

# An Experimental Physicist's View of the Coronavirus Pandemic

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Grandey Lecture  
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# Speaker background

- Experimental Physicist, PhD, University Chicago 12/1949
  - Enrico Fermi, thesis advisor. PhD thesis was first beta-gamma angular correlation measurement.
  - Worked with 100-MeV betatron and 450-MeV synchrocyclotron, primarily in a search for production of what was known at that time as "strange particles."
  - Assistant Professor.
  - IBM Watson Scientific Laboratory 12/15/52.
  - Consultant to the Los Alamos Scientific Laboratory.
    - With Fermi, learned about nuclear weapons and began to work in weapon-related physics, technology, and testing.
    - The LANL.org site credit for design of the first thermonuclear explosion of 11/01/52-- the MIKE test with a yield of 11 megatons-- some 600 times the yield of the nuclear weapons used against Japan in 1945.
- IBM
  - Extensive work on liquid and solid helium and He-3
  - Superconductors and superconducting technology, including the direction of an 80-person three-lab program to develop the first superconducting computer, based on the thin-film cryotron
  - Many other research and development, including attempt to detect gravitational radiation, first laser printer, display and input technologies-- touch screens and gaze-controlled computers, and the like.
- Member, National Academy of Sciences, of Engineering, and of Medicine,
- Consultant to or member (2 4-year terms) of the President's Science Advisory Committee-- PSAC-- 1957 to 1973
  - Chaired PSAC panels - Military Aircraft, and Naval Warfare. Served also on the Strategic Military Panel and many others.
- Abiding interest in survival of humanity, a strong US democracy, my family and friends,
  - How to prevent nuclear war, have an environment suitable for human life, and preserve our democratic system,
- New Technologies Panel of the National Commission on Health Manpower
  - Visiting hospitals in several of the United States and in Sweden as well and co-authored the report
- Council on Foreign Relations
- JASON Group; and Committee on International Security and Arms Control



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# The Corona Virus & Me

- First learned of the coronavirus outbreak in Wuhan in January 2020
  - 1/27/20. Wrote to leadership of the NAS CISAC to urge cancelling our planned meeting in China for May, and also to Moscow in March, because it was likely that the epidemic would be sufficiently serious as to make travel impossible.
- 02/04/20. Met with David Milliband and inquired about countering this coronavirus. Spoke with members of the American Academy of Arts and Sciences, sponsor of meeting. Followed up with calculations and graphs on the evolution of an epidemic of coronavirus from published material.
- **BACKGROUND IN BIOLOGICAL WEAPONS (BW).** As member of PSAC, was asked in ~1969 onto special committee responding to a request by Henry Kissinger, President Nixon's National Security Advisor, to study the wisdom of continuing research, development, and stockpiling of BW which US was bound not to use under the Geneva Convention, but which could be used "second" if somebody used them to attack US military or homeland. Report, delivered to Kissinger, helped Nixon decide on an Executive Order banning any US research, development, stockpiling, or, of course, use of BW. This, surprisingly to some, led to an early international agreement with the Soviet Union and then other nations on the same position.
- **FURTHER BACKGROUND.** Work with New Technologies Panel of the National Commission on Health Manpower. In ~1972 PSAC was asked for judgment on cessation of mandatory smallpox vaccination in US. By diligent vaccination worldwide, there was no wild smallpox, the only host of which is humans. The US government had already made the decision, up to the President, and PSAC voted also, with one exception— me, to cease mandatory vaccination. My analogy (for this energy-related audience) was from my background in nuclear weapons and nuclear power.
  - Can we remove the control rods from a nuclear reactor in which there is no neutron chain reaction because of their presence? No neutrons, no need for control rods, right? **WRONG.** And that was my fear with smallpox. With the virus, it is not a matter of a random cosmic ray stimulating one infection, that by chain reaction would infect two or four or six others, and in each successive few-day generation of the disease, would multiply itself by that same reproduction factor "*R<sub>0</sub>*." With the disease, the problem was, in part, that stocks were to be retained in two repositories at the CDC in the United States and in Moscow, and perhaps illegally or accidentally in other places. It turned out that in the United States in a ~1976 investigation of the Intelligence Community, 50 kg of illegal stocks had been retained by CIA and perhaps by others, and smallpox was being investigated legitimately in universities and government laboratories from the point of view of protection and understanding the behavior of the virus-- not from an offensive point of view-- and a couple of localized incidents of infection and transmission occurred that were quelled by "ring vaccination."

# Spreading knowledge



- Thus, I began sending many hundreds of emails aimed at alerting the population and authorities to the hazards of the coronavirus. Attempted to publish some OpEds and educate my circle on best practices to protect against what was soon to be called Covid-19.
- From an Op-Ed of 03/10/20 to my local newspaper:

*...MOST IMPORTANT is to recognize that without a vaccine for a year, or an effective, affordable anti-viral drug, with 52 million Americans over 65 in 2018, more than two million are likely to die from Covid-19, compared with the 35,000 annual average from seasonal flu, AND no matter how assiduously protective measures are practiced by an individual, her or his infection can be delayed but not prevented. Specifically, reducing an  $R_0 = 3.0$ , to  $R=0.5$  (by a factor 6), will delay a person's infection by the time required for the epidemic to grow by a factor 6 (2 weeks or so). But if we could ALL reduce  $R$  to 0.5 at some time, the TOTAL number of people infected in the country would only double from that point, and the epidemic would end. Few people understand this essential point, which means that YOUR health and the survival of your parents and grandparents depends on providing almost everybody else in the country with the tools and interest in social distancing and personal protection such as hand washing, keeping hands away from the face, and coughing or sneezing into the elbow instead of the hand.*



03\_20\_20 Scarsdale Inquirer news.pdf

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# What do we know and what can we do?



- The disease is spread mostly through the inhalation of droplets in the air from singing, or breathing. “Plosive” sounds, such as “b”, “t”, or “p” in particular, carry droplets in vortex rings out to six feet or more.
- 30% or more of those infected have no symptoms.
- There is an unquantified hazard from fomites-- the SARS-CoV-2 virus picked up from surfaces by the hand (or glove) and spread to the mouth, nose, eyes.

