style-type: none"> • Transition Analysis • Detailed Functional Analysis • Detailed Operational Analysis • Human Factors • Testing Concept • Maintenance (ILS) • Training (ILS) • Logistics (ILS) • Installation & Operation • Decommissioning |
|--|---|

The Facilities Design Review portion must include:

- Layout
- Heating Ventilation Cooling Requirements
- HVAC Design
- HVAC Filtration Considerations
- Air Monitoring
- Ceiling Level UV-C Design
- Far UV-222 Design
- UV Monitoring
- Maintenance

Each facility is different. It is easy if the facility is new and there are budget dollars available to apply massive technology. The challenge is what happens when the facility is old. In many old facilities the HVAC system may not even be a forced air system or it is a forced air system but it is too small for the needed ventilation rates. Further HVAC upgrades may not even be possible. In these facilities UV-C and Far UV-222 become the primary subsystems to mitigate or remove the risk of infection. Many do not know that UV is a form of ventilation and the introduction of these systems translate to massive ventilation rates. [3] This scenario applies to many schools around the country. The final take away is:

- Many facilities cannot be upgraded with new HVAC systems
- The only effective alternative is Ceiling Level UV-C and or Far UV-222
- This especially applies to old school buildings

It is important that all facilities staff now realize that their work is probably the most important work in the world today. They must reach out to industry and other facilities to understand what can be done to make their facilities safe and healthy now and for future generations. The technologies are there, they are almost 100 years old, the numbers are there. It is just a matter of focus and policy.

The following is an excerpt [4]:

November 10, 2020. ROCK HILL, SC.

The Chester County School District announced in October that they would use ultraviolet lights to help fight the spread of COVID-19. Lewisville Elementary, in Richburg, will be the first in the district to use this technology -- and one of the first in the nation, said district Public Information Officer Chris Christoff.

“We’re extremely honored to be among the first to utilize this technology,” said Chester County School District Superintendent Antwon Sutton at the time. “We’ve chosen Lewisville Elementary based on the fact that elementary schools have been identified as more high risk when it comes to exposure.”

The technology is already being installed, and the district anticipates completion this month, Christoff said.

Is UV technology safe? Will it be effective? Here’s what The Herald found out.

*The lights being used in Chester are called Germicidal Ultraviolet lights, also known as GUV. They will use 254 UV-C light -- 254 being the wavelength. There will be some overhead GUV lights installed throughout the schools, Christoff said. The units, provided by **NetZero USA**, also will include hand-held units, which will be used to disinfect classrooms and surfaces*

GUV of this type is not new technology. Articles on GUV date back to 1947 -- when it was used in a school outside of Philadelphia.

The effectiveness of GUV has been proven. A study done in South Africa, which was published in the U.S. Library of Medicine, states: “Upper room germicidal UV air disinfection with air mixing was highly effective in reducing tuberculosis transmission under hospital conditions.” Edward Nardell, a doctor and professor of medicine at Harvard Medical School, contributed to the study. He said it proved “80% efficacy,” in stopping the spread of tuberculosis.

GUV does work on COVID-19, the virus caused by the novel coronavirus. It disinfects by destroying the virus in the air. “UV works on every single kind of pathogen there is. It works on COVID,” Nardell said.

The reason this technology seems new to us is that it has not been necessary for a while. Since studies in the 1940s, which focused on stopping the spread of measles, the U.S. hasn’t needed

this technology, Nardell said. Schools that are implementing this technology during the coronavirus pandemic are among the first to use UV light in decades.

GUV is safe as long as it is installed properly. Ceiling fans and proper ventilation are important, Nardell said. He recommends that any school installing this program has an outside professional -- someone who has no stake in the game -- come and check that the system is installed correctly before they turn it on.

*If the above guidelines are followed, students will not experience side effects. **“There’s not much we don’t know,” Nardell said. “It doesn’t cause skin cancer, it doesn’t cause cataracts, it can’t even give you a good sunburn.” It can cause irritation of the skin and eyes; the eyes are the most sensitive. If students are complaining of eye irritation, Nardell said, the system has not been properly installed.***

Other schools are currently using this technology. Cambridge Friend’s School in Cambridge, Mass., installed Upper Room GUV lights (GUV light installed in the ceiling) earlier this year.

It won’t necessarily control the spread of coronavirus, unless exposure is strictly unlimited. In past studies, like the one in Philadelphia, the technology wasn’t effective in stopping the spread of disease because children rode the bus after school. Without the GUV technology, the disease (measles in their case) was quickly spread in other environments. Unless children are being strictly isolated outside of school, they will still be susceptible to the virus, Nardell said. The study in South Africa showed more effectiveness because it took place in hospital conditions where patients were strictly isolated.

It should be most helpful to teachers, who don’t mingle with students outside of school. “You may not protect every kid from this, if they’re touching and in close contact, but you could certainly protect your teachers,” Nardell said.

Philadelphia Schools are waiting for Fans for their classrooms as a ventilation solution. I reached out to one organization and found out that this organization was totally unaware of their ventilation options including various UV options. Unfortunately, in this time of massive communications and access it is not enough to just do research. Researchers must constantly reach out to the public because they just don't know for some odd reason. We rely on our home institutions to do this reach out but what happens when there is a breakdown for some reason. That is another research challenge. From my initial exposure today the Philadelphia Schools need help and guidance. [5] [6] [7]



Photo: WHYY [5]

Figure 45 - Philadelphia Schools COVID-19 Approach 2021

There are no words that this research can apply to the above picture other than extreme disgust. This is yet another example of the massive US systemic collapse [7].

The technology to deal with this disaster was developed and proven in Philadelphia PA 80 years ago.

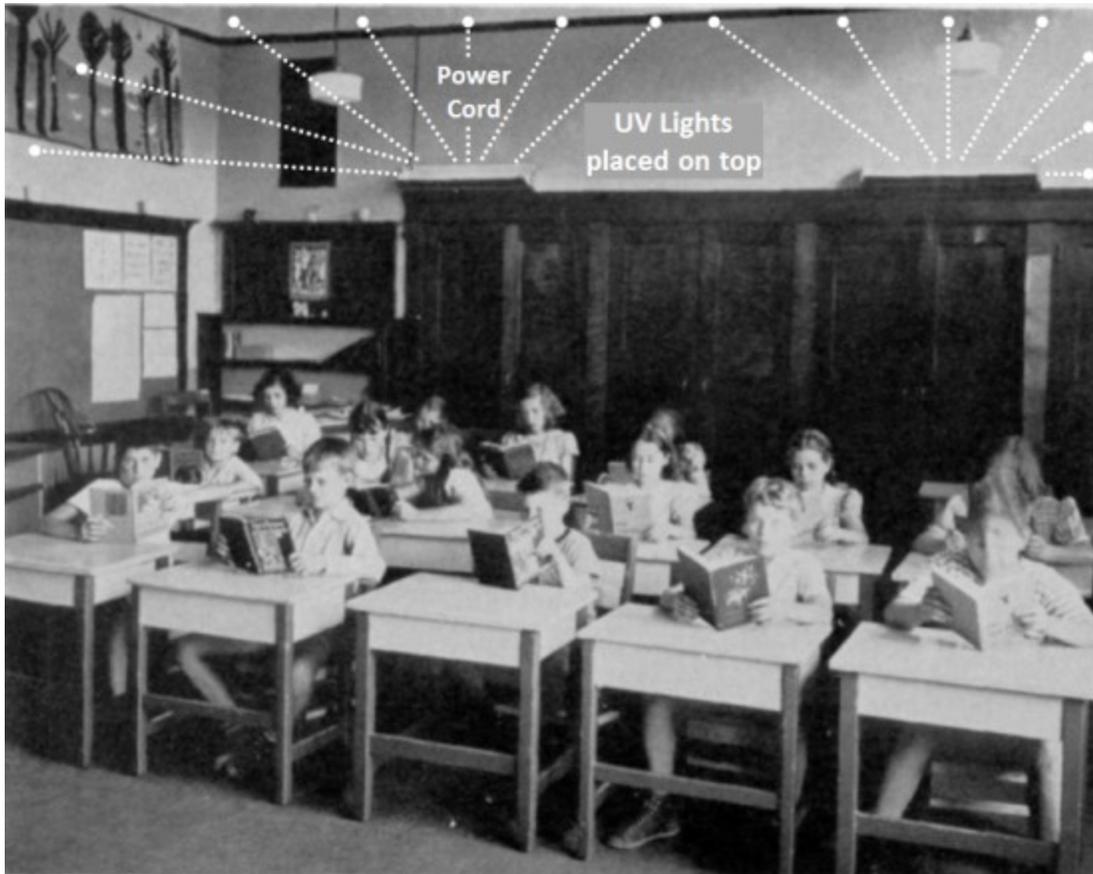


Photo: National Academies of Sciences, Engineering, and Medicine [8]

Figure 46 - Facilities Swarthmore Public School Classroom circa 1937 - 1943

The solutions in the 21st century exist but there is something seriously wrong within the system when some schools are able to use this technology and others are not even aware of this technology.



Photo: National Academies of Sciences, Engineering, and Medicine [8]

Figure 47 - Facilities Public School UV Light Installation circa 2020

The UV technology has moved on and there are now new state of the art solutions made possible because of the ability to control the wavelength bands emitted. The state of the art installations exist within elite settings circa 2021.



Photo: Columbia University For Radiological Research [3]

Figure 48 - Facilities Airport

In Philadelphia two-thirds of the elementary school classrooms do not meet the minimum industry recommended ventilation standard of 15 CFM per person and one-fifth of the elementary schools have no classrooms that can meet this standard. An earlier analysis found 80% of school buildings had ventilation problem. This is a general ventilation requirement and is not sufficient to mitigate the spread of an airborne pathogen. [9] [10]

The 15 CFM standard translates into an AUC of 1.5 for a 900 square foot classroom with a 10 foot ceiling and 15 students. The school district has had problems with air quality and ventilation in its buildings for years, but now that there is COVID-19 this serious problem can no longer be ignored. [9] Unlike a cold or a flu infection the COVID-19 virus makes this problem highly visible because of the large hospitalization and death rates.

This is interesting because a standard that describes performance in terms of CFM per person will not provide insight into when contaminated air from an infected person will be removed from the room. The number of air changes per hour (AUC) provide that information. Changing the air every 15 minutes is an AUC of 4 which suggests the infected air will be removed 4 times per hour or every 15 minutes. The next question is what happens during that 15 minutes. Is the virus load high enough from an infected person to infect another person. That is the essence of this study.

The big question is - what is the industry standard requirement and how applicable are any of the existing standards to this current situation as this analysis has disclosed.

This is all irrelevant because we know that these old standards no longer apply now that we have a deadly airborne contagion. New standards are needed and then proper technologies need to be applied to solve the problem. This analysis has information and offers multiple road maps including legislation to develop the new standards. The technologies are available in the industrial base and they include UV technologies and systems.

It is obvious that it is time to stop using vague words like more ventilation or more safe. It is time for testable performance requirements (proper standards) to be published and made available to everyone for analysis, review, and acceptance. The time for proprietary data that cannot be disclosed via non-disclosure agreements signed by professional engineers and others must end. These are public buildings and the data that affects the health and well being of the public must be ubiquitous common sense knowledge.

References:

[1] See section [Vaccine Systems Perspective](#).

[2] See section [Virus Mutations & Architecture Solutions](#).

[3] See sections [Ultraviolet Germicidal Irradiation \(UVGI\) - Open Air](#) and [UV-C Ventilation Design Solutions](#) and [FAR UV-222 Design Solutions](#).

[4] Some SC schools to use ultraviolet light to fight coronavirus. A few things to know. The Herald November 10, 2020. webpage

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[5] Hot air or actual solution? Experts on Philly's plan to ventilate schools during COVID, WHYY Article, February 2, 2021. webpage <https://whyy.org/articles/hot-air-or-actual-solution-experts-on-phillys-plan-to-ventilate-schools-during-covid>, February 2021. [Hot air or actual solution? Experts on Philly's plan to ventilate schools during COVID](#)

[6] In public protest, thousands of Philly teachers pushed back against reopening schools, The Philadelphia Inquirer, February 8, 2021. webpage <https://www.inquirer.com/education/philadelphia-school-district-reopen-teachers-union-pft-20210208.html>, February 2021. [In public protest, thousands of Philly teachers pushed back against reopening schools](#)

[7] See section [System Collapse](#).

[8] Upper-Room-Disinfection, National Academies of Sciences, Engineering, and Medicine, September 17, 2020. webpage <https://www.nationalacademies.org/event/09-16-2020/docs/D00062573057472031C5B95374B5C068AE9324D53EC4>, November 2020. [Upper-Room-Disinfection](#) . [local](#)

[9] Analysis: Just one third of elementary classrooms in Philadelphia meet minimum ventilation standards, Chalkbeat Philadelphia, October 29, 2020. webpage <https://philadelphia.chalkbeat.org/2020/10/29/21538436/analysis-just-one-third-of-elementary-classrooms-in-philadelphia-meet-minimum-ventilation-standards>, February 2021. [Analysis: Just one third of elementary classrooms in Philadelphia meet minimum ventilation standards](#)

[10] Is it possible to make school ventilation safe enough to open this fall?, The Notebook July 27, 2020. webpage <https://philadelphia.chalkbeat.org/2020/7/27/22186772/is-it-possible-to-make-school-ventilation-safe-enough-to-open-by-september>, February 2021. [Is it possible to make school ventilation safe enough to open this fall?](#)

Action Plan

🚩 If you are a government organization, you must reach out to other government organizations and start a dialog immediately. Do not wait for direction from the political appointee levels. The DOD is probably the only organization with the resources and capability to understand this need and able to structure an effective return to life system, call them now. Reach out to your local hospitals and try to understand what they established. Contact the CDC for specific guidance and have them assign staff to your organization. Reach out to NASA, they may have specific protocols for biohazard containment that may help. Contact [MITRE](#) . [COVID-19 Healthcare Coalition](#) (MITRE).

🚩 If you are a non-government organization, you have a bigger challenge. Reach out to other organizations including trade associations. Look to company leaders to gain insight. Now is not the time to cut corners or save pennies. A serious compromise will destroy your company.

🚩 Read the guidance from: [CDC](#) . [Coronavirus.gov](#) . [OSHA 3990 Guidance on Preparing Workplaces for COVID-19](#) . [Library on Reopening Guidance](#) (there is the original PDF then

new cleaned up PDF and .docx versions for those that want to expand on the content for their needs.)

▼ Read the guidance from the Department of Transportation (DOT) - [DOT-FAA-Framework-For-DOTs-Return-To-Normal-Operations.pdf](#) . [Library on Reopening Guidance](#) (there is a .docx version)

▼ Read the guidance from Canada: [Government of Canada](#)

▼ Read the guidance from the WHO: [The World Health Organization](#)

▼ Read this full report including the section that follows called The Collapse.

▼ Consider Engineering based solutions

▼ Consider augmenting commercial HVAC systems with massive internal UV-C light systems as soon as possible.

▼ Consider adding ceiling level UV-C lights to all public rooms as soon as possible.

▼ Consider significantly increasing HVAC air update rates, it is no longer a comfort versus cost issue, it is a grave sickness spread issue

▼ Consider adding natural ventilation and exhaust fans back into older buildings able to accommodate these systems

▼ Consider that just because a venue is outdoors it does not mean the air circulation is safe, it must be laid out and mechanically augmented with careful placement of fans

▼ Consider that airplanes must control and direct the air flow between passengers, seating must maintain 6 foot separation

▼ Consider various approaches for fighting the virus that are being developed outside the US. Look at the news report images from around the world.

▼ Other countries have significantly less deaths than the US. That has meaning that should affect your approach to the COVID-19 disaster.

▼ Guidance provided by the US Department of Transportation (DOT) can be used by others to help address their needs. Key items from the [DOT-FAA guidance](#):

- Consider improving the engineering controls using the building ventilation system. This may include the following activities:
 - Increase ventilation rates.
 - Increase the percentage of outdoor air that circulates into the system.
- As identified by CDC, vulnerable individuals are (i) those who have a higher risk for severe illness, including individuals who self-identify as having a serious underlying health condition, such as high blood pressure, chronic lung disease, diabetes, severe obesity, serious heart conditions, liver disease, chronic kidney disease, asthma, or a

compromised immune system (for example, because of chemotherapy); (ii) those who are over the age of 65; and (iii) those individuals in CDC Special Populations, including those who are pregnant.

- Phase 1: All vulnerable individuals are expected to remain on maximum teleworking status.
- Phase 2: Vulnerable individuals are expected to remain on maximum teleworking status.
- Phase 3: Vulnerable individuals will be permitted to make liberal use of teleworking arrangements where and as appropriate.

▼ The WHO provides effective information on dealing with the COVID-19 disaster. The presentation is clear and represents knowledge from across the planet.

▼ You must avoid information that is buried in useless confusing content and is insufficient for people to develop working solutions. It is a product of management engaged in damage control and talking points that confuse the situation. This happens in compromised organizations. The technical people do the work and dangerous management modifies the work based on hidden agendas.

▼ You must dig deep and have a Systems Perspective.

System Collapse

In the end there will be a system whether we like it or not. The system can be great and everyone will just smile and think, wow what a great system, or the system will be bad and everyone will be sad if forced to live with the bad system. If the system is severely compromised, then eventually there is a system collapse [1].

There is always an ideal system. The difficulty is to find the ideal system and then bring it into reality. Sometimes the ideal system surfaces quickly and everyone on the team agrees that it is the ideal system, but they do not know how to get to the ideal system. There could be many limitations that need to be addressed. These limitations include technology, politics, money, time, motivation, education, people, etc.

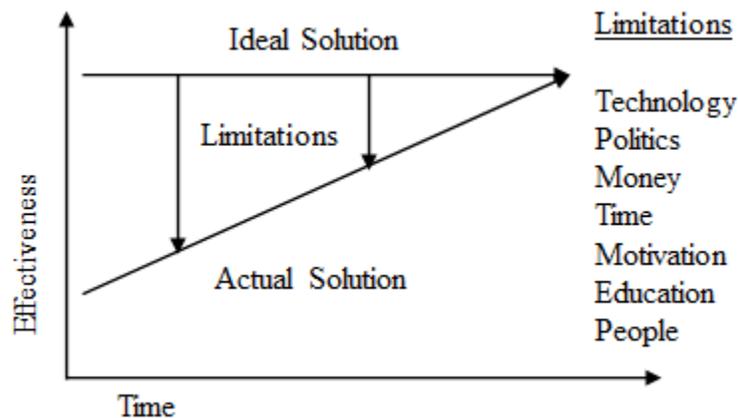


Figure 49 - Ideal System Convergence

Sometimes the ideal system is in clear sight and the approach for developing the ideal system is clearly visible. The system even may be in place but not necessarily available for the stakeholders. However, the ideal system and its availability fade as ignorance grips the stakeholders.