## **Therefore:**

- **WEAR A MASK.** Make sure it fits well. Keep it clean. This protects you and others.
- **CONSIDER A PAPR.** The HEPA filter in it is not exposed to exhalation, humidity, etc., so efficacy for 500 hours or more.
- **THE VACCINE IS COMING FOR ME AND YOU.** It is 95% effective and should be taken by all except those for whom it is contraindicated. But “Layered containment”.
- **PROTECT AGAINST CONTAMINATION BY PACKAGES, MAIL, AND FOOD.** Clean, heat, or let sit. Wear gloves when disinfecting with bleach diluted a further 100-fold.

# Needed Research on Corona



- With 58 million people over age 65 in the United States and the case-fatality rate observed in Wuhan and then in Italy, within a year the United States could expect to have two million people dead, under the reasonable assumption there would be no universal effective vaccination, and no effective antiviral drug, and without non-pharmaceutical measures that would reduce the reproduction factor of the vaccine from  $R_0$  of 3-6 to  $R_0 < 1.0$  – perhaps 0.55 – to quench the epidemic.
- Stephen Morse and I and Paula Olsiewski of the Alfred P. Sloan Foundation report in *Science*, ["Next Flu Pandemic: What to Do Until the Vaccine Arrives?"](#) what we learned from a two-day workshop we convened in early 2006 at Columbia University, with about 40 participants on the topic of pandemic influenza. We were well aware of the "Spanish flu" pandemic of 1918-1919, that killed at least 50 million people worldwide and > 650,000 in the United States, during and slightly after World War I, when the concept of "virus" was unknown, but by which time vaccines were old hat. Here are a couple of paragraphs from that 2006 report.

*Individuals must have good information on which to base choices. Guidelines remain a menu of general options with little specific advice. Some modeling results (ref. 18) suggest that simple measures could be quite effective. Although many of these suggestions seem just common sense (such as keeping a sick family member in a separate room with a closed door), there is no systematic evaluation of best practices for "home infection control." A starting point might be modifying experience from health-care settings for the home.*

# Research on Corona (2)

\*\* Will insert live link for Colgate \*\*

- Although it was by no means universal knowledge, in laboratory experiments guinea pigs and other animals susceptible to the human influenza infected one another by what could only have been aerosols— droplets from exhalation small enough that they remain in the air for hours— so I was interested in the effectiveness of face masks, and -- for the general population -- in the re-usability of highly effective masks such as the now familiar N95, that, despite the small leakage from a well-fitting mask, would reduce the infectious dose from ambient air by 95%. Here is a pointer to my presentation and "[Face Masks in Context for Fighting Flu-- Health Care Workers and the General Public](#)," by R.L. Garwin, presentation to the Institute of Medicine Study of Reusable Facemasks for Protection in Pandemic Influenza, March 6, 2006 A video on YouTube of work done by my physicist colleague at Los Alamos, Stirling Colgate, and a colleague from New Mexico Tech, on multiple washings of the N95 mask. The mask certainly survives, but unless one washes in plain water or perhaps hydrogen peroxide solution, the electret charge on the small fibers of the melt-blown plastic filter material is not restored after washing, and the effectiveness of the mask drops greatly.
- I was distressed by the lack of knowledge and the lack of ongoing work on modalities of transmission of a particular epidemic and for years at Erice, Sicily, with the World Federation of Scientists group organized by Prof. Antonino Zichichi, the head of the Ettore Majorana Centre for Science and Culture, I led a Permanent Monitoring Panel for Mitigation of Terrorist Acts, especially of bioterrorism acts, and we evolved an understanding and recommendations of what to do at various levels of society, to counter, nominally, pandemic influenza. Here is my presentation of the Panel's work, "[Conquering Pandemic Flu by Practical Measures](#)," as adopted by the Mitigation Sub-Group of the Permanent Monitoring Panel on Terrorism of the World Federation of Scientists, Erice, Sicily, May 22, 2006. Membership of the Sub-Group on Mitigation Aspects: Dr. Diego Buriot, Dr. Kevin Clark, Professor Baruch Fischhoff, Professor Richard L Garwin (Chairman), Professor Pervez Hoodbhoy, Dr. Sally Leivesley, Professor Ron Manley, Professor Richard Wilson.

# Research on Corona (3)

## **Primary PPM [from the 2006 Erice presentation] :**

1. Wash the hands after contact with potential contagion—e.g., when returning home, to the workplace, or frequently in space shared with others who may be symptomatic. If hand washing is inconvenient, use a 60+% alcohol-content hand sanitizing gel.
  2. When in the presence of others, use a surgical mask or an N95 filter mask to protect against droplets or aerosols respectively. If masks are not available, improvise a mask such as a scarf over the eyes and mouth.
  3. Don't shake hands; bump elbows in greeting.
  4. Keep hands away from your face—especially eyes, nose, and mouth.
  5. Don't infect others; use a tissue or piece of paper towel for sneezes and coughs and have a bag for used tissues.
  6. Eliminate or reduce unnecessary trips, even local ones.
  7. If you need to care for a person who might be sick with flu, use additional precautions such as diluted household bleach for bed clothes and for cleaning surfaces.
  8. Practice these procedures at least one day every two weeks.
  9. Clean and circulate air where people are in proximity, e.g., in transport, offices, assembly work.
- At the same time, I was trying to get the modelers of epidemics, who mostly employ the S-I-R model or extensions thereof to gain some intuition and understanding of the worth of various interventions, to take into account not only characteristics of the germ (virus, bacillus, parasite, etc.) but of various actions such as social distancing, reduction of travel, mask wearing, and the like. I have many letters outgoing and a few incoming on this, but little was accomplished and incorporated into policy or prediction.
  - The lesson that I took from my service with the New Technologies Panel of the National Commission on Health Manpower was that one needed primarily to copy "best practices" and not just seek new approaches to battling disease, although that might be most effective in the long run.