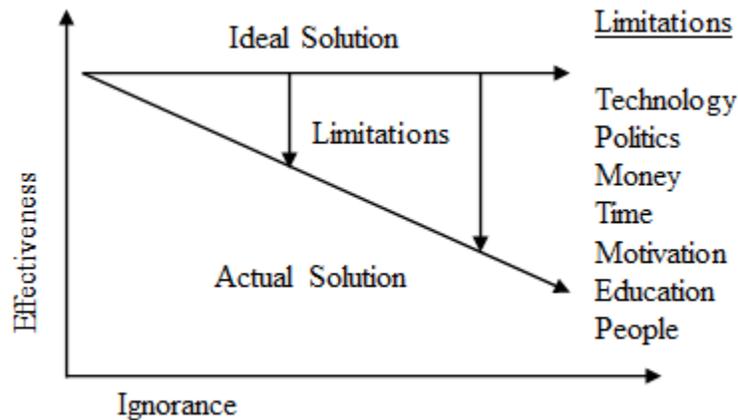


Figure 50 - Ideal System Loss

The possible scenarios associated with the ideal system and the actual solution can be identified. Realizing these possible scenarios exist will help system practitioners understand their roles in the organization. It will also act as a gage to measure the organizations' ability to engage in systems engineering, systems thinking, and systems practices.

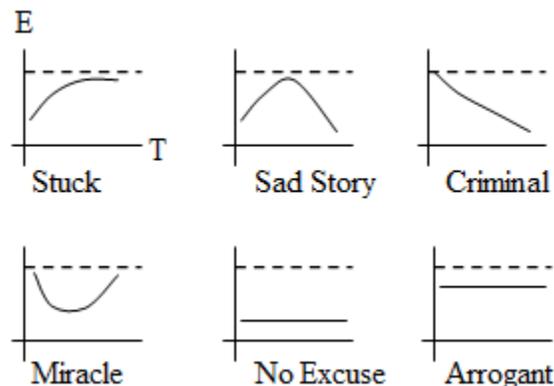


Figure 51 - Organizational Effectiveness

The reality is organizations that get lost are compromised. There is not much system practitioners can do once an organization is compromised other than attempt to point out the condition and the ramifications of the condition or leave the organization. In the case of the COVID-19 disaster no one can leave the organization.

The US policy clearly shifted on August 31, 2020 to use a non-vaccine herd immunity approach [2]. On September 16, 2020 it penetrated the popular media and death estimates were offered if this policy is permitted to proceed and they were between 6,385,500 and 2,150,000 as the best case just assuming 3X better [3] [4].

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[3] Math On Trump COVID Strategy Has Millions Dying Before It Works, The Rachel Maddow Show, MSNBC, September 16, 2020. webpage <https://www.msnbc.com/rachel-maddow-show>, September 2020.

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Future Generations Assessment

In taped interviews with journalist Bob Woodward on Feb. 7, 2020, President Trump said that the virus was more dangerous than the flu, even as he told the country otherwise [1]. It is clear that it was known from the beginning that the virus is spread through the air. President Trump stated the following in the audio interview.

- “This is deadly stuff,”
- “You just breathe the air and that’s how it’s passed,”
- "It’s also more deadly than even your strenuous flus."

It is obvious that the US Government and media knew that the virus was airborne but they did not inform the public or take action to mitigate the virus spread from the airborne element. This information was made public on September 09, 2020.

Today we have children wearing masks. They are unable to attend physical school, play with their friends, and interact with family members outside their home. This will leave a permanent mark on this generation of children. When they grow up and realize what happened the assessment will be brutal as it should be. All future generations will not look kindly on this generation.

References:

[1] Trump Admits Downplaying the Virus Knowing It Was Deadly Stuff, New York Times, September 09, 2020. webpage <https://www.nytimes.com/2020/09/09/us/politics/woodward-trump-book-virus.html>, September 10, 2020. [Trump Admits Downplaying the Virus Knowing It Was Deadly Stuff](#)

Government Failure

This section is presented as standalone statements. This is offered so that today's children in the coming years when they debate what happened in this time can easily see the arguments and thoughts from this analysis.

Key requirements to fix the system.

1. Accept that the system has collapsed
2. The COVID-19 disaster is a symptom not a cause
3. It needs to be fixed to have a safe and effective Return to Life system
4. The cracks in the system were visible for decades
5. Current approaches to correct the system are not working

There is a broader root cause analysis that includes analysis of the US government and its transformation as part of privatization

1. Privatization has changed the role of government
2. The government is hands off and relies on the market to solve problems
3. The government does not marshal resources like in the pre-1980's era
4. No one realizes the system of government has changed, even elected officials

There is a harsh and unfortunate finding.

1. There is no question that after 1945 the US led the world in dealing with massive crisis situations and the world became dependent on the US
2. Is it possible that because of the poor US response when COVID-19 first surfaced that the rest of the world was late to deal with this terrible event
3. Would it have been contained early if the US had a different attitude and policy towards threats like COVID-19
4. History will figure that out, but my guess is that it will be a very harsh accounting
5. Just like the states depended on the Federal Government to detect and marshal resources, the world depended on the US to detect and alert the world to the threat

We are in bigger trouble than we realize because we have a fundamental structural problem in our system that surfaced with privatization of government beginning in the 1980's.

1. The Federal Government is not the same government that we were born into and learned about in school
2. It has been transformed into something else and no one is aware of it, not even the people who are doing massive damage
3. This is a terrifying example of unintended system consequences
4. We can study this further but that will only delay actions that need to happen immediately, we can let history decide
5. It is clear that something has shut down the Federal Government and it needs to be restarted
6. The State Governments are attempting to do this in realtime
7. Meanwhile a return to life system needs to be developed everywhere and this will require our best and brightest to be at the table to make the right decisions and direct proper actions

Government Privatization

All systems analysis begins with identifying the system stakeholders and their needs. The stakeholders that matter must be addressed in a systems analysis. Who are all the system stakeholders? Why are some left out of the discussion? Why do some stakeholders have no voice?

Sometimes the ideal system is in clear sight and the approach for developing the ideal system is clearly visible. The system even may be in place but not necessarily available for the stakeholders and the ideal system and its availability fade as ignorance grips the stakeholders who are in control and making all the decisions. The stakeholders that matter in this case are all the US Citizens.

The tone and policy of the US between 1945 and 1980 was set when President Roosevelt requested a report from the Office of Scientific Research and Development on what can be done after the war. This resulted in the report Science the Endless Frontier [NSF] [1]. The government architecture was as shown below: Pre-Privatization US Federal Government [2].

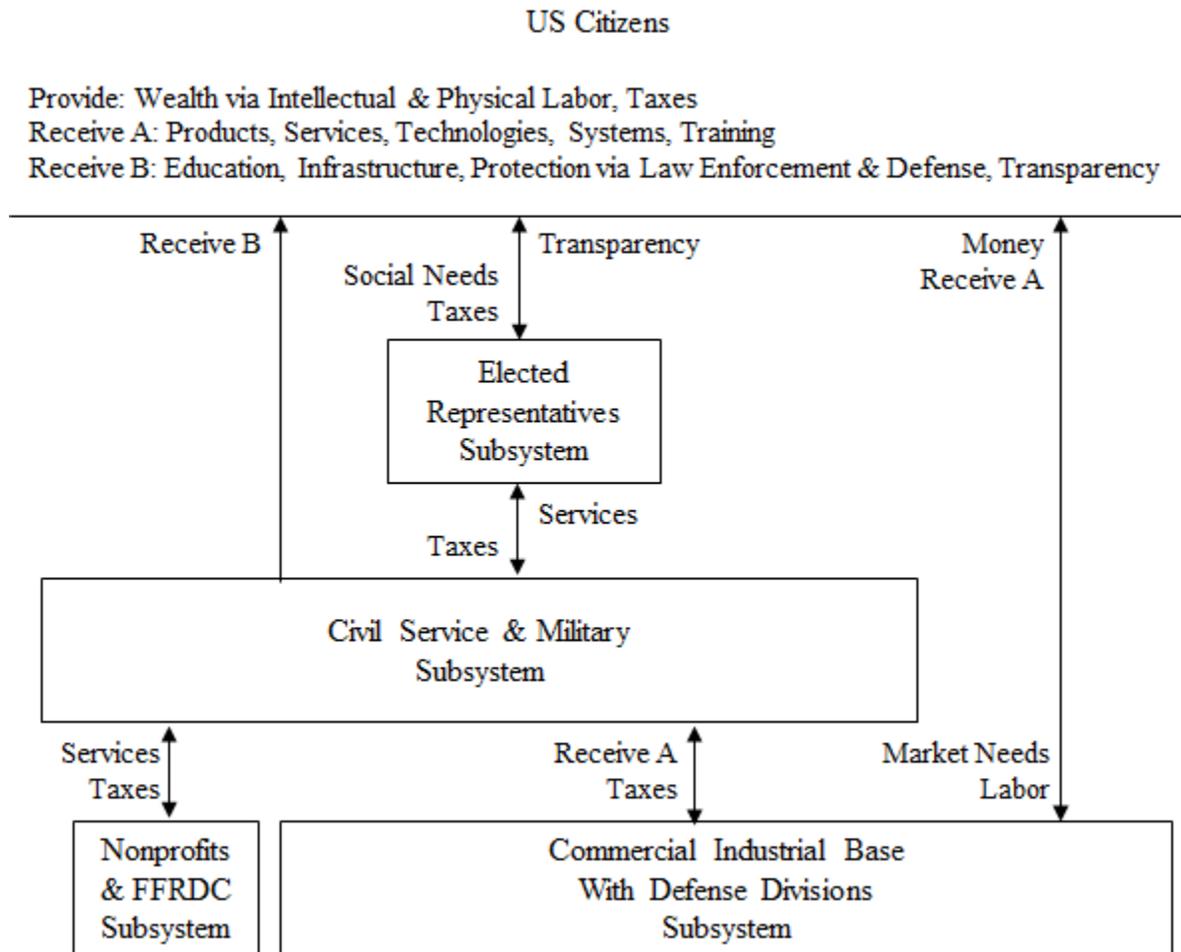


Figure 52 - Pre-Privatization US Federal Government

After 1980 there was a new set of policies that started to surface and became entrenched by 1987. Privatization of the US Government began in 1987 when President Reagan signed

Executive Order 12607. This resulted in the report, Privatization Toward More Effective Government. This set the tone and policy in the US that still exists today [2]. In their day even Hughes and Sarnoff at RCA would have contacted the Federal Government to offer help but they clearly would have stated that they could not deal with this challenge and that the **Federal Government must step in to marshal the needed resources in a coordinated systematic way.** Unfortunately the industrial base and the government architecture have changed as shown below: Post Privatization US Federal Government [2].

Currently the [National Governors Association](#) is the focal point for dealing with the US COVID-19 disaster [3].

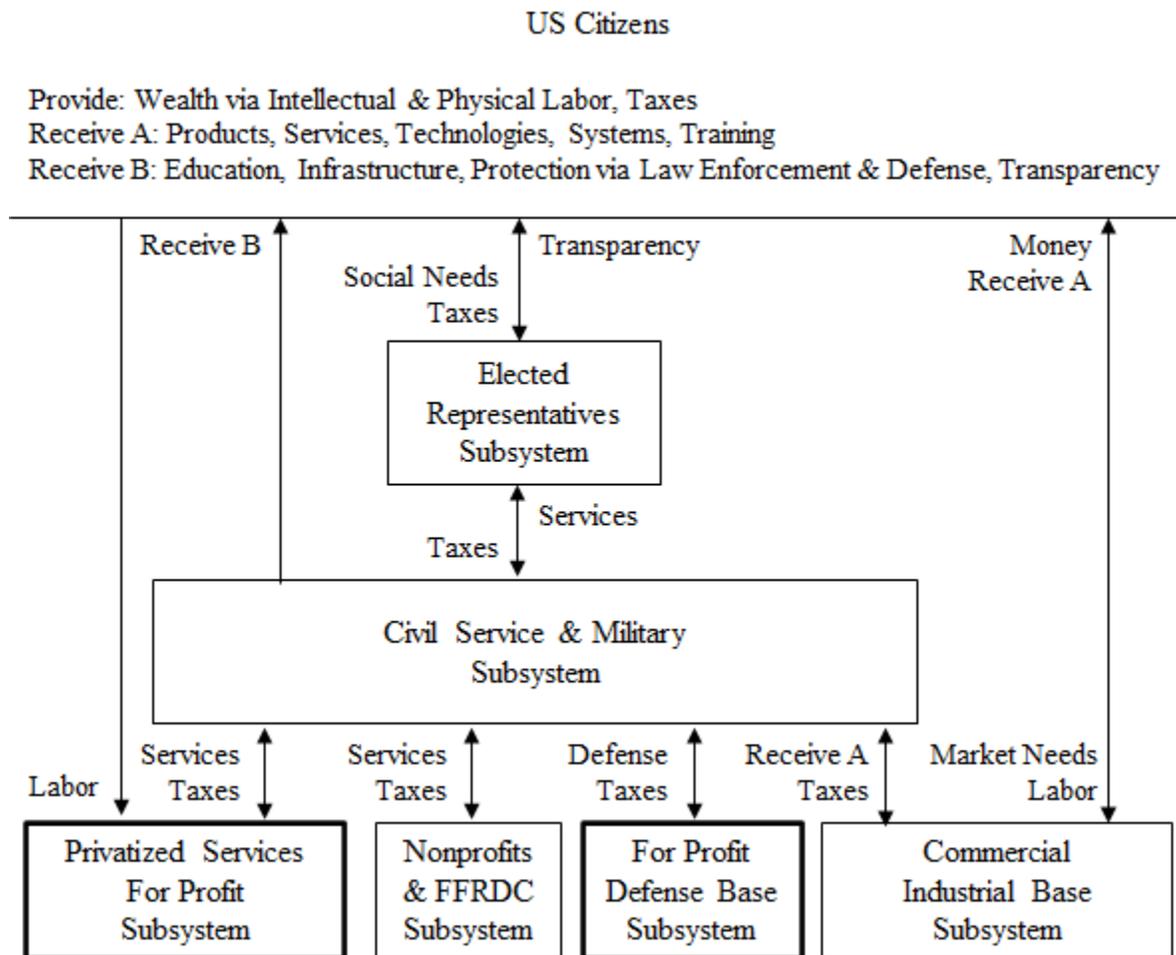


Figure 53 - Post Privatization US Federal Government

There is now evidence suggesting that privatization has led to systemic government shutdowns and other negative unintended consequences including serious damage to the industrial base, colleges, universities, and the citizens of the United States [2]. Is this why the USA is struggling and performing so badly when dealing with the COVID-19 Pandemic?

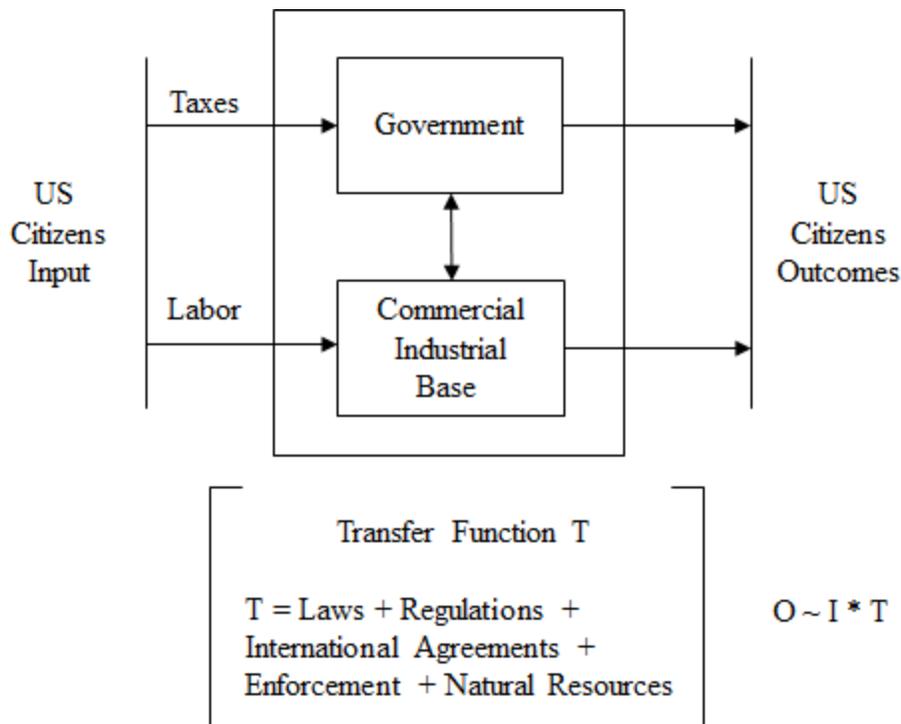


Figure 54 - Systems Architecture Big Picture

There is the big picture of the total system that includes both government and industry. When the big picture system is examined there are new insights that surface.

The big picture system has inputs and like all systems it has outputs based on a transfer function. The transfer function is based on laws, regulations, international agreements, enforcement, and available natural resources. As the transfer function changes, the outcomes change. This is a massive system so any changes in the transfer function have a large hysteresis. Most of the transfer function changes manifest themselves in the outcomes over years or decades. We also know that this is a complex system with massive internal dependencies, and it is difficult to predict the outcomes when there are changes. In most instances all we can really do is observe the outcomes. If the outcomes are bad, we can tweak the system in some direction until the outcomes move away from a bad condition. If the outcomes are good, we can still tweak the system to get even better outcomes.

The outcomes can be identified and tracked using quantitative and or qualitative data. The ultimate check comes with the citizens who control the system by votes and participation in the system.

The system should respond to the outcomes in a causal loop, but it does not in all instances. If the outcomes are ignored for a very long period and the population suffers long enough the system self corrects with a revolution. The big issue is the outcome levels between an ideal system and a poor system. The citizens may suffer but not enough to move into a revolutionary state.

The transfer function in the system might be reasonable or even the same as in other high-performance systems but the system outcomes may be very poor. In this case the system is compromised and the transfer functions while written down and institutionalized may not be

used by the actual system. Instead hidden stakeholders have implemented hidden transfer functions to game the system in their favor at the expense of everyone else. This is a compromised system [2].

Government Privatization Background

Privatization is the shifting of government functions into the private sector. The government either joins with private sector companies or shifts all responsibility to the private sector companies to provide services previously performed by the government. The forms of privatization are [2]:

- Contract Labor, Outsourcing or Contracting Out: A private company supplies a service to the government using taxpayer money.
- Contracting Out: This is an award of monopoly privilege to a private company to supply a service, with price regulation by a government agency.
- Grants: The government provides financial assistance to a private company to perform a service using taxpayer money.
- Vouchers: Consumers are subsidized by taxpayers and can spend the funds for a service provided by a private company.
- Franchise Agreements: The government grants monopoly rights to a private company to produce a given function or provide a service.

The term "privatization" appeared in a book, Cutting Back City Hall in 1980 by Robert Poole. He co-founded the Reason Foundation, a libertarian organization, in 1978. The book provided support for Margaret Thatcher's privatization efforts in the United Kingdom. He advised the administrations of Ronald Reagan, George H.W. Bush, Bill Clinton, and George W. Bush on privatization and transportation policy. The Reason Foundation publishes the Annual Privatization Report (APR). The APR came from Reason Foundation Trustee David Koch. [2]

The roots of privatization appear to come from the libertarian movement. From an elected representative perspective, the libertarians are far from the mainstream electorate as suggested by election results. Yet the idea of privatization has had a huge impact on the makeup of US government. [2]

Privatization is an international trend impacting the entire planet. However, it is important to realize that privatization in another country may be very different than privatization in the US. For example, a country or system with no free market will experience the introduction of a free market commercial and industrial base with privatization. Privatization in a country or system with a free market commercial industrial base, like the US, will experience fundamental changes in its government functions and performance. Both US and international government privatization comes from the same source and its advocates appear to treat both systems the same way - privatize all government functions even in the US. [2]

References:

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[2] Privatization A Systems Perspective, Walter Sobkiw, 2019, ISBN 9780983253068.
[Privatization A Systems Perspective](#)

[3] [National Governors Association](#), webpage <https://www.nga.org>, July 2020.

Key Requirements to Fix the Existing System

It is clear that the system is broken. The issue is does it need to be fixed in order to have a safe and effective Return to Life system.

1. The US industrial base needs to be immediately infused with massive capability and money to manufacture **billions** of test kits in the next 12 months to support multiple testing events of individuals over the next 2 - 3 years. That was written on April 5, 2020 when it was still possible to contain the virus. It is no longer enough. The virus has spread everywhere.
2. There needs to be a proper education program on social distancing and mask use with performance numbers provided to the people. As of November 2020 there have only been statements to practice social distancing and use masks but there have been no performance numbers provided to the people. The performance numbers are simple to present: 6 ft social distance reduces virus exposure by 36 times, 1 typical mask reduces virus exposure by 4 times, 2 masks by 16 times, social distance + 2 masks is 36 X 16 or 576 times. With the performance numbers the guidance cannot be politicized or negated by morally bankrupt stakeholders. The people can quickly use their common sense to determine their plight in different scenarios.
3. There needs to be an education program on various indoor versus proper outside venues with performance numbers provided to the people. This will clearly show why indoor systems need to be addressed. It will also show why people are getting infected. The venues include small indoor spaces, large indoor spaces, transportation systems and, various outside settings. In the absence of the proposed legislation provided by this analysis on July 3, 2020, this analysis provides these numbers for various venues.
4. As of November 2020 it is obvious that the virus can no longer be contained and now the following is needed to eradicate the virus: multiple vaccines, massive deployment of room based UV systems, massive upgrades of building HVAC systems, massive education programs on why room based UV systems and building HVAC upgrades are needed, and massive education programs on proper use of UV and HVAC systems. There needs to be an education program on room based UV and building HVAC performance numbers that are provided to the people. This information exists but it is buried in Government literature.
5. The manufacturing need includes test kits, vaccination delivery systems, ventilators, personal protection equipment, treatment drugs, UV systems, upgraded HVAC systems and everything else that is needed to address this grave citizen need.
6. The manufacturing challenge is an engineering problem and ineffective managers, narrow marketing, and irrelevant fast money people need to be pushed aside so that work can begin immediately. It cannot be solved with talking points, damage control, promoters, services, outsourcing, venture capital, sharks, or other techniques that are not associated directly with producing physical products on a massive scale. Extremely skilled and dedicated people with very high levels of character must rise and fast.

7. The Federal Government is the only entity that has access to the data to identify companies to retool to support the manufacturing of what is needed.
8. The Federal Government is the only entity that has the power to redirect and organize the industrial base to respond to this grave citizen need.
9. The citizens must hold the Federal Government accountable by letting them know in NO uncertain terms that the Federal Government must take responsibility and properly lead this effort immediately.
10. Everyone needs to work with existing people in positions of authority with access to government to communicate these key requirements.
11. The lobbyists and money machine in Washington D.C. will not go away so it must be shutdown by the people using new techniques.
12. The people must understand that social media is not effective in getting the Federal Government to change its policy of do nothing.
13. Relying on the magic hand of the market is not appropriate, there is no time and no room for error because all random missteps will lead to massive death.
14. There needs to be a massive physical mail campaign where millions of letters and postcards are set to Washington D.C. to demand that they step up and use citizen tax money and their resources locked in the Federal Government to redirect the US manufacturing industrial base to address this horrible disastrous and economically catastrophic pandemic. (see note 1)
15. It is clear that any Return to Life system needs to include a root cause analysis of how and why we got here so that the system can be corrected moving forward. (see note 2)

Note 1: It is understood that the mail is held up and not delivered to Congress and the President in a timely way. However when literally tons of mail is sitting in warehouses to be processed it sends a clear message. That is what happened with the Nixon impeachment. It sat in warehouses, the politicians and others were aware of it, and it made people in positions of power fearful of what can happen. Yes the mail was displayed on the nightly news for everyone to see. This is what happens with all citizen engagement that uses physical mail. It is the best metric that politicians understand and will respond to out of fear when it is clear that the citizens are very upset with their leadership. **There is no physical evidence with any electronic communications mechanisms. It is about the physical evidence, period.**

Note 2: It is clear that the system has collapsed and we are trying to recover it so that life can resume. The problem is we need to understand why it collapsed so that it can be modified to prevent this from continuing to get worse. It can get worse and we can find this civilization entering a dark age that may last for hundreds of years.

Root Cause Analysis

The COVID-19 pandemic is not a cause, it is a symptom.

Our system has been in serious trouble for decades. There were massive fissures in the system that were clearly visible. The COVID-19 disaster is a symptom not a cause.

There is no question that after 1945 the US led the world in dealing with massive crisis situations and the world became dependent on the US. Is it possible that because of the poor US response when COVID-19 first surfaced that the rest of the world was late to deal with this terrible event. Would it have been contained early if the US had a different attitude and policy towards threats like COVID-19. History will figure that out, but my guess is that it will be a very harsh accounting. Just like the states depended on the Federal Government to detect and marshal resources the world depended on the US to detect and alert the world to the threat.

1. It is clear that the Republican party has collapsed and is not meeting the needs of the people as they only respond to narrow sets of stakeholders with access while ignoring the largest and most important stakeholders, all the people everywhere, beginning in the US.
2. It is clear that the Democratic party has collapsed because they were there when the system was being modified to meet the needs of only narrow sets of stakeholders. They compromised with the Republicans to negotiate small elements for their narrow stakeholders with access rather than supporting the most important stakeholders, all the people everywhere, beginning in the US.
3. Both the Republicans and Democrats will not change and they will continue to only respond to their narrow interests unless the people get engaged in a meaningful way that is effective. (see note 1).
4. The USA is one of the rare nation states that has avoided a revolution. It has come close, but it did not happen. The reason was because of the separation of powers, the distributed form of government (fed, state, local), and a free and **effective press**. (see note 1)
5. Extremely skilled and dedicated people with very high levels of character have been pushed aside as the system erroneously shifted away from a production economy to a services and wealth management economy. (see note 2)

Note 1: Prior to any revolution there is usually physical evidence of extreme stakeholder damage. Tons of physical mail sitting in warehouses to be processed sends a clear message. During the Nixon impeachment it sat in warehouses, the politicians and others were aware of it, and it made people in positions of power fearful of what can happen. Yes the mail was displayed on the nightly news for everyone to see. This is what happens with all citizen engagement that uses physical mail. It is the best metric that politicians understand and will respond to out of fear when it is clear that the citizens are very upset with their leadership. There is no physical evidence with any electronic communications mechanisms. It is about the physical evidence, period.

Note 2: The people who think an economy is based on services and financial mechanisms of concentrating money as stakeholders must have their voices reduced in the system. The system stakeholders in the economy include all the stakeholders and they all must be at the table. The engineers have been pushed away from the table and are in the corner of the room hiding out in fear as they see the extremely stupid and morally bankrupt stakeholders destroy the system. This began circa 1987 with the rise of predatory capitalism that translated into corporate takeovers and the extraction of massive wealth from healthy and very viable companies.

Management Failure

Everyone that engages in systems development knows that humans are always the weakest link and the source of most system failures. So the systems are structured to deal with the human condition. As of August 2020 we see that most management in the US has ignored human behavior and structured systems that do not account for failures because of non-compliant human behavior. For example, not all people will wear masks, but more importantly people that will wear masks are unable to wear them 100% of the time. The analysis clearly shows that just 1 hour of not wearing a mask in a small indoor space with inadequate ventilation, such as during a meal or an 8 hour work shift will lead to infection. Management has failed to communicate the differences between small indoor spaces, large indoor spaces, and outside venues. Applying the same approach to these radically different settings is completely inappropriate and has caused the disaster to get worse.

It appears that most management has taken the approach of damage control and minimizing liability risks rather than solving the problem. Masks were issued, hand sanitizers were provide, plexiglass barriers were installed, and directives were sent to people of how they are to behave and check their symptoms when returning to work or school. As of August 2020 no institution, like a major university, has taken any action to update their facility ventilation systems or move activities outdoors prior to calling for students and workers to return. Only small businesses like restaurants, bars, hair dressers, and small retail shops have made these attempts with no help or guidance from the government or role models from universities or large companies. As of August 2020 there is no engineering paper analysis and or physical test and evaluations to see if plexiglass barriers provide any reduction in virus infection risk. However, they look good.

Organizations that are able to telecommute have chosen that path. The issue with this approach is that the root cause of the problem is not being sought and workable solutions are not being developed. This is a long term problem and not everyone can telecommute [1]. For example Google has 200,000 employees. This is a massive organization with massive capabilities. Instead of applying those resources to help address how people can return back to work including the small indoor spaces, they took the non-systems perspective approach and just addressed their narrow interests with the answer being we can telecommute so we will telecommute. It is not just Google, but Facebook and Microsoft have made similar decisions [2].

Major universities known for their engineering programs have ignored all the analysis associated with small indoor spaces. Instead they developed unworkable plans for students to return back to campus. As students started to return to schools across the country and COVID-19 infections started to take root some have decided to shut down in person classes for the Fall [3]. This wait and see attitude is not coming from the perspective of systems engineering managers or engineering managers. This is coming from managers that only maximize the benefits of a narrow set of stakeholders and engage in damage control when things go wrong.

This is a clear sign that the systems perspective has been removed from the culture and that we no longer have systems engineering managers or engineering managers. We have managers driven by narrow interests trying to maximize the outcomes of the narrow interests. Unless the pandemic subsides, the system that is our civilization will begin to self-correct [4] and that self-correction will be chaotic until stability is reestablished. That instability may be quick or long, easy or painful - but the natural system will self-correct.

Management in the US changed from what existed before 1980 to what exists today. Today management is lacking a systems perspective and this has led to disaster. Prior to 1980 there were many managers that had a systems perspective that they gained from formal education and or real world experience. Rebuilding after the disaster of the Great Depression and World War II led to a new way of management. This new way of management was fully demonstrated in the late 1960's when Walter Cronkite during a historic interview specifically asked President Johnson his thoughts on the new Management Techniques and Systems Engineering that were developed and how they might be applied broader to industry [5]. Having lived through that time I know that they were adopted and used across the spectrum of industry but then abandoned by the mid 1990's. This is coincident with the new generation of MBAs that started to enter into all the executive positions and eventually board rooms of the major corporations. Stories were written and movies were made about this massive movement and the resulting damage [6].

So what is the difference between the systems engineering or engineering management approach and the MBA management approach? The movies and stories in the last century tried to show the difference but the messages were ignored. Fundamentally the MBA management approach is compromised because it is unable to see the broader picture. It connects all systems success with financial success as the only systems metric that matters. The financial metrics will look great but when the system performs badly for the stakeholders that must use the system, damage control is used to hide the bad system performance. Some of the differences between the vastly different management approaches are humbly offered as follows.

Compromised Management Organization [6]:

1. Management always has the power of final say regardless of the science, engineering, findings, and tradeoffs
2. Decisions are made by management driven only by self interest
3. Decisions are hidden and can include any agenda including those that devastate the solution that will work
4. Always rejects the systems perspective because it gets in the way
5. Empowerment of the individual is removed
6. Reject all requests to facilitate and coordinate (because it requires work and may lead to an undesired effect)
7. Reject all requests to engage with all reasonable stakeholders
8. Reject root cause analysis requests and findings
9. Reject the identification of problems
10. All messengers outside the party line are silenced or fired (you better be a team player)
11. Reject solutions unless they have clear self-interest benefits
12. Stop the free flow of information
13. Do not care about even the appearance of a conflict of interest
14. Engage in micro management to spy on individuals that might not follow the party line
15. Polarize and divide to maintain control and push a toxic hidden agenda
16. Engage in damage control to hide poor decisions
17. Lie and Bullshit [7]
18. Delay, distract, and deflect
19. Use non-disclosure agreements to hide liability judgments and criminal activity

Systems Engineering Management Organization [8]:

1. Do the opposite of the compromised management organization
2. Concentrate on whole system as distinct from the parts
3. Look at the problem in its entirety
4. Take into account all the facets and all the variables
5. Relate the social to the technical aspect
6. See section [Systems Perspective](#)

This is a critical time in history for the US. There are University level systems engineering and engineering management programs across the US. It is important that these people are not targeted and their careers not sidelined as we move into this very unstable future. What took generations (1980 to 2020) to develop will take years to correct.

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[2] Big Tech was first to send workers home. Now it's in no rush to bring them back, Washington Post, May 18, 2020. webpage <https://www.washingtonpost.com/technology/2020/05/18/facebook-google-work-from-home>, August 2020. [Big Tech was first to send workers home. Now it's in no rush to bring them back](#)

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Industrial Base Failure

The following is a scenario of how this massive disaster would have been approached circa 1981 at Hughes Aircraft. Hughes was owned 100% by the Howard Hughes Medical Institute. It was organized and run like an institute with systems engineering as the core for solving problems. They addressed all problems except for those related to health because they did not want the appearance of a conflict of interest. Hughes was part of a short list of systems engineering companies. I was once told by someone from Martin Marietta that at the time there were only 6 systems engineering companies and Hughes was number 1 on that list.

Based on my experience on a program very similar to this challenge, this is what would have happened. It is offered as guidance for this new generation who I firmly believe don't know what to do after decades of extreme self-interest and the total removal from the culture of the systems perspective and its approach to solving grave complex problems.

In November 2019 US intelligence reported that something serious was happening in China. The intelligence was in the form of communications intercepts and overhead images showing increased activity at health facilities. The intelligence was distributed to some federal public health officials in the form of a situation report in late November 2019. Current and former officials say there was no formal assessment in November 2019 but that there was raw intelligence data that was part of formal assessments in December 2019 [1]. In late December, doctors in Wuhan were puzzled by many pneumonia cases of unknown cause. On December 30, 2019 the Wuhan CDC sent out an internal memo to all Wuhan hospitals to be alerted and started an investigation into the exact cause of the pneumonia. So here is what would have happened at Hughes circa 1981:

- November 2019, Some staff at Hughes would have been aware of the intelligence data. They would have alerted the company to prepare for something significant.
- December 2019, a small systems team would have formally formed from the informal team that started in November 2019. The team would be about 10 systems engineers where one would be the technical director. There might be a shared program manager. They would have already started informal analysis.
- December 2019, the systems team would have started the formal analysis on topics similar to what is found in this analysis.
- January 2020, the small systems team would have been augmented with perhaps 50 others representing different specialty areas. In 2 months they would have produced all the findings in this report plus more than this lone system engineer produced between March 2020 and January 2021 - 11 months.
- February 2020, I would have been flying to China to examine UV production facilities and to Washington DC with the systems team to brief our total systems findings. I also would be providing analysis similar to this analysis. My focus would eventually be Architecture. I would be part of a small team of perhaps 3 systems architects.
- March 2020, Hughes would have started to coordinate with the industrial base to develop strategies to roll out upgraded HVAC systems and UV systems. The Hughes ILS organization that included facilities experts would be working with the systems team that now might number between 50-75 systems engineers. The project team might now number 200 people.
- September 2020, Hughes would have perhaps 1500 people on the project team. There would be new HVAC standards for roll out to the country and all schools would have been upgraded with appropriate HVAC and UV systems. The reason this would happen is

because there would be massive analysis and data to support this policy coming from the most qualified organizations in the US with Hughes driving the systems perspective.

- September 2020, the undisputed solid findings from the respected Hughes organization and a functioning US Federal Government would have rolled out proper airplane and airport guidance along with appropriate UV and HVAC systems so that the expected Holiday Travel would not lead to disaster.

The above scenario represents what should have been. It is based on capabilities that no longer exist in the US. The challenge now is to recognize the massive loss of capabilities, recover, and then properly and effectively perform in 2021. I am not sure how to do that without entities like Hughes Aircraft and the collection of companies that previously solved massive problems using systems practices based on engineering, science, and the arts. It took decades and thousands of people to develop those cultures. The closest entity is MITRE, but MITRE does not implement. This requires entities like MITRE working with MITRE and others but also knows how to implement and get infrastructure into the society. The Pharmaceutical companies only know how to produce medicine and this is not just a medicine problem.

Just so I am clear - none of the new privatized services companies can do this, they have no capability other than bodies. None of the product based companies can do this. Their focus is protecting their business product base. None of the aerospace companies can do this because once again they are driven by protecting their markets and products. The new Internet companies, obviously no.

I am trying to avoid mentioning names in this dialog but in this case I have no choice but to mention a name - Disney. Disney might actually be able to rise to the occasion to work with the Federal Government to address this problem. Their business closely aligns with what needs to happen - upgraded facilities, safe air travel, and a healthy happy population. Because they are so good at what they do, they are no foreigner to technology and perhaps even the systems perspective.

Who would have thought we would be at this point and that we would call on our beloved Mickey Mouse for help. This is not meant to be disrespectful. To the contrary it is at extreme respect for the massive losses that this out of the box suggestion is offered. The status quo failed.

References:

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Second Wave Accountability

It is clear as of December 12, 2020 that there is a massive second wave in the US. We have the science and engineering that could have avoided this second wave. Instead those in positions of authority made the wrong choices. It is time for accountability to be documented.

🚩 President of the United States: Management has attempted to push the problem to the people that refused to wear masks and engage in social distancing. However, they are victims of

propaganda and disinformation. The President of the United States and Republican elements of the US political establishment are clearly at fault, not the victims of their talking points that embodied propaganda and disinformation.

▼ The Federal Aviation Administration: The FAA should have enacted emergency regulations to limit the assigned seating in all airplanes. Having people sit shoulder to shoulder on a flight was a severe act of disregard for human life. The seating should have followed the guidance of 6 or more feet. Further the DHS passenger screening should have been changed to pre-2001 levels to allow for social distancing in airports. The massive spike as a result of the Thanksgiving Holiday is a direct result of this grave negligent inaction.