# Corona comes to USA



1. Pandemic finally came to the United States in January/February. Spread quickly in New York City and in my neighboring community of New Rochelle, NY., and thus became of more than academic interest. Expert opinion of WHO and CDC-was to wash hands and limit exposure to other people. The main means of transmission was through hands to face, mouth, or nose, and from others airborne or "fomite" (surface) transmission.

2. China, after having denied the existence of the disease for some weeks and even punishing Dr. Li Wenliang in wunan who tried to alert his colleagues to it (and who later died of the disease), reversed priorities, took it very seriously, and implemented strict lockdown in Wuhan and in its province of Hubei. Chinese scientists and medical professionals were very active in research and in open publication of the genome of the SARS-CoV-2 virus responsible for Covid-19 disease. This enabled immediate vaccine development in Germany, US, and elsewhere.

3. As a member of the three National Academies of Science, Engineering, and Medicine I tried my best to have these entities take the initiative. Also tried to persuade elements of the US government. To no avail, alas.

4. 3/11/20. Watched television-- including session of a group from the National Academy of Sciences meeting with government officials from the agency responsible for biomedical research and development, BARDA of HHS, and head of the Office of Science and Technology Policy. The first four hours of that meeting was on CSPAN, and then it went into closed session. The government seemed to be most interested in future pandemics, though I knew effective solutions for future pandemics relied upon surviving this one. Academies were unresponsive to my suggestions after the meeting.

5. I am also a member of the JASON group of consultants to the US government-- to the Defense Department, the State Department, the Intelligence Community, and even to the Census Bureau of the Department of Commerce, and to the Department of Energy, which does a good deal of research in biology. All these government departments and agencies have enormous numbers of employees that they should be attempting to protect, in addition to the primary mission of the departments.

6. JASON had a normal Winter Study in La Jolla for almost two weeks in January before the pandemic was evident in the United States. The JASON Summer Study was done largely by remote participation-- particularly difficult for the classified tasks of the dozen or more items that we were contracted to work on in the summer of 2020. But JASON did get itself organized in a non-funded study and published a report initially 07/02/2020, to assess risks and best practices for restarting university research programs.

7. The series is at <https://fas.org/irp/agency/dod/jason/> and the particular item is [Managing the Risk From COVID-19 During a Return to On-Site University Research - covid-19.pdf](#) JSR-20-NS1, updated August 25, 2020

# What we didn't or still don't know



- We have learned much about Covid-19 but there is more to know.
  - Aerosols are produced in normal exhalation, speaking, loud speaking, shouting, and especially in amateur singing.
  - Masks. Worn by someone who is infected and perhaps asymptomatic, eliminate plosive projection of droplets and aerosols to a distance of six feet larger droplets that would become aerosols when the droplet evaporates and reduces its diameter by a factor five or so.
  - The other form of protection offered by face masks is to protect the wearer against ambient virus in the form of droplets or aerosols, which was the topic of my presentation to the Institute of Medicine in 2006.
- Covid-19 is NOT influenza. It is a disease primarily transmitted via the lungs and nose, affecting heart, blood vessels (clotting) and of many other systems in the human body. Some of the damage comes from the active immune system, and that, too, could be prevented by preventing infection.
- Newly learned: There is an enormous range of amount of virus— virion titer — in the aerosols emitted, presumably, as detected in the swabs used for Covid-19 assessment. The most usual COVID-19 infection may amount to  $10^4$  or  $10^5$  virions per cubic centimeter, but ~1% of the infected population has 1 million times this much— a titer of  $10^{11}$  or even  $10^{12}$  virions/cc.
- ***This means: By far, most of the virus among those infected comes from the 1 or 2% with the highest titer, and those are not necessarily those with severe symptoms.***
- Alerted by my colleague Michel Maharbis, in late May I wrote the group in Germany that had published the results in a paper that was addressed primarily to the time variation of viral titer in infected individuals, and I produced the first version of this graph that was included in the JASON Report and taken up seriously by my colleague, Scott Kemp, in the Nuclear Engineering Department at MIT. He gave a presentation via Zoom, to an international group centered in London, on 08/16/20, and I followed up with this presentation of 09/01/20, incorporating many of his and Maharbis's slides. By then, Abbot Labs had announced its lateral flow test for antigens of SARS-CoV-2, and I take that into account.
- **Where is the US government in all this?** Operation Warp Speed— OWS— led to the investment of billions of dollars with firms to buy vaccines before they were developed or tested, in order to stimulate their availability. The rest of the response of the federal government is dismal or negative, with the President actively denying the importance or even the existence of the pandemic in the United States, and White House staff interfering with the work of CDC and even the National Institutes of Health and the Food and Drug Administration-- FDA.
- The Administration early on eliminated the portion of the National Security Council in the White House that had the duty to respond to bioterrorism,
- In conversations with Robert Woodward, published by the Washington Post and Woodward in conjunction with his book ***Fear***, President Trump volunteers that he understood that the virus was lethal, but that he didn't want to cause panic by stating so.
- The Administration was unwilling to use the Defense Production Act, the DPA, for what it could readily have done (which it did, indeed, with OWS) – to buy large amounts of new production of N95 masks, of powered ventilators, and of innovative non-pharmaceutical intervention, NPI, materials such as the Aurora PAPR masks (powered air purifying respirator) that I have bought for \$70 at amazon.com and have now purchased (in a minimum lot of 100) for \$15 each from Shenzhen, China.
- Now for my September 1 presentation, from which I will read selected passages.

# Covid-19 Pandemic

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[www.fas.org/RLG/](http://www.fas.org/RLG/)  
[search with, e.g., \[site:fas.org/RLG/ pandemic\]](http://www.fas.org/RLG/pandemic)  
[RLG2@us.ibm.com](mailto:RLG2@us.ibm.com)

Cosmos Club National Security Group (Zoom) Meeting

September 1, 2020, 6:00 p.m.

## Abstract

The talk begins with the concept of epidemic disease, e.g., influenza epidemics, and then discusses some of the differences with the current pandemic of Covid-19. On September 1, the disease has infected at least 6 million people in the United States and has killed almost 200,000. Had measures not eventually been taken in the form of social distancing and mask wearing-- still only advised on a federal scale-- deaths in the United States would likely have amounted by now to 1 million, on track to about 2 million by the time *herd immunity* was reached. Without an effective vaccine or treatment of the disease, that number will still die to achieve herd immunity, although draconian measures with severe impact on the economy and other aspects of life can keep hospitals and funeral homes operable.