▼ Airline Company Executives: The airline company executives should have voluntarily done what the FAA refused to force them to do. Their morally bankrupt leadership and actions has led to death and massive disruption in the US. Aside from the deaths they are responsible for causing massive indirect costs to be forced on the society totaling in the trillions of dollars. When the virus first surfaced their inaction could have been excused because of disinformation and propaganda that the virus was not airborne. By the Thanksgiving Holiday it was accepted everywhere that the virus was airborne and that the information was suppressed by a compromised US Federal Government.

▼ School Boards and Local Government: By the start of the school year it was clearly known that the virus was airborne. Rather than upgrade their facilities with UV and upgraded HVAC systems to match what is found in elite settings they did nothing except open the school doors and provide relatively useless non airborne guidance to children unable to follow the guidance. Regardless of the management talking points that there have been few infections in the schools, those infections did come home to spread across the other members in the home and to the community. At this point the entire system is suspect and it is unclear if the virus tracing is being properly performed and reported. [1] [2]

▼ Bars, Restaurants, Small Retail Shops: Although the small space establishments such as bars, restaurants and small retail shops did not take action to fix their unsafe facilities, they did not contribute to the massive spike associated with Thanksgiving Holiday Travel. In many ways they are also victims of the US Government. Massive funding and UV / HVAC guidance should have been provided to these establishments to properly upgrade their facilities.

People have died and whole economies and cultures have been disrupted and devastated. It is unclear what will happen after the COVID-19 World War is over. As of December 2020 there is massive political pressure from the Republicans to remove COVID-19 civil liability law suits. This may be the least of the problems for those that have caused great grave harm. After each war there are war criminals charged with Crimes Against Humanity.

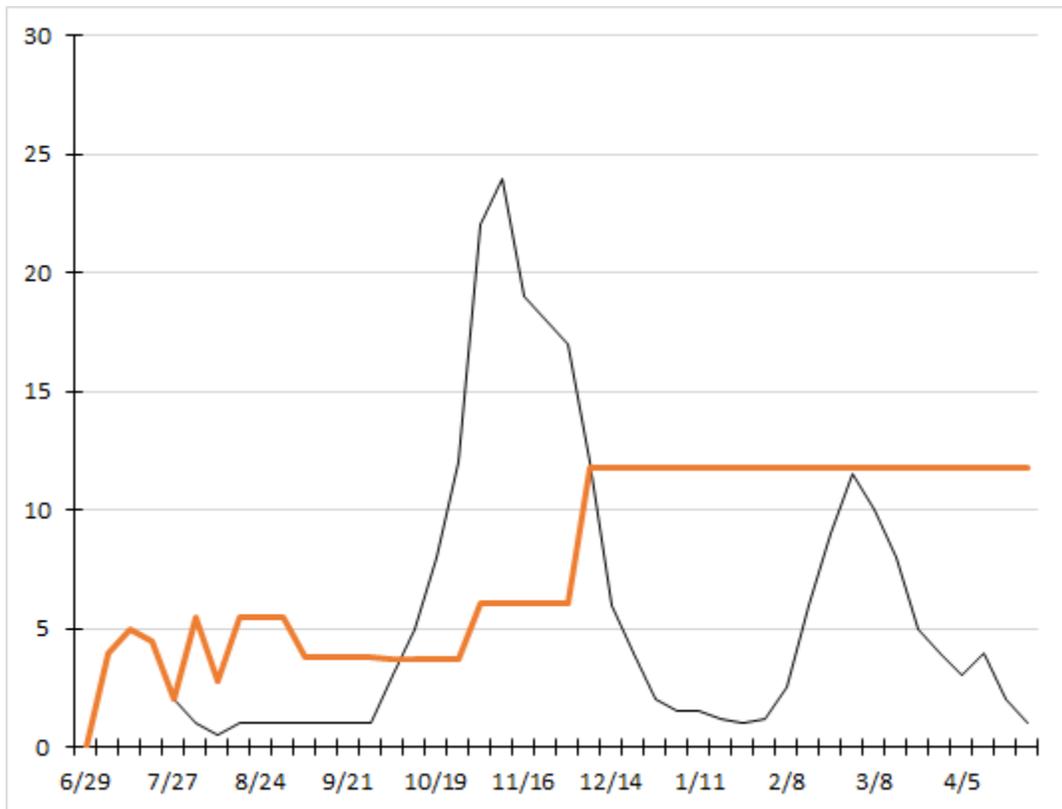


Figure 55 - Second Wave Accountability

Stability ignored, massive political pressure to open in October 2020.
 Some schools opened physical classes that started later than normal in 2020 !!!
 Thanksgiving Holiday travel via airplanes and airports 2020 !!!
 Based on Data up to December 10, 2020

The roots of the response go back to the start of the new administration under President Trump and the Republican controlled Senate:

🚩 May 2018: The Administration disbands the White House pandemic response team. On March 19, 2020, former Vice President and Democratic presidential candidate Joe Biden called the changes elimination. He tweeted: “The Obama-Biden Administration set up the White House National Security Council Directorate for Global Health Security and Biodefense to prepare for future pandemics like COVID-19. Donald Trump eliminated it - and now we're paying the price.” [4]

🚩 July 2019: The Centers for Disease Control (CDC) epidemiologist embedded in China's disease control agency left her post, and the Administration decided to eliminate the role. [5]

🚩 October 2019: The Crimson Contagion exercise concluded that there are insufficient federal government funds to use in response to a severe influenza pandemic. [6]

The handling of the news that the Trump Administration disbanded the White House pandemic response team is a classic example of damage control using disinformation to deflect from the obvious. The focused team was eliminated, period. The remaining staff was dispersed into lower

level organizations with less direct access to the White House. This loss of visibility was critical and there is a reason why the Obama-Biden Administration thought that this visibility was critical.

Once the COVID-19 disaster started this is the response that was provided at various points in time leading up to the second wave. The quotes are from President Trump.

1. January 22: "We have it totally under control. It's one person coming in from China. It's going to be just fine."
2. January 24: Trump praises China's handling of the coronavirus: "China has been working very hard to contain the Coronavirus. The United States greatly appreciates their efforts and transparency. It will all work out well. In particular, on behalf of the American People, I want to thank President Xi!"
3. January 28: "This will be the biggest national security threat you face in your presidency...This is going to be the roughest thing you face" Trump's National Security Advisor to Trump
4. January 30: "The lack of immune protection or an existing cure or vaccine would leave Americans defenseless in the case of a full-blown coronavirus outbreak on US soil,...This lack of protection elevates the risk of the coronavirus evolving into a full-blown pandemic, imperiling the lives of millions of Americans." [Memo from Trump Trade Advisor Peter Navarro]
5. February 2: "We pretty much shut it down coming in from China."
6. February 7: "It's also more deadly than even your strenuous flu... This is deadly stuff" [Trump in a private taped interview with Bob Woodward, made public September 9]
7. February 10: "I think the virus is going to be - it's going to be fine." "Looks like by April, you know in theory when it gets a little warmer, it miraculously goes away."
8. February 24: "The Coronavirus is very much under control in the USA... Stock Market starting to look very good to me!"
9. February 25: "CDC and my Administration are doing a GREAT job of handling Coronavirus."
10. February 25: "I think that's a problem that's going to go away... They have studied it. They know very much. In fact, we're very close to a vaccine."
11. February 26: "The 15 (cases in the US) within a couple of days is going to be down to close to zero." ... "We're going very substantially down, not up." ... "Well, we're testing everybody that we need to test. And we're finding very little problem. Very little problem." ... "This is a flu. This is like a flu."
12. February 27: "It's going to disappear. One day, it's like a miracle, it will disappear."
13. February 28: "We're ordering a lot of supplies. We're ordering a lot of, uh, elements that frankly we wouldn't be ordering unless it was something like this. But we're ordering a lot of different elements of medical."
14. March 2: "You take a solid flu vaccine, you don't think that could have an impact, or much of an impact, on corona?" ... "A lot of things are happening, a lot of very exciting things are happening and they're happening very rapidly."
15. March 4: "Now, and this is just my hunch, and - but based on a lot of conversations with a lot of people that do this. Because a lot people will have this and it's very mild." ... "If we have thousands or hundreds of thousands of people that get better just by, you know, sitting around and even going to work - some of them go to work, but they get better."

16. March 5: "I NEVER said people that are feeling sick should go to work." ... "The United States... has, as of now, only 129 cases... and 11 deaths. We are working very hard to keep these numbers as low as possible!"
17. March 6: "I think we're doing a really good job in this country at keeping it down... a tremendous job at keeping it down." ... "You have to be calm. It'll go away." ... "Anybody right now, and yesterday, anybody that needs a test gets a test. They're there. And the tests are beautiful... the tests are all perfect like the letter was perfect. The transcription was perfect. Right? This was not as perfect as that but pretty good." ... "I like this stuff. I really get it. People are surprised that I understand it... Every one of these doctors said, 'How do you know so much about this?' Maybe I have a natural ability. Maybe I should have done that instead of running for president." ... "I don't need to have the numbers double because of one ship that wasn't our fault."
18. March 7: "When we get into April, in the warmer weather-that has a very negative effect on that, and that type of a virus." ... "No, I'm not concerned at all.
19. March 8: "We have a perfectly coordinated and fine-tuned plan at the White House for our attack on CoronaVirus."
20. March 9: During a news conference, White House officials say the U.S. will have tested one million people that week and thereafter would complete 4 million tests per week. By the end of the week, the CDC had only completed a paltry 4,000 tests. ... "This blindsided the world."
21. March 10: "Just stay calm. It will go away."
22. March 11: "It goes away....It's going away. We want it to go away with very, very few deaths."
23. March 12: Dr. Anthony Fauci, director of the National Institute of Allergy and Infectious Diseases, tells Congress that the country does not have sufficient testing. "The system is not really geared to what we need right now," he said. "That is a failing. Let's admit it." ... "You know, you see what's going on. And so I just wanted that to stop as it pertains to the United States. And that's what we've done. We've stopped it."
24. March 13: "I don't take responsibility at all." ... The Atlantic reported that less than 14,000 tests had been done in the ten weeks since the administration had first been notified of the virus, though Mike Pence had promised the week prior that 1.5 million tests would be available by this time.
25. March 14: "I'd rate it a ten," [Trump's rating of his coronavirus response]
26. March 15: "Relax" ... "This is a very contagious virus. It's incredible. But it's something that we have tremendous control over."
27. March 16: "Respirators, ventilators, all of the equipment - try getting it yourselves,"
28. March 17: "The only thing we haven't done well is get good press." ... "I felt like it was a pandemic long before it was called a pandemic."
29. March 19: I intended "to always play it down." [Trump in a private taped interview with Bob Woodward, made public September 9]
30. March 20: "I say that you're a terrible reporter, that's what I say. I think it's a very nasty question, and I think it's a very bad signal that you're putting out to the American people." [Response to reporter's question: "What do you say to Americans who are watching you right now who are scared?"]
31. March 22: "WE CANNOT LET THE CURE BE WORSE THAN THE PROBLEM ITSELF."
32. March 24: "I'm also hopeful to have Americans working again by that Easter - that beautiful Easter day." ... "We've never closed down the country for the flu," Trump said.

- "So you say to yourself, what is this all about?" ... "They have to treat us well, also. They can't say, 'Oh, gee, we should get this, we should get that.'"
33. March 25 : "The faster we go back, the better it's going to be."
 34. March 26: "Congratulations AMERICA!" [On Senate passage of third relief bill] ... "I don't believe you need 40,000 or 30,000 ventilators. You go into major hospitals sometimes, and they'll have two ventilators. And now all of a sudden they're saying, 'Can we order 30,000 ventilators?'" ... "We've had a big problem with the young, a woman governor from - you know who I'm talking about - from Michigan,"
 35. March 27: "I love Michigan, one of the reasons we are doing such a GREAT job for them during this horrible Pandemic. Yet your Governor, Gretchen "Half" Whitmer is way in over her head, she doesn't have a clue. Likes blaming everyone for her own ineptitude!" ... "Mike, don't call the governor of Washington. You're wasting your time with him..." ... "I want them to be appreciative. We've done a great job." ... "We're doing a great job for the state of Washington and I think the Governor...he's constantly chirping and I guess complaining would be a nice way of saying it."
 36. March 29: "Where are the masks going? Are they going out the back door? How do you go from 10,000 to 300,000?" ... "Unfortunately the enemy is death. It's death. A lot of people are dying. So it's very unpleasant."
 37. March 30: "Stay calm, it will go away. You know it -- you know it is going away, and it will go away, and we're going to have a great victory." ... "I think New York should be fine, based on the numbers that we see, they should have more than enough. I mean, I'm hearing stories that they're not used or they're not used right." ... "I haven't heard about testing in weeks. We're testing more than any other nation in the world. We've got these great tests...But I haven't heard about testing being a problem." ... "We inherited a broken test - the whole thing was broken."
 38. March 31: "...it's not the flu. It's vicious."
 39. April 1: "They have to treat us well, also. They can't say, 'Oh, gee, we should get this, we should get that.'"
 40. April 2: "Massive amounts of medical supplies... are being delivered directly to states...Some have insatiable appetites & are never satisfied (politics?). The complainers should have been stocked up and ready long before this crisis hit." ... "...the Federal Government is merely a back-up for state governments."
 41. April 3: "I'm feeling good. I just don't want to be doing -- somehow sitting in the Oval Office behind that beautiful resolute desk, the great resolute desk, I think wearing a face mask as I greet presidents, prime ministers, dictators, kings, queens, I don't know, somehow I don't see it for myself. I just don't. Maybe I'll change my mind."
 42. April 5: "FEMA, the military - what they've done is a miracle...And you should be thanking them for what they've done, not always asking wise-guy questions."
 43. April 6: "LIGHT AT THE END OF THE TUNNEL!" ... U.S. death toll passes 10,000
 44. April 7: "So, you know, things are happening. It's a -- it's -- I haven't seen bad. I've not seen bad." ... "You are not going to die from this pill...I really think it's a great thing to try." ... "That was a flu. OK. So you could say that I said it was a flu, or you could say the flu is nothing to -- sneeze at," [Regarding Spanish Flu]
 45. April 8: "I read about it maybe a day, two days ago,...It was a recommendation that he had, I think he told certain people on the staff, but it didn't matter. I didn't see it." [Regarding Peter Navarro's January warning]
 46. April 9: "I couldn't have done it any better," [When asked if his coronavirus response could have been better]
 47. April 11: U.S. death toll passes 20,000

48. April 13: "But I guess I'm doing OK, because, to the best of my knowledge, I'm the President of the United States, despite the things that are said."
49. April 14: "Enough!" [When a reporter questioned his claim that his authority as president is "total"] ... "[w]hen somebody's the president of the United States, the authority is total."
50. April 15: U.S. death toll passes 30,000 ... As Trump focuses on reopening, a leaked CDC and FEMA report warns of "significant risk of resurgence of the virus" with phased reopening.
51. April 19: "Now we're going toward 50, I'm hearing, or 60,000 people [dead from the coronavirus]"
52. April 22: "If [coronavirus] comes back though, it won't be coming back in the form that it was, it will be coming back in smaller doses that we can contain....it's also possible it doesn't come back at all."
53. April 23: "I see the disinfectant that knocks it out in a minute, one minute. And is there a way we can do something like that by injection inside or almost a cleaning? As you see, it gets in the lungs, it does a tremendous number on the lungs, so it would be interesting to check that." ... "So, supposing we hit the body with a tremendous, whether its ultraviolet or just very powerful light, and I think you said, that hasn't been checked but you're gonna test it. And then I said, supposing it brought the light inside the body, which you can either do either through the skin or some other way..." ... "You see states are starting to open up now, and it's very exciting to see," ... 26 million jobless claims
54. April 24: U.S. death toll passes 50,000
55. April 26: "The people that know me and know the history of our Country say that I am the hardest working President in history."
56. April 27: "I can't imagine why," [Regarding influx in poison control calls about disinfectant]
57. April 29: "It's gonna go away, this is going to go away."
58. May 3: "Look, we're going to lose anywhere from 75,000, 80,000 to 100,000 people,"
59. May 5: U.S. death toll passes 70,000 ... Consumer debt hits an all-time high ... "Well run States should not be bailing out poorly run States, using CoronaVirus as the excuse!" ... "I always felt 60, 65, 70, as horrible as that is. I mean, you're talking about filling up Yankee Stadium with death! So I thought it was horrible. But it's probably going to be somewhat higher than that," ... "There'll be more death, that the virus will pass, with or without a vaccine. And I think we're doing very well on the vaccines but, with or without a vaccine, it's going to pass, and we're going to be back to normal," ... "I don't want to be Mr. Gloom-and-Doom. It's a very bad subject,...I'm not looking to tell the American people when nobody really knows what's happening yet, 'Oh, this is going to be so tragic.'"
60. May 6: Brookings reports that children were "experiencing food insecurity to an extent unprecedented in modern times" and "40.9 percent of mothers with children ages 12 and under reported household food insecurity since the onset of the COVID-19 pandemic." Republicans block proposals to expand food stamps. ... "Sporadic for you, but not sporadic for a lot of other people." [In response to a nurse telling him that equipment supply has been "sporadic"]
61. May 7: 33 million jobless claims
62. May 8: "This is going to go away without a vaccine. It is going to go away. We are not going to see it again."
63. May 9: "This is going to go away without a vaccine."

64. May 11: "Coronavirus numbers are looking MUCH better, going down almost everywhere. Big progress being made!" ... "We have met the moment and we have prevailed,"
65. May 14: "Could be that testing's, frankly, overrated. Maybe it is overrated."
66. May 14: "Don't forget, we have more cases than anybody in the world. But why? Because we do more testing,"
67. May 15: "Vaccine or no vaccine, we're back. And we're starting the process. In many cases, they don't have vaccines and a virus or a flu comes and you fight through it.
68. May 16: "We've done a GREAT job on Covid response, making all Governors look good, some fantastic (and that's OK), but the Lamestream Media doesn't want to go with that narrative, and the Do Nothing Dems talking point is to say only bad about "Trump". I made everybody look good, but me!"
69. May 18: U.S. death toll passes 90,000
70. May 19: "When we have a lot of cases, I don't look at that as a bad thing, I look at that as, in a certain respect, as being a good thing,...Because it means our testing is much better. I view it as a badge of honor, really, it's a badge of honor."
71. May 21: USA Today reports that mortgage delinquencies surged by 1.6 million in April, the largest single-month jump in history.
72. May 22: 38 million jobless claims
73. May 27: U.S. death toll passes 100,000
74. May 29: "We will be today terminating our relationship with the World Health Organization"
75. June 6: U.S death toll passes 110,000 ... "Hopefully George is looking down right now and saying this is a great thing that's happening for our country...This is a great day for him. It's a great day for everybody. This is a great day for everybody. This is a great, great day in terms of equality."
76. June 15: "At some point this stuff goes away and it's going away."
77. June 17: "It's fading away. It's going to fade away."
78. June 18: "And it is dying out. The numbers are starting to get very good."
79. June 20: "Testing is a double-edged sword,...When you do testing to that extent, you're going to find more people, you're going to find more cases, so I said to my people, 'Slow the testing down, please.'"
80. June 22: U.S death toll passes 120,000
81. June 23: "Cases are going up in the U.S. because we are testing far more than any other country, and ever expanding. With smaller testing we would show fewer cases!" ... "It's going away,"
82. June 25: "The number of ChinaVirus cases goes up, because of GREAT TESTING, while the number of deaths (mortality rate), goes way down. The Fake News doesn't like telling you that!" ... "Coronavirus deaths are way down. Mortality rate is one of the lowest in the World. Our Economy is roaring back and will NOT be shut down. "Embers" or flare ups will be put out, as necessary!"
83. June 30: U.S. has just 4% of the global population, but 25% of global coronavirus cases and the second highest death rate per capita.
84. July 1: "I think we're going to be very good with the coronavirus." "I think that, at some point, that's going to sort of disappear, I hope."
85. July 6: U.S. death toll passes 130,000
86. July 7: "I think we are in a good place." ... The president predicted that in the next two to four weeks, "I think we're going to be in very good shape."

87. July 8: "In Germany, Denmark, Norway, Sweden, and many other countries, SCHOOLS ARE OPEN WITH NO PROBLEMS. The Dems think it would be bad for them politically if U.S. schools open before the November election, but it is important for the children & families. May cut off funding if not open!" ... "I disagree with @CDCgov on their very tough & expensive guidelines for opening schools. While they want them open, they are asking school [sic] to do very impractical things. I will be meeting with them!!!"
88. July 18: U.S. death toll passes 140,000
89. July 19: "I think we have one of the lowest mortality rates in the world" ... "Many of those cases are young people that would heal in a day" ... "They have the sniffles, and we put it down as a test"
90. July 21: "You will never hear this on the Fake News concerning the China Virus, but by comparison to most other countries, who are suffering greatly, we are doing very well - and we have done things that few other countries could have done!"
91. July 27: "America will develop a vaccine very soon, and we will defeat the virus. We will have it delivered in record time."
92. July 28: U.S. death toll passes 150,000 ... "He's got this high approval rating. So why don't I have a high approval rating with respect -- and the administration -- with respect to the virus?" (Trump referring to Anthony Fauci)
93. August 1: "Wrong! We have more cases because we have tested far more than any other country, 60,000,000. If we tested less, there would be less cases," (Donald Trump in a retweet of Anthony Fauci saying the U.S. has seen more cases than European countries because it only shut down a fraction of its economy amid the pandemic)
94. August 3: "I think we are doing very well and I think ... as well as any nation," ... "They are dying. That's true. And you - it is what it is." ... "OPEN THE SCHOOLS!!!" ... "Right now I think it's under control." ... "You know, there are those that say you can test too much, you do know that."
95. August 4: "...we have among the lowest numbers." - White House Press Briefing
96. August 5: "If you look at children, children are almost - and I would almost say definitely - but almost immune from this disease." ... "We're supplying the world now with ventilators. You go back four months, we didn't have any" - Fox and Friends ... "It will go away like things go away"
97. August 6: U.S. death toll passes 160,000
98. August 12: U.S. reports highest number of COVID-19 deaths in one day since mid-May
99. August 16: U.S. death toll passes 170,000
100. August 22: "Many doctors and studies disagree with this!" (Donald Trump in a quote tweet of a Twitter moment stating that the FDA is revoking hydroxychloroquine and chloroquine for COVID-19 treatment, as they are "unlikely to be effective") ... "The deep state, or whoever, over at the FDA is making it very difficult for drug companies to get people in order to test the vaccines and therapeutics. Obviously, they are hoping to delay the answer until after November 3rd. Must focus on speed, and saving lives!"
101. August 23: The President claims that ballot drop boxes are a "voter security disaster" and a "big fraud," "possible for a person to vote multiple times" and that they aren't "Covid sanitized."
102. August 26: U.S. death toll passes 180,000
103. August 31: "We've done a great job in Covid but we don't get the credit." ... Six million Americans have now been infected by the coronavirus.
104. September 4: There will be a vaccine "before the end of the year and maybe even before Nov. 1. I think we can probably have it sometime in October."
105. September 9: U.S. death toll passes 190,000

106. September 10: "I really do believe that we are rounding the corner. The vaccines are right there" ... "This is nobody's fault but China." ... "We've possibly done the best job" ... "We have rounded the final turn" ... "I think that we've probably done the best job of any country"
107. September 14: Trump, was asked if he is afraid of Coronavirus risk at his rallies: "I'm on a stage, it's very far away, so I'm not at all concerned."
108. September 16: "If you take the blue states out, we're at a level I don't think anybody in the world would be at." ... Reporter: "[The head of the CDC] said that the vaccine for the general public wouldn't be available until next Summer or maybe even early fall. Are you comfortable with that timeline?" Trump: "I think he made a mistake when he said that. That's just incorrect information."
109. September 19: U.S. death toll passes 200,000
110. September 21: "Take your hat off to the young because they have a hell of an immune system. But [the virus] affects virtually nobody. It's an amazing thing. By the way, open your schools everybody, open your schools." ... "We're rounding the corner," "With or without a vaccine. They hate when I say that but that's the way it is. ... We've done a phenomenal job. Not just a good job, a phenomenal job. Other than public relations, but that's because I have fake news. On public relations, I give myself a D. On the job itself, we take an A+." ... "In some states, thousands of people - nobody young. Below the age of 18, like, nobody. They have a strong immune system, who knows? Take your hat off to the young, because they have a hell of an immune system. But it affects virtually nobody. It's an amazing thing."
111. September 23: "I think we're rounding the turn very much."
112. September 28: "And I say, and I'll say it all the time: We're rounding the corner. And, very importantly, vaccines are coming, but we're rounding the corner regardless. But vaccines are coming, and they're coming fast. "
113. September 29: "Well, so far we have had no problem whatsoever. " (referring to crowds of thousands at rallies) "I don't wear a mask like him. Every time you see him, he's got a mask. He could be speaking 200 feet away from him and he shows up with the biggest mask I've ever seen."
114. October 2: Trump and First Lady test positive for Coronavirus. Also, more than a dozen White House staff and aides tested positive.
115. October 5: U.S. death toll passes 210,000 ... "Don't be afraid of Covid."
116. October 6: "Many people every year, sometimes over 100,000, and despite the Vaccine, die from the Flu, Are we going to close down our Country? No, we have learned to live with it, just like we are learning to live with Covid, in most populations far less lethal!!!" - Trump post, taken down by Facebook and Twitter
117. October 10: "But it's going to disappear; it is disappearing."
118. October 11: "...We have done a "phenomenal" job, according to certain governors. Many people agree...And now come the Vaccines & Cures, long ahead of projections!"
119. October 12: "Under my leadership, we're delivering a safe vaccine and a rapid recovery like nobody can even believe. And if you look at our upward path, no country in the world has recovered the way we've recovered economically or otherwise, not even close."
120. October 12: "I went through it. Now, they say I'm immune. I can feel - I feel so powerful." ... "When this first came out, if we didn't do a good job, they predicted 2.2 million people would die, we're 210,000. We shouldn't be at, one, it's China's fault. They allowed this to happen."

121. October 15: "Excess mortality, we're a winner on the excess mortality. And what we've done has been amazing. And we have done an amazing job. And it's rounding the corner and we have the vaccines coming, and we have the therapies coming."
122. October 18: [On Biden] "He'll listen to the scientists... If I listened totally to the scientists, we would right now have a country that would be in a massive depression instead - we're like a rocket ship. Take a look at the numbers."
123. October 19: U.S. death toll passes 220,000 ... "People are saying whatever. Just leave us alone. They're tired of it. People are tired of hearing Fauci and all these idiots...Fauci is a nice guy. He's been here for 500 years." ... "They are getting tired of the pandemic, aren't they? You turn on CNN, that's all they cover. 'Covid, Covid, Pandemic, Covid, Covid.' You know why? They're trying to talk everybody out of voting. People aren't buying it, CNN, you dumb bastards."
124. October 20: Politico reports that The White House is considering slashing millions of dollars for coronavirus relief, HIV treatment, screenings for newborns and other programs in Democratic led cities that President Donald Trump has deemed "anarchist jurisdictions."
125. October 22: "We are rounding the turn (on coronavirus). We are rounding the corner."
126. October 24: "Turn on television: 'covid, covid, covid, covid, covid.' A plane goes down, 500 people dead, they don't talk about it - 'covid, covid, covid, covid,' "By the way, on November 4th, you won't hear about it anymore."
127. October 26: "Cases up because we TEST, TEST, TEST. A Fake News Media Conspiracy. Many young people who heal very fast. 99.9%. Corrupt Media conspiracy at all time high. On November 4th., topic will totally change. VOTE!" ... "We have made tremendous progress with the China Virus, but the Fake News refuses to talk about it this close to the Election. COVID, COVID, COVID is being used by them, in total coordination, in order to change our great early election numbers. Should be an election law violation!"
128. October 27: "So they brought it down now, immunity, from life to four months. And you know now with them, you can't watch anything else. You turn on... COVID, COVID, COVID, COVID, COVID, COVID, COVID, COVID, COVID, COVID. Well, we have a spike in cases. You ever notice, they don't use the word death. They use the word cases, cases. Like, "Barron Trump is a case." He has sniffles. He was sniffing. One Kleenex, that's all he needed. One, and he was better. But he's a case" ... "November 4th. On November 4th, you'll hear, "It's getting better. It's getting better." You watch. No, no, they're doing heavy COVID because they want to scare people, and people get it."
129. October 28: "Covid, Covid, Covid is the unified chant of the Fake News Lamestream Media. They will talk about nothing else until November 4th., when the Election will be (hopefully!) over. Then the talk will be how low the death rate is, plenty of hospital rooms, & many tests of young people."
130. October 30: "More Testing equals more Cases. We have best testing. Deaths WAY DOWN. Hospitals have great additional capacity! Doing much better than Europe. Therapeutics working!" ... Nine million Americans have now been infected by the coronavirus. ... "Our doctors get more money if someone dies from Covid," and so "when in doubt choose Covid."
131. November 1: U.S. death toll passes 230,000 ... "Biden wants to LOCKDOWN our Country, maybe for years. Crazy! There will be NO LOCKDOWNS. The great American Comeback is underway!!!"

132. November 2: "Joe Biden is promising to delay the vaccine and turn America into a prison state-locking you in your home while letting far-left rioters roam free. The Biden Lockdown will mean no school, no graduations, no weddings, no Thanksgiving, no Christmas, no Fourth of July" ... "We have more Cases because we have more Testing!"
133. November 9: "If Joe Biden were President, you wouldn't have the Vaccine for another four years, nor would the @US_FDA have ever approved it so quickly. The bureaucracy would have destroyed millions of lives"
134. November 10: U.S. death toll passes 240,000
135. November 11: U.S. hits record 140,000 COVID-19 cases per day ... Texas hits 1 million COVID-19 cases
136. November 18: U.S. death toll passes 250,000
137. November 24: U.S. death toll passes 260,000
138. December 2: U.S. death toll passes 270,000
139. December 7: U.S. death toll passes 280,000
140. December 9: 3,103 U.S. COVID-19 deaths in one day
141. December 10: U.S. death toll passes 290,000

Notice there is no policy to solve the problem. The only policy offered was to re-open and ignore the virus. Also there was no money allocated to solve the problem. Placing orders for a vaccine is not a policy [7]. The only money allocated was to continue with the current economy. There was no attempt to redirect resources to try and solve the problem. This is classic hands off government associated with deregulation and privatization that started circa 1980 and it has hit a new massive grave catastrophic failure in 2020.

It is unclear what will follow next in 2021.

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US Insurrection 2021

On January 6, 2021 Congress met to certify the Presidential election results and declare Vice President Biden the new President of the United States while President Trump held a simultaneous rally. President Trump spoke to the crowds at the rally and falsely claimed he had won the election [1].

- For most of the hour, he claimed that the election had been stolen, the claims were rejected as unfounded by 59 courts, including many headed by Trump-appointed judges
- Repeatedly intimated that his followers should take action
- Made what appeared to be an indirect threat to Vice President Mike Pence, who, Trump incorrectly told his supporters, had the power to overturn the Nov. 3 election results
- As the speech continued, Trump called for direct action by his supporters:
 - “We will never give up; we will never concede”
 - “We’re going to walk down Pennsylvania Avenue, and we’re going to the Capitol”
 - “We’re going to try and give our Republicans, the weak ones ... the kind of pride and boldness that they need to take back our country

Later the rally attendees marched on the Capital and pushed past the police who were trying to block them from entering the Capital Building where lawmakers debated counting electoral college votes confirming Biden’s victory. They breached security and entered the building where they caused serious damage. Simultaneously 2 pipe bombs were found at other locations. The mob included members with weapons and hand ties used to restrain people when captured. Fortunately all the legislators and staff were evacuated before the mob entered the Capital Building. A capital police officer died and 3 others died during the mob riot.

During the insurrection local leaders wanted to deploy National Guardsmen, but their requests were denied by the Federal Government. D.C. Council issued this statement via Twitter on January 6, 2021 [2]:

"Today, the Department of Defense denied a request by Mayor Muriel Bowser to expand the responsibilities of the District of Columbia National Guard so that they would be authorized to protect and restore order at the Capitol Building. That request was denied." It continued to state that the Council "is in full support of the Mayor's request. We are appalled that this fundamental request was denied. We urge the Department of Defense to reconsider their decision, and to allow the National Guard to restore safety and sanctity to the Capitol, the cornerstone of our Democracy."

Maryland Governor Hogan mobilized Maryland State Police troopers and the Maryland National Guard to help but that his requests were denied by the Federal Government. Governor Hogan said at a press conference Thursday [2]:

"However we were repeatedly denied approval to do so," ... "Under federal law the Mayor of the District of Columbia does not have authority over the Guard, and we must receive approval from the Secretary of Defense before we're able to send the Maryland National Guard across the border into the federal city into the District of Columbia."

An hour and a half passed as the insurrection riot was raging at the Capital building. Eventually a call came from the secretary of the Army. It is unclear if this is a departure from the command chain which may have been issuing illegal orders to not respond. Maryland Governor Hogan stated:

"Approximately an hour and a half later, I got a call on my cell phone from the Secretary of the Army, Ryan McCarthy, who gave us the authority that we needed to be able to move into the city,"

Maryland Governor Hogan and Virginia Governor Northam were coordinating and both Maryland and Virginia deployed the guardsmen once the approval was provided by the secretary of the Army. Delaware Governor John Carney approved the Delaware National Guard to be sent down to Washington D.C. in support of local law enforcement and other state National Guards who were down there currently [2] [3]. By January 9, 2021 New Jersey and Pennsylvania also deployed their national guard to Washington D.C. based on reports of future unrest.

President Trump rebuffed and resisted requests to mobilize the National Guard to stop violent protests at the Capital Building. Defense and administration officials said that eventually Vice President Mike Pence approved the order to deploy. It was unclear why Mr. Trump, who is still technically the commander in chief, did not give the order. The mobilization was initiated with the help of the White House counsel, among other officials [4].

The following discussion focuses on a potential Peace Scale that can be used to measure the level Conflict and System Instability [A]. It is based on measuring levels of: Happiness, Suffering, Conflict, and System Instability. The peace elements and their levels are:

- **Happiness**
 - 1H All are Happy
 - 2H Most are Happy
 - 3H Some are Happy
 - 4H None are Happy
- **Suffering**
 - 1S No Suffering Detected
 - 2S Rumors of Suffering
 - 3S Suffering Detected
 - 4S Massive Suffering
- **Conflict**
 - 1C No Conflict Detected
 - 2C Rumors of Conflict

- 3C Conflict Detected
- 4C Massive Conflict
- **System Stability**
 - 1PS Stable System
 - 2PS Unstable System
 - 3PS Collapse Immanent
 - 4PS Collapsed System

The following table attempts to predict the potential for conflict:

Table 104 - Suffering and Happiness Potential for Conflict

| Suffering / Happiness | 1H | 2H | 3H | 4H |
|-----------------------|-----------|-----------|-----------|-----------|
| 1S | 1C Green | 1C Green | 2C Yellow | 3C Yellow |
| 1S | 2C Yellow | 2C Yellow | 2C Yellow | 3C Yellow |
| 3S | 2C Yellow | 2C Yellow | 3C Red | 3C Red |
| 4S | 2C Yellow | 3C Red | 4C Red | 4C Red |

This does not match the plight of the insurrectionists specifically 4S.

There are different levels of conflict. It ranges from friendly disagreement to armed conflict. The conflict includes:

- CA Friendly Words
- CB Hostile Words
- CC Threats with Actions
- CD Armed Conflict

The following table attempts to predict the range of conflict based on the measures of Happiness and Suffering.

Table 105 - Suffering and Happiness Potential Conflict Ranges

| Suffering / Happiness | 1H | 2H | 3H | 4H |
|-----------------------|------------|------------|------------|------------|
| 1S | 1C Green | 1C Green | 2CA Yellow | 3CA Yellow |
| 1S | 2CA Yellow | 2CA Yellow | 2CB Yellow | 3CB Yellow |
| 3S | 2CC Yellow | 2CC Yellow | 3CC Red | 3CC Red |
| 4S | 2CC Yellow | 3CD Red | 4CD Red | 4CD Red |

This does not match the plight of the insurrectionists specifically 4S.

The big question is at what point does a stable system move from a safe stable condition to an unstable condition. The levels of System Stability are:

- 1PS Stable System
- 2PS Unstable System
- 3PS Collapse Immanent
- 4PS Collapsed System

The following table attempts to predict the range of system instability based on the measures of Happiness and Suffering.

Table 106 - Suffering and Happiness Potential for System Instability

| Suffering / Happiness | 1H | 2H | 3H | 4H |
|-----------------------|------------|------------|------------|------------|
| 1S | 1PS Green | 1PS Green | 2PS Yellow | 2PS Yellow |
| 1S | 2PS Yellow | 2PS Yellow | 2PS Yellow | 2PS Yellow |
| 3S | 3PS Yellow | 3PS Yellow | 3PS Red | 3PS Red |
| 4S | 4PS Yellow | 4PS Red | 4PS Red | 4PS Red |

Insurrectionists have introduced massive instability but are not 4S.

The system instability result departs from the conflict prediction table. This is based on the observation that if there is truly legitimate suffering it does not matter what the happiness level is at that moment. An example of this are all the movements in the US that expanded the Bill of Rights and Constitution to those that were previously denied the rights embodied in those documents, specifically the Women's Suffrage movement that led to the right for women to vote and the social unrest in the 1960's where an entire segment of the population was forced to live in a very segregated, toxic, and lethal society. The society is still struggling with the fact that people whose skin color is different are still being murdered by authorities charged with protecting those very same people.