The talk then introduces results new since late May, that a couple percent of those infected have viral titers that contain 95% of the total viral load, so that it is only these individuals with million-fold greater viral load than the median infected person who need to be isolated, while the rest can work while infected with normal masking and social distancing, if they are without symptoms, though still infected. Some 30% or more of those who recover from Covid-19 never have symptoms.

And on August 26, Abbott Labs obtained FDA emergency use authorization-- EUA-- for a "\$5, 15 minute" test that does not require an instrument to read it and that identifies a person with the highest titer probably in a couple of minutes, although requiring 15 minutes to show that a person does not have antigens present at the sensitivity of the test. Understanding the mechanism of creation of the super-titers of viral load is not essential to the utility of the strategy enabled by their existence, but might be important in the longer run in eliminating such super titers. There seems to be only one published study, from Charité – Universitätsmedizin Berlin, with data on the range of viral load from 3.6 to 11.7 "log<sub>10</sub> viral load"-- that is from 5,000 to 500 billion virions per cc of fluid from a nasal swab, and that is a matter of concern. [One hour after I distributed this Abstract as D9.doc, I received from Scott Kemp a paper<sup>1</sup> with his comment, "*This comparison between two PCR methods shows a range of  $3 \times 10^{10}$ , see figure 1, also attached.*" This is the only modification from D9.doc as presented.]

Without major action by the CDC, other countries can benefit from these perceptions and advances, and it may also happen that states and cities, universities and large corporations may proceed. FDA approval of workplace and home employment of this and analogous tests is essential and might be facilitated by adoption of such an approach abroad.

<sup>1</sup> <https://jcm.asm.org/content/58/6/e00599-20> Posted online 10 April 2020, "Clinical Evaluation of the cobas SARS-CoV-2 Test and a Diagnostic Platform Switch during 48 Hours in the Midst of the COVID-19 Pandemic"

## Partial Bibliography for Garwin on This COVID-19 Pandemic

...”\*\*

1. Conquering Pandemic Flu by Practical Measures. <https://fas.org/rlg/060521-flu.pdf>
2. <http://gabgoh.github.io/COVID/index.html> (Gabriel Koh) with Epidemic Calculator
3. <https://fas.org/rlg/conquering.pdf> Mt. **Sinai** School of Medicine, New York, NY February 16, “Conquering **Pandemic** Flu by Non-Pharmaceutical Means, and Other Thoughts on Health Care”
4. March 11-12 Partial C-SPAN transcript of House Committee Hearing with Dr. Robert R. Redfield, CDC Director and others.
5. How Much Worse the Coronavirus Could Get, in Charts, by [Nicholas Kristof](#) and [Stuart A. Thompson](#), March 13, 2020 [with epidemic simulator]
6. <https://www.erinbromage.com/post/the-risks-know-them-avoid-them> [05/06/20 Excellent, readable]
7. *COVID Immune Responses Explained*, Eric J. Topol, MD; Abraham Verghese, MD; Akiko Iwasaki, PhD August 21, 2020
8. <https://www.newyorker.com/tech/annals-of-technology/jonathan-rothbergs-race-to-invent-the-ultimate-rapid-at-home-covid-19-test>
9. *You're Positive, But Are You Contagious?* by [Apoorva Mandavilli](#), 08/29/2020, at <https://nyti.ms/31DJixp>.

Thank you for the opportunity to discuss the current Covid pandemic. This is the third version of this talk I have prepared, and I feel that I have been working on it for 15 years. Here is a brief section of a presentation I gave in Erice, Sicily, in 2006. This is not new, and certainly not original with me. It is hard-won knowledge in fighting pandemics and was put to good use in the Ebola outbreak and in other quite different diseases.

**Primary PPM<sup>2</sup>:**

1. Wash the hands after contact with potential contagion—e.g., when returning home, to the workplace, or frequently in space shared with others who may be symptomatic. If hand washing is inconvenient, use a 60+% alcohol-content hand sanitizing gel.
2. When in the presence of others, use a surgical mask or an N95 filter mask to protect against droplets or aerosols respectively. If masks are not available, improvise a mask such as a scarf over the eyes and mouth.
3. Don't shake hands; bump elbows in greeting.
4. Keep hands away from your face—especially eyes, nose, and mouth.
5. Don't infect others; use a tissue or piece of paper towel for sneezes and coughs and have a bag for used tissues.
6. Eliminate or reduce unnecessary trips, even local ones.
7. If you need to care for a person who might be sick with flu, use additional precautions such as diluted household bleach for bed clothes and for cleaning surfaces.
8. Practice these procedures at least one day every two weeks.
9. Clean and circulate air where people are in proximity, e.g., in transport, offices, assembly work

<sup>2</sup> From Conquering Pandemic Flu by Practical Measures <https://fas.org/rlg/060521-flu.pdf> (05/21/2006)

What is the problem, and why does this work?

Most epidemics arise from diseases communicated from one individual to another (community transmission) by means that are implicit in the prescription for quenching the pandemic. The germ (which includes bacteria, viruses, parasites, and other forms of "life") has evolved to make a living, so to speak, by infecting humans. One speaks of these episodes in terms of the population (number of people) susceptible— S, infected— I, and removed (recovered or dead)— R and assumed no longer infectible, at least in the short term. Such models have existed for almost a century, and are available in many examples, e.g. in a NYT article of 04/13/20<sup>3</sup>. I will exercise such a model, Zoom willing<sup>4</sup>.

In the early days of this epidemic, one person with the disease infects more than one other person, so the disease grows with a reproduction factor  $R_0 > 1.0$  per generation of the epidemic. It grows exponentially, so that if in a certain time interval  $T_2$ , the number of those infected doubles, then in the next interval it will double again, and again, and again. It is the nature of the exponential that not only does the number I of those currently infected expand in this fashion, but also those that have been infected and that join the population in the R category. You can play with this yourself. If the current case load expands by a factor 10 in  $T_{10}$  days, it will expand a further ten-fold (one log) in the next  $T_{10}$  days.