The US Insurrection of 2021 was an attempted coup not for the express purpose of expanding freedom and working towards a more perfect union. Instead it was about a group of people who hate freedom and liberty because it gets in the way of their extreme toxic self-interest. It is not just about the mob that stormed the Capital Building. It is about a very large group of people in the US who will do anything to maintain their own narrow interests and the elected representatives who are severely compromised by that group.

This system of extreme self-interest started to surface shortly after the Reagan Revolution to deregulate and privatize the Government. That system showed series cracks by 1987 as represented by movies, magazine articles, newspaper reports, books, TV, etc. from that time. Unfortunately rather than perform a minor system correction when the problem was detected, those that gamed the system in their favor refused to change and eventually just started to lie and bullshit [5] the citizens who were essentially their pawns.

The people engaged in the US Insurrection of 2021 are the same people that caused the COVID-19 virus to spread and become one of the worst disasters in human history. We failed to contain the virus because of this group. This group is also preventing the roll out of effective measures to contain and eventually remove the COVID-19 virus.

- Refused to wear masks as a political stance
- Refused to practice social distancing as a political stance
- Refused to close businesses at the height of infection rates
- Refused to close schools at the height of infection rates
- Forced people to sign COVID-19 waivers
- Ordered successfully teleworking privatized workers back into government facilities
 - October 2, 2020 timing was coincident with the upcoming election
 - They were to sit in their office areas regardless of if there was any work
 - Accommodation to continue telework for COVID-19 vulnerable was refused
 - Vacation, Sick, and Leave without pay were all refused
 - Company(s) forced to terminate employees and find new employees via contract violations threats
- Attended large parties in direct violation of state orders at the height of infection rates
- Sabotaged efforts to vaccinate the people including destroying vaccines at facilities
- Deliberately provided disinformation on what was happening in hospitals as people were dying and staff was collapsing from stress
- Refused to ensure and enforce social distancing in airports
- Refused to ensure and enforce social distancing in airplanes

The broken gamed system that evolved in the past 40 years now needs massive change. During this time of instability the change can go in either direction. The official spin has already started, January 09, 2021, to suggest that the attempted coup from this insurrection was not that serious.

Now we sit with the COVID-19 disaster and the US Insurrection of 2021.

Propaganda and Disinformation

The peace scale analysis does not match the plight of the insurrectionists. The insurrectionist mob should have been people who have had their lives disrupted by the massive COVID-19 disaster not those in denial of the COVID-19 disaster. There is a serious disconnect and that disconnect can only be attributed to propaganda and disinformation.

Without worldwide communications and an effective free press there is a serious peace system collapse. Worldwide communications and press is part of a peaceful stable system. However, communications has changed. The Internet has displaced previous communications and press mechanisms.

The previous mechanisms had a few hundred years of evolution and were difficult to compromise on a worldwide scale. There were always opposing views even if propaganda or disinformation was spread. This would prevent the spread of propaganda and disinformation unless the communications and press was shut down in a particular region like in a totalitarian regime.

The Internet with its current structure that feeds users a certain profile of information is exactly the same as a press that has been shut down and only communicates propaganda and disinformation. What happens with the Internet may determine what happens with world peace or with policy in a country. In this case the Internet played a significant role in the COVID-19 disaster and the US Insurrection of 2021.

The other factor that cannot be ignored is the rise of ignorance in a population. The source of the ignorance can be denial of access to education or self-inflicted where the individual rejects education because of some serious character flaw. There always will be some segment of population in this category. However, the culture may influence the numbers in this category. For example a shift to extreme self-interest may lead to increasing the numbers of ignorant people; it is just too hard to learn and stay abreast of current events because it gets in the way of other pleasurable daily activities and my world view where I believe I benefit. For example, the insurrectionists could have turned off their talk radio, stopped visiting their lunatic fringe websites, and just bought a newspaper or turned on the nightly news on TV. However, they were told that this was liberal media and that all liberal media was filled with lies. At some point common sense needs to surface unless once again there is some character flaw in the person.

This is as serious mega trend and there needs to be a root cause analysis. In the previous century when President Roosevelt was dealing with a collapsing civilization they knew that education was key to uplifting humanity. Systems were established so that education was available to everyone and it came in many forms. What happened with these systems? Are we seeing the effects of No Child Left behind policies established in previous decades? Or is this nothing more than a culture of extreme self-interest which led to isolation from the society of those that were able to benefit from the extreme self-interest actual or perceived financial gains?

It is an extremely serious problem when the people are fed Propaganda, Disinformation, and Lies. This led to the rise of brutal totalitarian regimes in the previous century. Millions of people died.

Presidential Impeachments

Science and engineering are only as good as the political system in which they must function. As soon as the political system starts to fail the civilization suffers and the science and engineering is suppressed and made ineffective or eliminated. The COVID-19 virus became a disaster because of the US compromised political system which started to walk away from its rule of law foundations. The first presidential impeachment failed. It is unclear if the Vice President would have behaved the same way as the President during the initial stages of the COVID-19 virus spread. It is reasonable to expect that the answer is NO. Common sense and reason would have overcome self-interest and the dogma of privatization and deregulation would not have been used to stop the Federal Government from applying the resources to stop the virus before it became a disaster. The specific actions might have included:

1. Not removing CDC epidemiologist disease specialists from China
2. Immediately admitting that the virus was airborne
3. Not equating the virus with the everyday flu but instead equating it with the deadly MERS and SARS-1 outbreaks.

The failure to impeach the President in 2019 is an example of massive cause and effect with massive negative consequences. In this case the consequences were not unanticipated. History will have a harsh judgment.

Impeachment 2021 Summary

Passed House (01/13/2021)

This resolution impeaches President Donald John Trump for high crimes and misdemeanors.

Specifically, the resolution sets forth an article of impeachment stating that President Trump incited an insurrection against the government of the United States.

The article states that

- prior to the joint session of Congress held on January 6, 2021, to count the votes of the electoral college, President Trump repeatedly issued false statements asserting that the presidential election results were fraudulent and should not be accepted by the American people or certified by state or federal officials;
- shortly before the joint session commenced, President Trump reiterated false claims to a crowd near the White House and willfully made statements to the crowd that encouraged and foreseeably resulted in lawless action at the Capitol;
- members of the crowd, incited by President Trump, unlawfully breached and vandalized the Capitol and engaged in other violent, destructive, and seditious acts, including the killing of a law enforcement officer;
- President Trump's conduct on January 6, 2021, followed his prior efforts to subvert and obstruct the certification of the presidential election, which included a threatening phone call to the Secretary of State of Georgia on January 2, 2021;
- President Trump gravely endangered the security of the United States and its institutions of government, threatened the integrity of the democratic system, interfered with the peaceful transition of power, and imperiled a coequal branch of government; and
- by such conduct, President Trump warrants impeachment and trial, removal from office, and disqualification to hold U.S. office.

Impeachment 2019 Summary

Passed House (12/18/2019)

This resolution impeaches President Donald J. Trump for high crimes and misdemeanors.

The resolution sets forth two articles of impeachment of the President: (1) abuse of power by soliciting the interference of Ukraine in the 2020 U.S. presidential election, and (2) obstruction of Congress by directing defiance of certain subpoenas issued by the House of Representatives.

Impeachment 2021 Full Text

Engrossed in House (01/13/2021)

[Congressional Bills 117th Congress]

[From the U.S. Government Publishing Office]

[H. Res. 24 Engrossed in House (EH)]

H. Res. 24

In the House of Representatives, U. S.,

January 13, 2021.

Impeaching Donald John Trump, President of the United States, for high crimes and misdemeanors.

Resolved, That Donald John Trump, President of the United States, is impeached for high crimes and misdemeanors and that the following article of impeachment be exhibited to the United States Senate: Article of impeachment exhibited by the House of Representatives of the United States of America in the name of itself and of the people of the United States of America, against Donald John Trump, President of the United States of America, in maintenance and support of its impeachment against him for high crimes and misdemeanors.

ARTICLE I: INCITEMENT OF INSURRECTION

The Constitution provides that the House of Representatives "shall have the sole Power of Impeachment" and that the President "shall be removed from Office on Impeachment for, and Conviction of, Treason, Bribery, or other high Crimes and Misdemeanors". Further, section 3 of the 14th Amendment to the Constitution prohibits any person who has "engaged in insurrection or rebellion against" the United States from "hold[ing] any office . . . under the United States". In his conduct while President of the United States--and in violation of his constitutional oath faithfully to execute the office of President of the United States and, to the best of his ability, preserve, protect, and defend the Constitution of the United States, and in violation of his constitutional duty to take care that the laws be faithfully executed--Donald John Trump engaged in high Crimes and Misdemeanors by inciting violence against the Government of the United States, in that:

On January 6, 2021, pursuant to the 12th Amendment to the Constitution of the United States, the Vice President of the United States, the House of Representatives, and the Senate met at the United States Capitol for a Joint Session of Congress to count the votes of the Electoral College. In the months preceding the Joint Session, President Trump repeatedly issued false statements asserting that the Presidential election results were the product of widespread fraud and should not be accepted by the American people or certified by State or Federal officials. Shortly before the Joint Session commenced, President Trump, addressed a crowd at the Ellipse in Washington, DC. There, he reiterated false claims that "we won this election, and we won it by a landslide". He also willfully made statements that, in context, encouraged--and foreseeably resulted in--lawless action at the Capitol, such as: "if you don't fight like hell you're not going to have a country anymore". Thus incited by President Trump, members of the crowd he had addressed, in an attempt to, among other objectives, interfere with the Joint Session's solemn constitutional duty to certify the results of the 2020 Presidential election, unlawfully breached and vandalized the Capitol, injured and killed law enforcement personnel, menaced Members of Congress, the Vice President, and Congressional personnel, and engaged in other violent, deadly, destructive, and seditious acts.

President Trump's conduct on January 6, 2021, followed his prior efforts to subvert and obstruct the certification of the results of the 2020 Presidential election. Those prior efforts included a phone call on January 2, 2021, during which President Trump urged the secretary of state of Georgia, Brad Raffensperger, to "find" enough votes to overturn the Georgia Presidential election results and threatened Secretary Raffensperger if he failed to do so.

In all this, President Trump gravely endangered the security of the United States and its institutions of Government. He threatened the integrity of the democratic system, interfered with the peaceful transition of power, and imperiled a coequal branch of Government. He thereby betrayed his trust as President, to the manifest injury of the people of the United States.

Wherefore, Donald John Trump, by such conduct, has demonstrated that he will remain a threat to national security, democracy, and the Constitution if allowed to remain in office, and has acted in a manner grossly incompatible with self-governance and the rule of law. Donald John Trump thus warrants impeachment and trial, removal from office, and disqualification to hold and enjoy any office of honor, trust, or profit under the United States.

Speaker of the House of Representatives.

Attest:

Clerk.

Impeachment 2019 Full Text

[Congressional Bills 116th Congress]
[From the U.S. Government Publishing Office]
[H. Res. 755 Enrolled Bill (ENR)]

Articles of Impeachment Against Donald John Trump {House Resolution 755, One Hundred Sixteenth Congress, First Session}

CONGRESS OF THE UNITED STATES OF AMERICA, IN THE HOUSE OF REPRESENTATIVES, December 18, 2019.

RESOLUTION

Resolved, That Donald John Trump, President of the United States, is impeached for high crimes and misdemeanors and that the following articles of impeachment be exhibited to the United States Senate:

Articles of impeachment exhibited by the House of Representatives of the United States of America in the name of itself and of the people of the United States of America, against Donald John Trump, President of the United States of America, in maintenance and support of its impeachment against him for high crimes and misdemeanors.

ARTICLE I: ABUSE OF POWER

The Constitution provides that the House of Representatives "shall have the sole Power of Impeachment" and that the President "shall be removed from Office on Impeachment for, and Conviction of, Treason, Bribery, or other high Crimes and Misdemeanors". In his conduct of the office of President of the United States--and in violation of his constitutional oath faithfully to execute the office of President of the United States and, to the best of his ability, preserve, protect, and defend the Constitution of the United States, and in violation of his constitutional

duty to take care that the laws be faithfully executed--Donald J. Trump has abused the powers of the Presidency, in that:

Using the powers of his high office, President Trump solicited the interference of a foreign government, Ukraine, in the 2020 United States Presidential election. He did so through a scheme or course of conduct that included soliciting the Government of Ukraine to publicly announce investigations that would benefit his reelection, harm the election prospects of a political opponent, and influence the 2020 United States Presidential election to his advantage. President Trump also sought to pressure the Government of Ukraine to take these steps by conditioning official United States Government acts of significant value to Ukraine on its public announcement of the investigations. President Trump engaged in this scheme or course of conduct for corrupt purposes in pursuit of personal political benefit. In so doing, President Trump used the powers of the Presidency in a manner that compromised the national security of the United States and undermined the integrity of the United States democratic process. He thus ignored and injured the interests of the Nation.

President Trump engaged in this scheme or course of conduct through the following means:

(1) President Trump--acting both directly and through his agents within and outside the United States Government--corruptly solicited the Government of Ukraine to publicly announce investigations into--

(A) a political opponent, former Vice President Joseph R. Biden, Jr.; and (B) a discredited theory promoted by Russia alleging that Ukraine--rather than Russia--interfered in the 2016 United States Presidential election.

(2) With the same corrupt motives, President Trump--acting both directly and through his agents within and outside the United States Government--conditioned two official acts on the public announcements that he had requested--

(A) the release of \$391 million of United States taxpayer funds that Congress had appropriated on a bipartisan basis for the purpose of providing vital military and security assistance to Ukraine to oppose Russian aggression and which President Trump had ordered suspended; and

(B) a head of state meeting at the White House, which the President of Ukraine sought to demonstrate continued United States support for the Government of Ukraine in the face of Russian aggression.

(3) Faced with the public revelation of his actions, President Trump ultimately released the military and security assistance to the Government of Ukraine, but has persisted in openly and corruptly urging and soliciting Ukraine to undertake investigations for his personal political benefit. These actions were consistent with President Trump's previous invitations of foreign interference in United States elections.

In all of this, President Trump abused the powers of the Presidency by ignoring and injuring national security and other vital national interests to obtain an improper personal political benefit. He has also betrayed the Nation by abusing his high office to enlist a foreign power in corrupting democratic elections.

Wherefore President Trump, by such conduct, has demonstrated that he will remain a threat to national security and the Constitution if allowed to remain in office, and has acted in a manner grossly incompatible with self-governance and the rule of law. President Trump thus warrants impeachment and trial, removal from office, and disqualification to hold and enjoy any office of honor, trust, or profit under the United States.

ARTICLE II: OBSTRUCTION OF CONGRESS

The Constitution provides that the House of Representatives "shall have the sole Power of Impeachment" and that the President "shall be removed from Office on Impeachment for, and Conviction of, Treason, Bribery, or other high Crimes and Misdemeanors". In his conduct of the office of President of the United States--and in violation of his constitutional oath faithfully to execute the office of President of the United States and, to the best of his ability, preserve, protect, and defend the Constitution of the United States, and in violation of his constitutional duty to take care that the laws be faithfully executed--Donald J. Trump has directed the unprecedented, categorical, and indiscriminate defiance of subpoenas issued by the House of Representatives pursuant to its "sole Power of Impeachment". President Trump has abused the powers of the Presidency in a manner offensive to, and subversive of, the Constitution, in that:

The House of Representatives has engaged in an impeachment inquiry focused on President Trump's corrupt solicitation of the Government of Ukraine to interfere in the 2020 United States Presidential election. As part of this impeachment inquiry, the Committees undertaking the investigation served subpoenas seeking documents and testimony deemed vital to the inquiry from various Executive Branch agencies and offices, and current and former officials.

In response, without lawful cause or excuse, President Trump directed Executive Branch agencies, offices, and officials not to comply with those subpoenas. President Trump thus interposed the powers of the Presidency against the lawful subpoenas of the House of Representatives, and assumed to himself functions and judgments necessary to the exercise of the "sole Power of Impeachment" vested by the Constitution in the House of Representatives.

President Trump abused the powers of his high office through the following means:

(1) Directing the White House to defy a lawful subpoena by withholding the production of documents sought therein by the Committees.

(2) Directing other Executive Branch agencies and offices to defy lawful subpoenas and withhold the production of documents and records from the Committees--in response to which the Department of State, Office of Management and Budget, Department of Energy, and Department of Defense refused to produce a single document or record.

(3) Directing current and former Executive Branch officials not to cooperate with the Committees--in response to which nine Administration officials defied subpoenas for testimony, namely John Michael "Mick" Mulvaney, Robert B. Blair, John A. Eisenberg, Michael Ellis, Preston Wells Griffith, Russell T. Vought, Michael Duffey, Brian McCormack, and T. Ulrich Brechbuhl.

These actions were consistent with President Trump's previous efforts to undermine United States Government investigations into foreign interference in United States elections.

Through these actions, President Trump sought to arrogate to himself the right to determine the propriety, scope, and nature of an impeachment inquiry into his own conduct, as well as the unilateral prerogative to deny any and all information to the House of Representatives in the exercise of its "sole Power of Impeachment". In the history of the Republic, no President has ever ordered the complete defiance of an impeachment inquiry or sought to obstruct and impede so comprehensively the ability of the House of Representatives to investigate "high Crimes and Misdemeanors". This abuse of office served to cover up the President's own repeated misconduct and to seize and control the power of impeachment--and thus to nullify a vital constitutional safeguard vested solely in the House of Representatives.

In all of this, President Trump has acted in a manner contrary to his trust as President and subversive of constitutional government, to the great prejudice of the cause of law and justice, and to the manifest injury of the people of the United States.

Wherefore, President Trump, by such conduct, has demonstrated that he will remain a threat to the Constitution if allowed to remain in office, and has acted in a manner grossly incompatible with self-governance and the rule of law. President Trump thus warrants impeachment and trial, removal from office, and disqualification to hold and enjoy any office of honor, trust, or profit under the United States.

Speaker of the House of Representatives.

Attest:

Clerk.

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New Administration In Washington DC

There was a White House Press Briefing by Press Secretary Jen Psaki, February 3, 2021. That press briefing is a snapshot in time but it indicates much of the serious systemic problems in the US.

There were very few questions from the press on the COVID-19 disaster yet the country is basically in a horrible state because of the disaster. The COVID-19 questions that were asked were superficial suggesting that the press is ignorant of the details of the disaster. The country just went through an insurrection in an attempt to pull off a coup for a previous administration that was so entrenched in the dogma of privatization and deregulation that the country is now in a collapsing state. A majority of the questions should have been centered on the COVID-19 disaster. The questions should have included the mistakes from the previous administration and the relationship of those mistakes to the official policy and platform of the Republican party, which is currently in chaos. The questions then should have moved on to how this administration intends to undue the massive damage that occurred from that failed political platform and resulting policies. Earlier in this analysis there was an evaluation of a conceptual virus defense system and the press was marked as a failed subsystem. The press is still in a failed state.

The press briefing had 71 questions. These are the number of COVID-19 related questions:

- 4 Vaccines
- 2 School Ventilation

Only 6 out of 71 questions were asked or just 8%.

There were no follow up questions to responses like: **benefit of tuition and things along those lines --- need to have proper ventilation..** The next set of questions should have been:

1. Do you mean some schools are more safe because of the systems they are able to afford?
2. What is the nature of the systems in the schools with better ventilation, are they installing UV ventilation systems?
3. How many schools have already done this and where are they?
4. How long have we known about these systems and why did the previous administration not act?
5. In the past you mentioned that the previous administration had no plan for vaccine distribution, does this fall into the same category?
6. Why did the previous administration essentially have no plans to deal with this disaster other than let the States handle it?
7. Do you think it is associated with their platform of reduced government, deregulation, and privatization?
8. Do you think the COVID-19 disaster will cause the Republicans to reflect on their platform of reduced government, deregulation, and privatization?
9. How will President Biden deal with the Republicans that refuse to change what appears to be a massive platform and policy failure?

Press Briefing by Press Secretary Jen Psaki, February 3, 2021

1:44 P.M. EST

MS. PSAKI: Good afternoon. I just have a couple of items for you all at the top. I was a little worried about getting that mask off with the earrings. Okay, successful. Good start.

Today, President Biden joined the House Democratic Caucus meeting by phone to discuss the American Rescue Plan. The President made clear that the American Rescue Plan was designed to meet the stakes of the public health and economic crisis. And the President and caucus agreed that a final package must address the crises facing working families, including housing and food insecurity and reopening schools.

President Biden said the cost of inaction and doing too little is greater than the cost of doing too much.

The President also had the opportunity to meet in the Oval Office just a few minutes ago with Leader Schumer and the Democratic chairs of the Senate committees with jurisdiction over the American Rescue Plan as part of his ongoing engagement with lawmakers with --- from both sides of the aisle.

During the meeting, they had a productive conversation on the status of legislative proceedings on the package. They were in agreement over the need to move swiftly to ensure that we get \$1,400 direct payments to middle --- and working-class Americans as soon as possible; that we need to take steps to get immediate relief to the Americans who are struggling with food insecurity or facing eviction; and that we need to provide more resources to get shots into arms faster.

The President and the senators were also in agreement over the need to go big and to meet the challenges we face with a response that will get the job done: in beating this virus and in protecting our economy from long-term damage.

During the conversation, the President and Democratic leaders also agreed to continue working to find areas of bipartisan agreement in an effort to integrate ideas and make the process as bipartisan as possible.

There have been lots of questions from some of you and others about the differences between the Presidents' plan, the Democratic plan, and the plan that has been proposed by 10 Republican senators. So I wanted to outline some of those specifics here for you.

The President's plan would fulfill his pledge to finish getting \$2,000 checks to hard-hit Americans, and ensure that, for example, a kindergarten teacher making \$60,000 a year isn't left without additional support. Their plan wouldn't provide that teacher with direct relief.

The President's plan would give Americans who are out of work, through no fault of their own, a \$400 weekly supplement and the certainty that it would last through the worst of the pandemic. Their plan would give unemployed Americans less money and, therefore, less certainty.

The President's plan would keep hundreds of thousands of teachers, cops, firefighters, paramedics, and other public servants on the job. Their plan offers no money to state and local governments to keep people on the frontlines of this fight employed.

The President's plan would assist the millions of families who are faced --- who are behind on their rent and facing potential --- potential eviction. Their plan wouldn't offer any support to these families.

The President's plan would provide targeted, immediate relief to families with children and essential workers through an emergency expansion of the Child Tax Credit and the EITC. Their plan would deny relief to 15 million lower-income essential workers.

The President's plan together would reduce the number of kids living in poverty by 5 million this year and cut child poverty in half. Their plan would likely leave millions of additional kids out.

Just as importantly, the President's plan would make sure we have every resource we need to defeat this virus and get life back to normal, **including \$130 billion to help ensure our kids can go back to school safely; \$20 billion to mount a nationwide vaccination campaign; \$50 billion for more and better testing; and critical funding to improve our ability to track and defeat emerging COVID-19 strains.**

I know that was a lot, but there's a lot of interest in this issue.

Go ahead, Josh.

Q Thanks so much, Jen. Two questions. President Biden told House Democrats today that he considered the \$1,400 direct payment a promise that he can't break. At the same time, a new analysis from the Penn Wharton Budget Model suggests that 73 percent of those payments would go into savings instead of be spent in ways that could boost growth. I'm wondering, what's more important: to keep the promise, or to ensure that the package does all it can to maximize growth?

MS. PSAKI: Well, first, on the Penn Wharton analysis, we've seen that analysis, and I've talked to our economic team about it, and frankly feel it's way out of step with the majority of studies on this plan, including independent analysis from the Wall Street firm, Moody's; JPMorgan Chase; and the Brookings Institution. And the analysis concludes that our economy is near capacity, which would be news to the millions of Americans who are out of work or facing reduced hours and reduced paychecks. So this starting place means their model is way off.

So our view is we're going to listen to governors; we're going to listen to a broad range of economists; we're going to listen to health experts on what is needed, what the American people need at this point in time. And when one in seven American families don't have enough food to eat, it's clear that there is a great deal of need for assistance.

Q Secondly, the President is set to speak to the State Department tomorrow. How does he expect to change the tone with regard to refugees, China, and Russia, relative to his predecessor?

MS. PSAKI: Well, first, I would say the President's visit tomorrow, which we rescheduled because of snow, is largely focused on his desire to thank the men and women who are us --- who are Foreign Service officers, civil servants, who are the heart and soul of that institution and, frankly, our government. And I worked there for two and a half years; it's an incredible place. And they've had --- many of them have had a challenging couple of years.

But he will also, of course, talk broadly about foreign policy --- how could he not? --- if he is there. This will not be a laydown of his vision for every issue and every foreign policy issue. He will have plenty of time to do that. So I just want to, kind of, expectation-set on what to expect for tomorrow.

But you were also asking about the difference between his approach on Russia and China. You know, I think, on Russia, you know, his call to President Putin is --- a couple of weeks ago --- two weeks ago? --- is clear evidence of exactly that. When he called President Putin, he did not hold back. He made clear that while there are areas where we can work together --- say, New START, which is in the interest of the security of the United States --- he has concerns about a number of areas of their reported interference, whether it's in elections; in the hacking of the United States --- the SolarWinds hacking, I should say; reports of bounties on American troops. There's an ongoing review that's happening, which he also stated in that --- in that conversation.

So his engagement, even directly with President Putin, tells you a bit about the difference alone.

And on China, you know, the President's view and the administration's view is that we need to work with our allies, we need to work with our partners to align on how we're going to approach our relationship with China. And we need to approach that relationship from a position of strength. There are obviously key components of that relationship; there are economic, there are strategic.

And --- but we are going to work closely with our allies --- he's having those engagements now; we've done a lot of call readouts, of course --- and also with partners on the Hill, Democrats and Republicans, on the best path forward.

Go ahead.

Q Thanks, Jen. The Republican plan matches you guys up on the national vaccine top line and also the testing top line, but you ticked through some pretty significant differences between the two proposals. And I know we ask this seemingly daily at this point, but where is the ---

MS. PSAKI: It's okay. It's your job.

Q Where is the space for bipartisan agreement when the differences are that significant across major components of what the President wants?

MS. PSAKI: Well, you know, an area where there's agreement to work together on is funding for small business, and that's something, of course, Democrats and Republicans want to do.

Our view is that this bill itself is bipartisan; 74 percent of the public support it --- Republicans and Democrats, independents across the country. And there is agreement that it's important to work with many Republicans and Democrats who fall in different --- different parts of the political spectrum to put their ideas forward and consider them. And that's part of the conversation and part of the process now happening on the Hill. We will see. We will see what proposals that improve the bill, that make it better. And there's certainly an openness to that.

Q Just one more on COVID relief. Several Republican senators have said publicly that they believe the President is in a different place than his staff on this issue in particular, and he's more

willing to deal perhaps than his staff. Is there daylight between the President and his staff on the \$1.9 trillion proposal?

MS. PSAKI: Absolutely not. I've seen some of those reports. Some --- many of them are ludicrous. I've sat in a lot of meetings with the President of the United States in the last few weeks and even before then. There is no one who's going to tell him what to do or hold him back from his commitment to delivering relief to the American people.

And I would point you to the fact that he talked about the importance of going big on a package, back to the campaign. He talked about the importance of meeting this moment, back to the campaign. So that is certainly his commitment, and that's exactly what he's working to deliver on.

Q And then, just one quick one on vaccines, and circling back to something you guys talked about last week, I believe: Defense Production Act. I know you've said all options are on the table, you guys are working through, and that it has been launched in at least a couple of areas.

On vaccine supply, is the Defense Production Act being utilized on that front? And if not, is there a timeline? Is that something that remains on the table right now to bolster, I think, one of the issues that you guys have identified as being the biggest problem right now?

MS. PSAKI: Absolutely, it's on the table. And, you know, the reason the President invoked the Defense Production Act was because he wanted to have a range of options for any moment where there was a reduction in supply on --- on, you know, materials on PPE, on syringes. And at the appropriate time, we can certainly use it for that.

But, right now, our focus is working with Pfizer and Moderna. We have confidence in their ability to produce the number of vaccines that the government has ordered on the timeline that we have committed to. And so --- and that means that we would have enough vaccines here to be able to vaccinate every American by the summer.

So our focus is really more on evaluating our team, evaluating where there are needs for supplies and materials that would help deliver the vaccines into the arms of Americans.

Go ahead, Ed.

Q You saw the President say earlier he's still confident he can get some Republican support. Mitt Romney was asked about that a little while ago, and he said, "Well, if they're not going to budge off the \$1.9 trillion number, it's not going to happen." He was then asked, "Well, is there --- can you give us a specific example of something that demonstrates the differences?" You didn't mention it. He says the \$360 billion or so for states and localities. Is that something that is considered negotiable by the White House?

MS. PSAKI: Well, I'd be interested, because I didn't see --- so now I guess I'm asking you a question --- what Senator Romney said about whether they would propose any funding for state and local.

Q He said that the most recent reports show that the average state in America only lasts about a tenth --- the 1 percent --- of their revenue, so it should perhaps be adjusted.

MS. PSAKI: Well, they are not proposing any. So I would suggest, given that they also supported \$160- or \$180 billion in a package that moved forward under the Trump administration, that that's a place where we would certainly welcome an offer from their end on what state and local funding they'd support.

Q And one other on economic relief related to the pandemic. There was a full-page ad in the New York Times last week, put there by several prominent women, calling on the Biden administration to implement what they call a "Marshall Plan for Moms" in the first 100 days. Has the President seen the ad? And would he support the idea of monthly payments to mothers who are saddled by this pandemic?

MS. PSAKI: Well, as a mom myself, I can confirm for you that the conversation I have most frequently with friends on Zoom calls is about the impact of the pandemic on working moms across the country.

And what the President has --- certainly concerned about, as we all are, is the fact that this has a disproportionate impact on communities of color, on women of color, who are working --- many of them working on jobs as frontline workers and vital --- playing vital roles in industries across the country. And it's certainly an issue that Secretary Yellen, his economic team are focused on and will be looking for ways to help appease.

Q Two other quick ones. The President said yesterday he hadn't yet had a chance to contact the families of the FBI agents killed in South Florida. Has he been able to do that yet?

MS. PSAKI: We will follow up with you after the briefing. I did not have a chance to ask about that before I came out here today.

Q And then, earlier today, Canada designated the Proud Boys as a terrorist organization, putting them alongside al-Qaeda, ISIS, and al-Shabaab. Does the U.S. plan to do the same?

MS. PSAKI: I had seen that, Ed, before we came out here, and had asked, certainly, our team to make sure we had a little bit of guidance on that for all of you.

We, of course, have a review underway --- a domestic violence extremist --- extremism, I should say, review that's underway by our national security team to take a look at violence and this type of concerning group activity across the country. I expect we will wait to --- for that review to conclude before we make any determinations.

Q So no final decision on that?

MS. PSAKI: It's an ongoing review, and when it's concluded, I'm sure we'll have more to say about our view.

Go ahead.

Q Thank you, Jen. The top Republican on the House Armed Services Committee is asking you to apologize for some of the comments that you made yesterday in the briefing room about the Space Force. Will you apologize?

MS. PSAKI: I did send a tweet last night. You may not all be on Twitter. Maybe they're not on Twitter. That said, we invite the members of Space Force here to provide an update to all of you on all of the important work they're doing, and we certainly look forward to seeing continued updates from their team.

Q But big picture here: I mean, does the Space Force have the full support of the Biden administration, or is the President at some point perhaps going to try to get rid of it or in some way diminish it?

MS. PSAKI: They absolutely have the full support of the Biden administration, and we are not revisiting the decision to establish the Space Force.

The desire for the Department of Defense to focus greater attention and resources on the growing security challenges in space has long been a bipartisan issue informed by numerous independent commissions and studies conducted across multiple administrations. And thousands of men and women proudly serve in the Space Force. As you know, it was established by Congress, and any other steps would actually have to be taken by Congress, not by the administration.

Q One more space question. NASA's Artemis program, which was the Trump-era program to return American astronauts to the Moon by 2024, what is the President's plan? What is he going to do with that program? Is he going to keep it intact?

MS. PSAKI: I am personally interested in space; I think it's a fascinating area of study. But I have not spoken with our team about this particular program so let me see if we can get you a more informed overview of that.

Q Okay. And one more --- one more question, if I could --- sorry --- about the President's comments last night as he was paying his respects to the FBI agents that lost their lives or were injured. He said, "By and large, the vast" majority of these men and women are decent, honorable people." What did he mean by that --- the "vast majority" part?

MS. PSAKI: That's exactly what he meant.

Go ahead, Kristen.

Q Thank you, Jen. President Biden has been very clear that one of his core promises to the American people is to try to unify this country. How can he take steps to unify the country while the impeachment trial is going on next week?

MS. PSAKI: Well, he can focus his efforts, which is exactly what he's doing, on delivering necessary relief to the American public and using his forum to talk about **how he's going to reopen schools; how he's going to get shots in the arms of Americans; how he's going to ensure that the one in seven American families, who are concerned they can't put food on the table**, can do exactly that. That's how he's spending his time as we started this briefing and how he will continue to spend it moving forward.

Q What's his message to Republicans who say that the very trial itself undercuts any efforts at unity?

MS. PSAKI: He invites Republicans to work with him on bringing relief to the American public, and that's why he invited them here --- many of them here on Monday and why he will continue to engage with them moving forward.

Q And you talk about his agenda. President Biden has been signing executive orders, speaking to the American people almost on a daily basis. Obviously, the focus is going to shift to the Senate next week. How concerned is he that the Senate trial will undercut his momentum?

MS. PSAKI: I think the President has been clear there is an urgency to delivering relief to the American people. And it's important and vital that the House and Senate work quickly to get this bill packet passed.

Q Do you see it wrapped up within a week, when you say (inaudible)?

MS. PSAKI: I'm not giving a deadline; I'm just conveying what he has stated many times publicly. And we are confident they have the ability to walk and chew gum at the same time.

Q And finally, one more question. There's discussion on the Hill about stripping Congresswoman Marjorie Taylor Greene of her committee assignments. Does President Biden believe that she should be stripped of those assignments?

MS. PSAKI: We've resisted speaking of her in this briefing room, and I'm not going to do that today.

Q Why not weigh in on her assignments though, Jen?

MS. PSAKI: Because it's up to the Hill to make that determination.

Go ahead.

Q Thank you, Jen. I'm Nandita with Reuters. President Biden has always expressed support for unions and, in fact, has distributed a plan to, kind of, strengthen worker organizing around the country. There are thousands of workers at an Amazon facility in Alabama that are currently gearing up to cast a vote and potentially form a union inside the company. This will be the first of its kind inside Amazon. Does the White House and President Biden support their efforts to organize and form a union?

MS. PSAKI: As you've noted, the President is a strong, longtime believer and supporter of the efforts of labor unions and workers. I have not spoken with him or our economic team about this particular report, nor had I seen it before I came out here. If there's anything more to provide you, we're happy to follow up with you directly.

Q And I did have another question on ---

MS. PSAKI: Sure.

Q --- Secretary Yellen calling for a meeting with top financial regulators on GameStop. And we understand the meeting is likely to happen this week. Will the meeting be held on Thursday?

And will the focus really be on whether Robinhood treated retail investors unfairly over large institutional investors?

MS. PSAKI: Well, I would send you to the Treasury Department for any specifics on the timing of the meeting or the focus of the meeting. For any of you who have not seen this report, Secretary Yellen has called a meeting with the SEC, FRB, FRBNY, and CFTC. She believes the integrity of markets is important and has asked for a discussion of recent volatility in financial markets and whether recent activities are consistent with investor protection, and fair and efficient markets.

That will be the focus of the meeting, but for more details, I would certainly send you to the Treasury team.

Go ahead, Jennifer.

Q Any update on the release of the White House visitor logs? Either --- were you able to figure out if you can technically access the Trump administration visitor logs?

MS. PSAKI: I was. We cannot. That is under the purview of the National Archives. So I'd certainly point you to there.

And in terms of the --- our plans to release the visitor logs, we do plan to do that on a quarterly basis, just as the Obama-Biden administration did as well.

Q And then one other thing, also on unions. **Mitch McConnell was critical today of giving generous funding to school districts where the unions are not allowing the schools to open. Do you have any reaction to that?**

MS. PSAKI: I would say that the purpose of giving funding, or supporting funding and getting it to school districts is to ensure that teachers are safe, that kids are safe, that there is necessary PPE, that there is ventilation in the school, that there is the environment that allows for children to return safely. And that is the President's focus. That's why he also wants to reopen schools and wants them not just to reopen but wants them to stay open, which, as a mom, that is pivotal. And that's --- that's --- but he knows it's essential that it's done in a safe way.

Q But anything on the unions not allowing some school districts to reopen?

MS. PSAKI: There's discussions in different districts, as you well know, between school districts or --- and elected officials and the unions. And we certainly hope and encourage progress on that front. **But the President's focus is on the schools reopening safely and them staying open.**

Go ahead.

Q I have a couple questions. Thanks, Jen. So during the Georgia runoffs, President Biden campaigned specifically on \$2,000 stimulus checks. And obviously, as we've discussed, the payment is \$1,400. There doesn't seem to be an active discussion on actually raising that amount. So is that a broken promise to voters who may have been expecting \$2,000 checks if Democrats won? And would the administration be open to raising that amount?

MS. PSAKI: Well, you're right that the President is very focused on ensuring millions of Americans receive those checks and that pivotal relief at this point in time. There were \$600 payments, as you know, in the \$900 billion package that passed in December; this is \$1,400. Together, that's \$2,000. So it would be delivering on the promise he made, and it's something that he is firmly sticking by.