About February 1, 2020, when I became well aware of the Covid-19 epidemic that began in Wuhan, Hubei Province, China, in December 2019 or earlier, I tried, as did others, of course, to warn that according to the data made available by China at that time, the United States could expect to lose two million people— mostly old people. What were those data?

Calculator, <http://gabgoh.github.io/COVID/index.html>

<sup>3</sup> How Much Worse the Coronavirus Could Get, in Charts, by [Nicholas Kristof](#) and [Stuart A. Thompson](#), March 13, 2020 [with epidemic simulator]

<sup>4</sup> Epidemic

The table shows data from China about the age distribution of victims of the novel coronavirus-- Covid-19, *COVID-19 Fatality Rate by AGE:*

AGE	DEATH RATE confirmed cases	DEATH RATE all cases
80+ years old	21.9%	14.8%
70-79 years old		8.0%
60-69 years old		3.6%
50-59 years old		1.3%
40-49 years old		0.4%
30-39 years old		0.2%
20-29 years old		0.2%
10-19 years old		0.2%
0-9 years old		no fatalities

**\*Death Rate** = (number of deaths / number of cases) = **probability of dying if infected by the virus (%)**. The percentages do not have to add up to 100%, as they **do NOT represent share of deaths by age group**.

The *case-fatality ratio-- CFR--* was a few percent, overall. This compares with the ~35,000 people in the United States who die of seasonal influenza each year, of many tens of millions of people infected– or a *CFR* in the case of seasonal flu of about 0.1%.

Clearly this was a serious disease. After initially denying the existence of an epidemic in Wuhan, and even punishing physicians who attempted to alert their colleagues, China came relatively clean, inviting representatives of the World Health Organization– WHO– to the scene of the epidemic, providing a joint WHO-China report on the visit of 16-24 February 2020<sup>5</sup>. The Wuhan Institute of Virology (WIV) early-on sequenced the genome of the SARS-CoV-2 virus responsible for Covid-19, and published it freely on 1/10/20, which allowed scientists in China and anywhere else in the world to begin efforts to create a vaccine and pharmaceuticals for treatment of the disease; there are none yet accepted as a result of this effort.

It is essential to understand that with an *Ro* of 3.0 and an inter-generation time (*serial interval—i*) of 5 days, the doubling time of the case load is 3.1 days, and with an *Ro* of 6.0, as seems to have been the case in the crowded quarter of Wuhan, the doubling time is half that, or 1.5 days. So a short response time is of the essence; for *Ro* = 3, a week's delay increases the number of cases by a factor 4.7

<sup>5</sup> <https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf>

The world was left with non-pharmaceutical intervention-- *NPI*-- or non-pharmaceutical measures-- *NPM*. These were exactly what I, as an observer, had been advocating for many years, especially after the SARS outbreak in 2002-2004. SARS-- *sudden acute respiratory syndrome* – began in Guangdong province, China. SARS is much more lethal than SARS-CoV-2-- with a *CFR* of 11% but was vanquished with a total number of cases worldwide<sup>6</sup> <9,000, and deaths <900; no case of SARS has been reported since 2004. The world was lucky with SARS that an infectee can communicate the virus only after showing symptoms, namely an elevated body temperature. China led the way (after initially denying the existence of the disease) by deploying remote body temperature monitoring equipment at travel centers, diverting and quarantining those with elevated body temperature. [RLG demo].

That this was a fortunate accident, became apparent with Covid-19, for which it is clear that people who do not yet show symptoms, and people who have and recover from the disease in a couple of weeks without any symptoms, effectively transmit the disease during the first days of the infection and for about two weeks.

What is the mechanism of transmission? This is a crucial point, emphasized in my talks a decade ago, for instance one of 02/16/2016 at Mount Sinai Hospital Medical Center in NYC<sup>7</sup>,

Economists are largely undeterred by lack of facts, which only make their job more difficult. But I mean this as approbation for the presentation and papers of Wein, in this case. First, Larry Wein judges (without much experimental confirmation) that influenza is communicated in large part by aerosol transmission and not by droplets or by fomites. His prescription, therefore, is that individuals wear N95 masks, capable of trapping 95% of aerosols of diameter 0.3 micron or larger. There are, of course, many problems with such a prescription. The masks are uncomfortable and warm or even stifling. They are often not fitted very well, and there are, by far, insufficient masks and money to pay for them if they are used by the public as they are in the hospital surroundings, with a new mask for every encounter. So I long ago set out with my friend Stirling Colgate to encourage simple experimental determination of the possibility of multiple reuse of N95 masks. I referred to this in my presentation to an Institute of Medicine panel and, of course, made it a point to bring up at our 2006 workshop.

In February 2020, the United States with no intervention and essentially no guidance from CDC-- the Centers for Disease Control and Prevention-- was on track for two million deaths. The CDC later advised voluntary lock-down and optional mask wearing, after explicitly recommending that the population should not wear masks or face covering. I will discuss this further with a verified C-SPAN transcript of a long House hearing of 03/11-12/20 with CDC Director, Dr. Robert R. Redfield.

Epidemics are typically self-limited by the development of "herd immunity" where the number of susceptible people is reduced sufficiently by transfer from the *S* to the *I* and then to the *R* category so that, with a given *Ro*, the virus doesn't find enough susceptibles to spread, so it gradually and totally dies out.

<sup>6</sup> [https://en.wikipedia.org/wiki/Severe\\_acute\\_respiratory\\_syndrome](https://en.wikipedia.org/wiki/Severe_acute_respiratory_syndrome) [Good article]

<sup>7</sup> <https://fas.org/rlg/conqueringpdf>

I should also have commented that in the early days of this epidemic in the United States-- in New York in particular-- the doubling time for the infected population was 2-3 days. Had total isolation been introduced, the virus would have been gone in about two weeks, although 2% or even 15% of those infected (depending on age) would have died over the next month. Furthermore, the epidemiological modeling community has not over the decades properly identified and observed  $R_0$  as characteristic not of the virus itself, but also strongly affected by the social conditions.