Q And I had another question on immigration. The Biden administration has extended temporary protected status for Syrian nationals. Obviously, the Trump administration cut off TPS protections for many other countries such as El Salvador, Nicaragua, and Haiti. So does the administration plan to reinstate those TPS protections for those countries?

MS. PSAKI: It is all under review at this point in time, and obviously, the President has talked about his own commitment to reinstating TPS in certain cases. But it has not --- the review has not been completed at this point in time.

Go ahead.

Q Thanks, Jen. Earlier today, on the call with House Democrats, the President talked about better targeting in the stimulus checks. I'm wondering if you could just explain what he meant by that and what might be under consideration.

MS. PSAKI: Sure. Well, as we've said in here a few times but --- but I know this is an ongoing process --- you know, the President, having served in the Senate for 36 years, fully recognizes that the bill he proposed, that he did a primetime address on two weeks ago, that may not look exactly like the bill that comes out. And he knows that. That's part of the legislative process.

So further targeting means not the size of the check, it means the income level of people who receive the check, and that's something that has been under discussion. There hasn't been a conclusion, but certainly he's open to having that discussion.

Q And I also wanted to ask: In the previous administration, often when coronavirus cases came up in the White House --- people tested positive --- it came out in the news media. I was wondering if the --- if this White House has a policy on releasing information about people who test positive in the White House and in the administration who have contact with White House officials?

MS. PSAKI: Sure. Well, if --- for anybody who covered the campaign --- and I was not on the campaign --- but what they tried to do was be very transparent about anyone who had any contact with --- would have been in close proximity to the President or Vice President, and release if they had a COVID-positive test.

And so we will certainly model that transparency if and --- if and when that occurs here, and venture to provide accurate and up-to-date information as quickly as possible to all of you, not through the media, but directly. I mean, you are the media, but you know what I mean.

Go ahead.

Q Hi. Thanks, Jen. I have one question, and I have one from a colleague who can't be here due to ---

MS. PSAKI: Sure.

Q --- social distancing. The CDC Director is saying that the vaccination of teachers is not a prerequisite for safe reopening of schools. Does the White House agree with this? And should states be prioritizing teachers over other essential workers in the vaccine line?

MS. PSAKI: Well, I saw the comments of Dr. Walensky, but I will say that even she would say, if she were standing here --- she's welcome to come anytime, but she's in Atlanta --- that they have not released their official guidance yet from the CDC on the vaccination of teachers and what would be needed to ensure the safe reopening of schools. And so we'd certainly defer to that, which we hope to see soon.

The President himself has talked about the importance and the priority of vaccinating teachers, and in most states they're in the 1b category of vaccination. And --- but it is up to states to determine prioritization. Obviously, there's federal guidelines, but --- and we work closely with governors, but we leave it to them. But certainly, ensuring teachers are vaccinated, prioritizing teachers is important to the President.

Q And this is from a colleague.

MS. PSAKI: Oh, sorry. Go ahead.

Q Yeah. Following the 2020 Election, 28 states have brought forward 106 different bills related to voting access, according to the Brennan Center for Justice. Is President Biden keeping track of those efforts? And will he talk with states to ensure Americans aren't restricted from voting in future elections?

MS. PSAKI: Well, the President's priority is certainly ensuring, and the Vice President's priority, is certainly ensuring more people, not fewer people, have access to voting and that it is easier, not harder, to do that.

We saw some examples of voting by mail or early voting, given COVID, that could be models for the future. It's certainly an issue he's following and his team keeps him abreast on. I don't think there's been an update in --- since he was inaugurated to him, but it's certainly an issue he cares personally about, as does the Vice President.

Go ahead, in the back.

Q Good afternoon. Owen Jensen with EWTN Global Catholic Network. President Biden has stated he wants to unite the country. In the first two weeks he's been in office, however --- and much to the great disappointment of pro-life Americans --- he has revoked the Mexico City Policy, he has ordered a review of Title 10, and issued a statement strongly supporting Roe v. Wade. Is the President going to make any effort to reach out to pro-life Americans in his administration?

MS. PSAKI: Well, those have long been the President's positions, and he certainly was just restating them and delivering on promises he made on the campaign trail. But the President will reach out to all Americans. And that is how he's going to govern --- what he talked about in his inaugural address --- and he has every intention of delivering on that promise.

Q If I could follow up on that: Will he --- you describe him as a "devout Catholic." Will he use his faith to guide him in any policy decision-making?

MS. PSAKI: He does attend church nearly every weekend, and that's something that's important to him personally and to his family. And he's talked about the impact of his faith on healing and everything he's been through as a human being. So certainly it's a guide to him as a human being.

Go ahead.

Q Thanks. Earlier, you mentioned a number of topics that Presidents Biden and Putin had discussed. One that you didn't mention is the two Marines who are imprisoned, Trevor Reed and Paul Whelan. Trevor Reed from Texas had an appeal today in Moscow. The U.S. ambassador called his conviction "a mockery of justice." What is the U.S. doing to secure their release? And do you consider these two Marines to be hostages?

MS. PSAKI: Well, Ambassador Sullivan, who I think you were referring to, today called Trevor Reed's trial "a mockery of justice," and we certainly agree. And, as you know, we have a range of means of communications with the Russians at several levels. We have a Secretary of State who is now confirmed. We have a national security advisor and we have a number of officials in the State Department.

But I'll use this as an opportunity to once again call on Russia to swiftly release both Mr. Reed and Paul Whelan. And doing so on the heels of extending New START would demonstrate that Russia is ready to move past intractable issues within the bipartisan --- the bilateral, excuse me -- - lots of bipartisan talk in here today --- bilateral relationship. But that's our view, and we certainly raise this at every opportunity.

Q Are sanctions or any other consequences under consideration?

MS. PSAKI: Well, there's also a review --- we've announced here, of course, and I talked about a little bit at the beginning of our relationship --- and certainly a number of issues that are being looked into by the national security team. And once that review is concluded, we'll have more to say on our policies moving forward.

Q Does the administration consider them to be hostages?

MS. PSAKI: I don't think I'm going to add a new category or categorization from here today.

Go ahead.

Q Jen, I want to follow up on ventilation in the schools, in terms of reopening them safely. How exactly does the White House see that playing out? Is the President saying that no school should be reopened unless they get a brand-new or renovated ventilation system?

MS. PSAKI: I think the President is saying that --- and the CDC, I should say, more importantly, and our health and medical experts are saying that ventilation and proper ventilation in schools, and especially schools --- public schools that have --- don't have often the benefit of tuition and things along those lines --- need to have proper ventilation.

We've seen from health and medical experts that that is something that contributes to ensuring the safety of people indoors, which is part of what school is. So they're just conveying that that's an important component of looking at school safety and how we can reopen schools.

Q So it's not a prerequisite then?

MS. PSAKI: Well, there haven't been prerequisites set. There have been --- there have been, you know, broad objectives that have been set by the CDC and others. They have also not put out their specific detailed guidelines yet. And we'll look forward to seeing those and abiding by them, and communicating about them from here.

Go ahead, Josh.

Q The President has said he really wants to protect the middle class. And I'm wondering, when it comes to things like direct payments, what's the income range by which you define the middle class? Like, how much does someone who is middle class --- how much do they earn? What's the range?

MS. PSAKI: Well, there are ranges in the bill, as you know, that are what the President proposed and what he outlined during his primetime address. I don't know that he looked at the bill as his own personal definition of the middle class, as much as a definition of the people who need help the most.

Q So that's the --- that bill is the rough range in how you're thinking about it? Or ---

MS. PSAKI: I don't --- I think I just said it's not the definition; he wasn't looking to answer the question for economists around the world on how to define the middle class. He was defining who needs help the most now, and that's how the bill is defined and why he's so focused on ensuring those checks get out to the American people.

Go ahead.

Q Two quick follow-ups. One on the voting question --- the Voting Rights Act update --- or the John Lewis Voting Rights bill. You guys have majorities in the House and the Senate. I know you talked about it on the campaign trail, but given *Shelby v. Holder* and the change of preclearance, is that a priority? And if it's a priority, when --- I understand you've only been here two weeks, but with the majorities, when do you push forward on that priority?

MS. PSAKI: It remains a priority, of course. The President's number-one focus though remains getting the American Rescue Plan through. He's also going to talk more about a Build Back Better plan, as we get into the early spring or late winter, I guess, and that will be another priority. There's an immigration package that he has proposed to the Hill as well.

So, ensuring that it is easier to vote, that more people have access to voting, that we are making it, you know, a part of the right of being an American is a priority to the President. But I don't have a timeline or a date for you on when we would push for that bill to move forward.

Q And then, one other quick one on Burma. Leader McConnell, after he spoke with the President yesterday, said he expects quickly --- expects the administration to quickly censure the military leaders. I know we've talked about the changes in foreign aid. What is the timeline on sanctions? Is Leader McConnell right that sanctions will be coming quickly?

MS. PSAKI: Well, one, I will note that the State Department very rapidly completed their review designating or naming the military coup in Burma in a very short period of time, which I think is something --- this is bipartisanship in action --- that Senator McConnell agreed on.

And, obviously, the detention continued --- detention of Aung San Suu Kyi, other civilian officials, and the declaration of national state of emergency are a direct assault on Burma's transition to democracy and the rule of law.

We're continuing to review sanction --- our sanctions authorities and other options. It is certainly a priority to this administration. I can tell you Jake Sullivan called me on Sunday night to tell me we had to put a statement out because it was so important we had our vos- --- voi- --- voice out there. And we obviously put out a statement from the President, acted quickly.

I don't have an exact timeline for you, but it is a --- it is a priority. And certain --- certainly reviewing our sanctions authorities, and seeing where there's action to take there, is something the team is focused on.

Go ahead, Jennifer.

Q Have you guys been talking at all about the Iowa Caucuses or the lineup for the next presidential ---

MS. PSAKI: Too soon, Jennifer. Too soon.

Q So no discussion about Nevada wanting to go first? The (inaudible).

MS. PSAKI: I don't --- we are certainly not focused on --- on the next political campaign here quite yet, and we don't have any --- any point of view to share on the order of the presidential nominating contests --- though Nevada is a little warmer, but, you know, all great states.

Go ahead.

Q Jen, you had said that you would be checking with the NSC and the President about the Summer Olympics, I believe.

MS. PSAKI: Mm-hmm.

Q Can you tell us, does he think at this point that it is safe for the U.S. team to go to Tokyo?

MS. PSAKI: Well, I know there's been some reporting on this. We're not currently talking about changing our posture or our plans as it relates to the Beijing Olympics. We consult, of course, closely with allies and partners at all levels to define our common concerns and establish a shared approach. But this is --- there's no discussion underway of a change in our plans from the United States at this point in time.

Go ahead, Todd.

Q Thanks. One of the law enforcement gaps that was identified after the riot on January 6th was that President Trump had insisted on this focus on Antifa. And I'm wondering what President Biden has done to redirect an emphasis on right-wing extremism.

MS. PSAKI: Well, we've launched an entire review on domestic violent extremism that would cover that across the board --- activity across the board --- concerning activity across the board. It's not a political review; it's a review of domestic violent extremism. And our plan is to look at that --- have our team look at that --- again, not through a political lens, but through the lens of national security experts and teams who have expertise in this area. And when that review has concluded, we will have more to say on it.

Q Sorry, Jen, can I just follow up very quickly on the Olympics?

MS. PSAKI: Sure.

Q You said "Beijing." I'm asking about Tokyo.

MS. PSAKI: Oh, sorry. There's a lot of Olympics questions going on.

Q I just want to --- does the President think that it is safe for U.S. athletes this year?

MS. PSAKI: Again, nothing has changed about our plans, and I would send you to the USOC to discuss anything further on plans for athletes.

Kristen, go ahead. Thank you for that clarification, too. Lots of Olympics.

Q Jen, can I follow up with a previous question and just circle back to President Biden's comments yesterday in the Oval Office ---

MS. PSAKI: Mm-hmm.

Q --- when he said the "vast, vast majority" of U.S. law enforcement officers were "decent, honorable people"? Why did he want to --- why did he think it was important to stress that the "vast majority" are?

MS. PSAKI: Because I think he believes that the men and women who have been serving our country in a variety of capacities have, you know, been criticized, been --- some have been threatened; the roles they're playing have been questioned over the last several years. And he wanted to reiterate his support for the important work they do. It's also why he's visiting the State Department tomorrow.

Q But not to say that all of them are. I mean, he made that delineation.

MS. PSAKI: Well, I think the point he's making is that despite reports of, you know, individuals in different areas who may have done things that are problematic, that the vast majority of men and women serving in our law enforcement roles, serving in civil service roles, serving in roles across government do vital and essential work for the American people.

Go ahead.

Q Thanks. Sebastian Smith, AFP.

MS. PSAKI: I know. I remember your mask. It stands out. It has flamingos on it, in case anyone is wondering.

Q But I don't want to be known as the "flamingo guy." (Laughter.)

MS. PSAKI: Uh-oh. Sorry about that. I'm going to --- I'm going to owe you a drink later.

Q Sebastian Smith, Flamingo Guy. There you go.

MS. PSAKI: Okay. (Laughs.)

Q On --- again, on sanctions --- this time on Russia --- is there any discussion of targeting people close to Putin over what's happening with Navalny and the opposition there? And has the President talked to EU allies about this?

MS. PSAKI: The President has certainly spoken with a number of European allies about a range of issues of mutual interest, of course, including Russia.

In terms of what sanctions options may exist or what options, in terms of a response, may exist, the President, of course, reserves the right to respond in the manner and course of his choosing at any point in time. But we're going to let this review complete, and then our policy teams will make decisions about any specific steps they'll take in response.

Q Okay. Another one related, but not exactly the same. Does the President have any position on the activity, the presence of outlets like Russia Today and Sputnik? Which I believe maybe come here sometimes; I don't know. Does he have a position on that? Because in some countries, they're seen as out-and-out propaganda tools of the Kremlin. Given that things are fairly frosty with Putin right now, what's the position on that?

MS. PSAKI: I think it's --- I have not spoken with the President about RT or Sputnik. I think it's pretty factual to say they are tools of propaganda who work on behalf of the Russian government. I don't know that anyone would question that. Or raise your hand; I'm happy to discuss. But I have not discussed that with him specifically.

I do know that when I was at the State Department, they attended the briefing. I had a little fun with them from time to time, but they attended the briefing, they asked questions. But I think there's no question, as we're trying to decipher information that's accurate and inaccurate, it's important for the American people to know that there are outlets working on behalf of foreign

governments who have an agenda, and they're not playing the role of free press and free media as you all are.

Q Are you okay with them working in the White House, for example?

MS. PSAKI: I haven't seen them around here. I'm not sure if they're in the White House Correspondents' Association. You'd have to ask them that question. But all I'm conveying is it's important for people to understand and know that there's an agenda and that they are not the same as AP, ABC --- other outlets --- BBC --- around the world.

Go ahead, Todd.

Q Can you clarify what President Biden's goal is for the number of vaccines? I thought he had raised it to 150, but Zients, on today's call, said that it was 100 million.

MS. PSAKI: The President is always going to push his team to go as big on vaccine distribution as possible, but our goal remains 100 million shots in the arms of Americans in 100 days. And that was a goal that was set in the fall, before a single vaccine had been put in the arm of an American, and it was seen as bold and ambitious at the time.

But we're not going to stop at 100 million. We're not declaring victory. That's --- we wanted to set markers for ourselves, so that's the marker we set, and we're working to achieve it.

Go ahead.

Q Senators Coons and Carper earlier today said that Cabinet confirmations came up during their meeting. I was wondering if the President has been frustrated by the pace on the Senate side and whether he had raised that, or what his message is to senators.

MS. PSAKI: Well, presidents always want it to move faster; that's what I can confirm having been here twice. But, you know, there certainly was a delay in the confirmation of a number of our Cabinet nominees over the course of weeks. Some of them were slower paced than they should have been early on, and there are people we would like to see in place.

Obviously, Ali Mayorkas was fortunately confirmed yesterday to Secretary of Homeland Security. We'd, of course, love for the Senate to move forward with the confirmation of Attorney General Merrick Garland --- future Attorney General, I guess I should say, Merrick Garland in order to deliver on the President's promise of an independent Justice Department that's not influenced by politics. That would certainly be a break in the past.

So there are still key positions that have not moved through the confirmation process that we are eager to see move forward. We have seen, though, some progress in the last week or so and a number of who have moved forward. Former Mayor Pete Buttigieg, of course, yesterday, just confirmed as the first LGBTQ secretary in a Cabinet. He's going to play a pivotal role on our economic planning.

But there's more to be done. It's something that the President and his team will continue to push on to get his full team in place.

Go ahead.

Q Do you know, on the cloud contract for the --- that the Pentagon awarded to Microsoft --- do you know if the Biden White House is going to review that at all? Because, I mean, you know that during the Trump administration, it was awarded to Microsoft instead of Amazon, and President Trump had some feelings about Amazon. And --- do you think ---

MS. PSAKI: I heard that --- saw that.

Q Do you think (inaudible) purview?

MS. PSAKI: I would certainly send you to the Pentagon on that, Jennifer. And I --- if there's more to report from here, I will let you know, but I would certainly send you to the Pentagon.

Go ahead, all the way in the back.

Q Yeah. Would President Biden be open to having mandatory, year-round schooling to get kids caught up? So many kids who are falling behind. Would he be open to something like that, or having full-time summer school, whatever it takes?

MS. PSAKI: I have not discussed full-time or year-round schooling with the President. Of course, as you know, that requires often state funding, and that often is up to governors to know if they can provide that funding. But I don't think I have anything further for you on that.

Q Thank you.

MS. PSAKI: All right, did anyone not get a question? Okay. Thank you, everyone.

END 2:27 P.M. EST

What Does This Mean

We have problems with our existing public indoor spaces because they are sources of infection. People have been getting sick for decades since building ventilation systems were modified to deal with the energy crisis in the 1970's. Now that we have a contagion that is deadly the problems with the indoor public spaces have become visible. We have the technology to solve this problem and the costs are very low. Also the costs once compared to loss of life or shutdown scenarios are massively trivial. So we do not have a technology problem or an economic problem. We have a social problem that includes the entire society and most importantly the Federal Government.

➤ We are in bigger trouble than we realize because we have a fundamental structural problem in our system that surfaced with privatization of government beginning in the 1980's.

➤ The Federal Government is not the same government that we were born into and learned about in school. It has been transformed into something else and no one is aware of it, not even the people who are doing massive damage. This is a terrifying example of unintended system consequences.

▼ There is a related topic on US Research and the US Industrial Base. The findings are the same. It is possible that privatization has done massive damage to our industrial base and that is why we are struggling to deal with the COVID-19 disaster. [Systems Perspective](#)

We can study this further but that will only delay actions that need to happen immediately. We can let history decide. It is clear that something has shut down the Federal Government and it needs to be restarted. The State Governments are attempting to do this in realtime [[National Governors Association](#)]. Meanwhile a return to life system needs to be developed everywhere and this will require our best and brightest to be at the table to make the right decisions and direct proper actions.