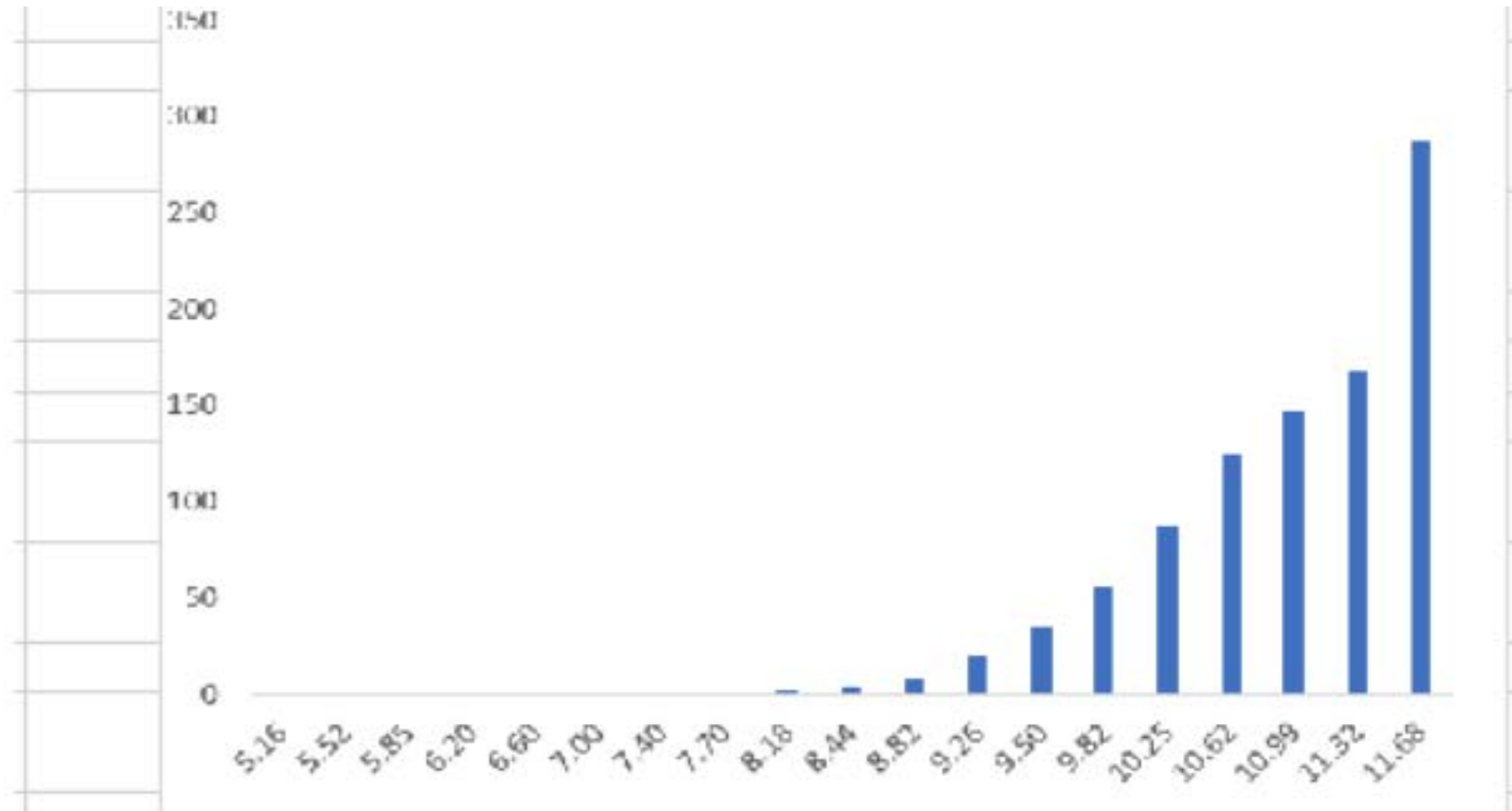
I do emphasize that whether herd immunity is developed by inaction or by continued limitation of social contacts to limit the steady case load to numbers that do not overwhelm hospital facilities, we will still suffer the two million deaths in the United States in achieving herd immunity, unless an effective vaccine or treatment is developed. To say that this is "unacceptable" is not helpful. But new developments, even in the last few days, show the way out.

Now I quote from the work of Scott Kemp, physicist at MIT, who was a principal in writing the JASON report<sup>8</sup> of July 10 on reopening university research laboratories in a Covid-19 era. In a Zoom presentation 08/17/20, Kemp has included the next five slides. The first two build on a finding<sup>9</sup> from May 2020, that a few percent of those infected (of 3712 in the cohort) harbor 95% of the viral load, and, if identified quickly after they are infected, could be quarantined, while the rest of those infected could go about its business with  $R_0 < 1.0$ , and so the epidemic would die out in that society, as did SARS in 2004. Kemp's theory, sketched on these slides, accounts for the fact that a tiny fraction of people infected have a million times the viral load usual to those who have Covid-19. And his final slide shows the potential solution to this problem. [→ Kemp slides]

Kemp's Slide 11 reproduces the banal-appearing data of that "Viral load" publication. On 06/03/20 I had written the authors with an early version of Kemp's Slide 12. So the analysis goes from "Distribution of viral titers found in PCR samples" to "Contribution of total viral load by PCR-sample bin," via "Temporal Pattern of Average Infection" to "Distribution of Viral Titers." The top curve is the prediction for the highest 2% of the viral titers of Kemp's Slides 11 and 12, via a theory of viral reproduction and suppression in the human body. The Red curve, peaking at 1 is the single curve of the previous slide on a log scale of Viral Titer, making clear the exponential nature of the growth and decay of the virus in this simple theory.

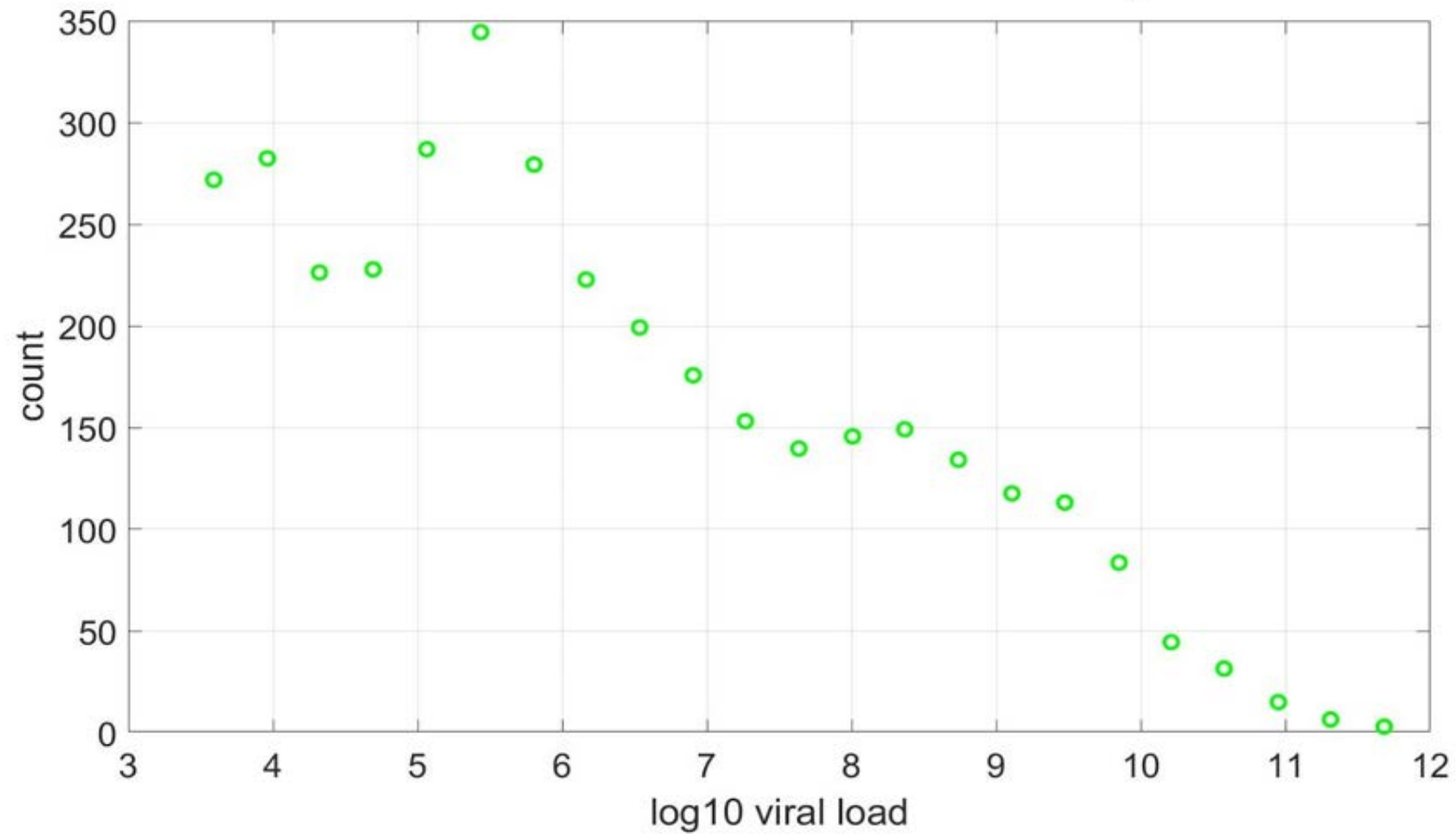
<sup>8</sup> <https://fas.org/irp/agency/dod/jason/covid-19.pdf>

<sup>9</sup> [https://zoonosen.charite.de/fileadmin/user\\_upload/microsites/m\\_cc05/virologie-ccm/dateien\\_upload/Weitere\\_Dateien/analysis-of-SARS-CoV-2-viral-load-by-patient-age.pdf](https://zoonosen.charite.de/fileadmin/user_upload/microsites/m_cc05/virologie-ccm/dateien_upload/Weitere_Dateien/analysis-of-SARS-CoV-2-viral-load-by-patient-age.pdf)

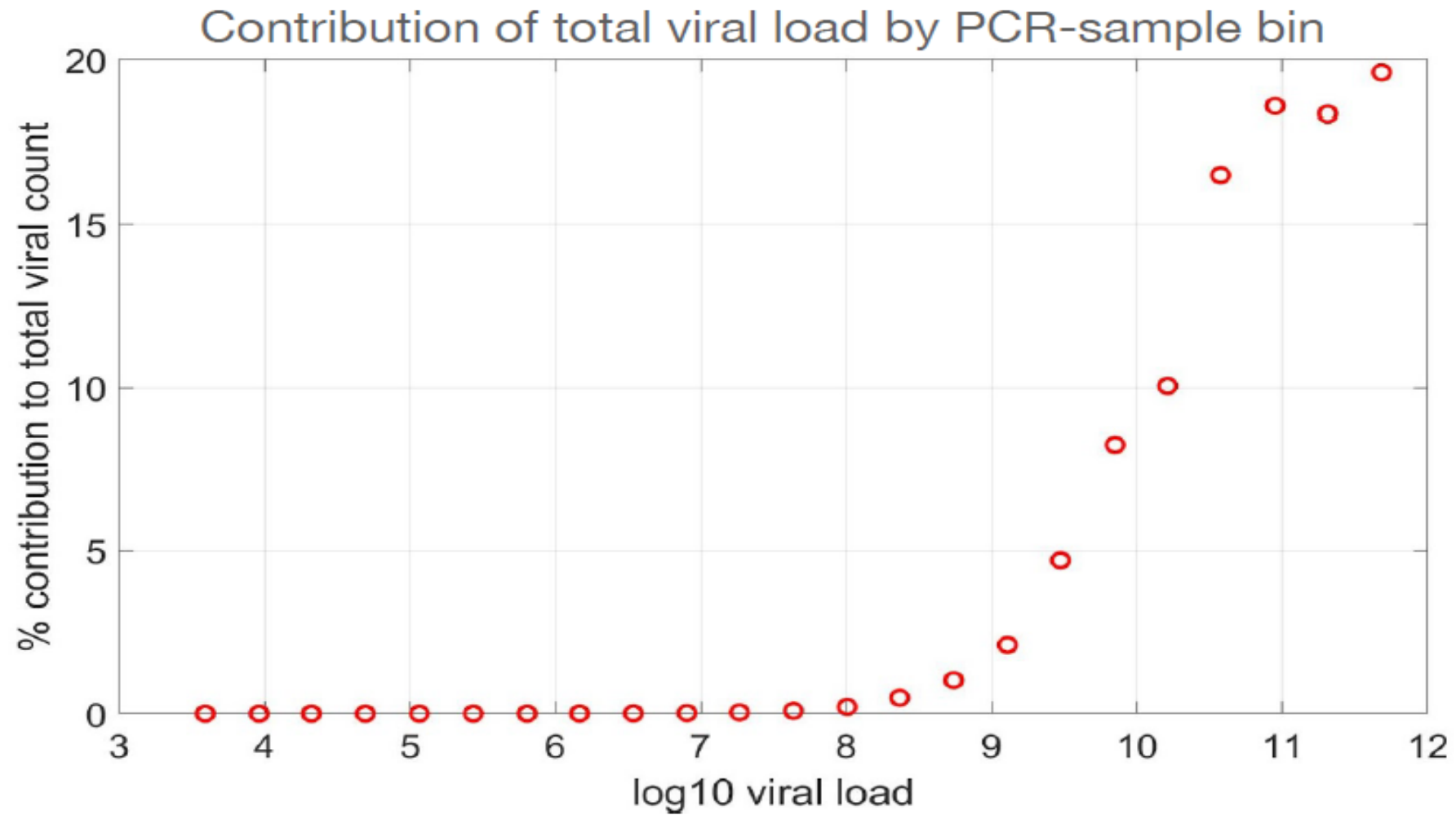


The right-hand chart I reconstructed from the image of Figure 1 in your publication, and in the left chart I plotted it multiplied the the numerical value of the viral load in that bin.

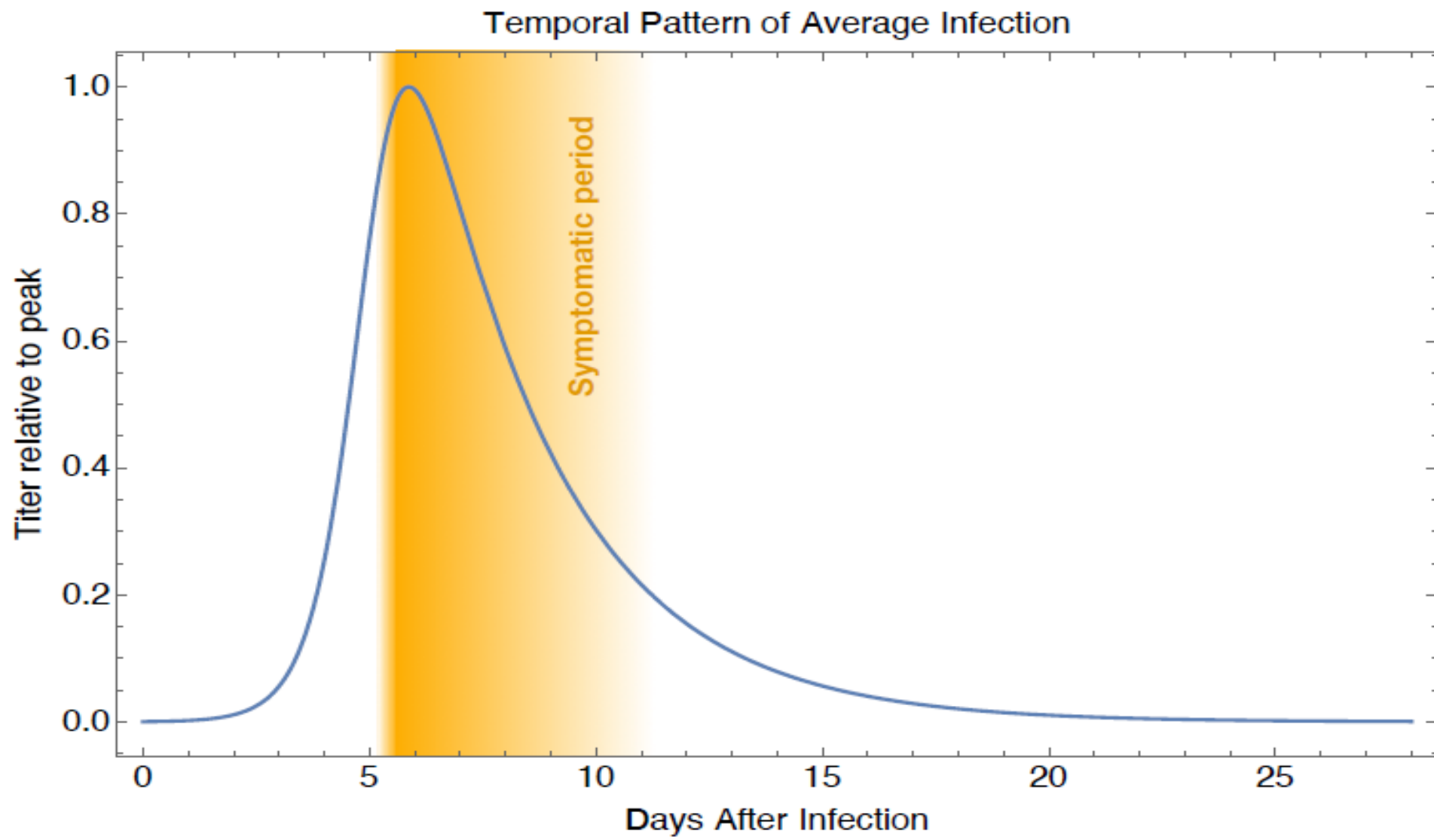
Distribution of viral titers found in PCR samples

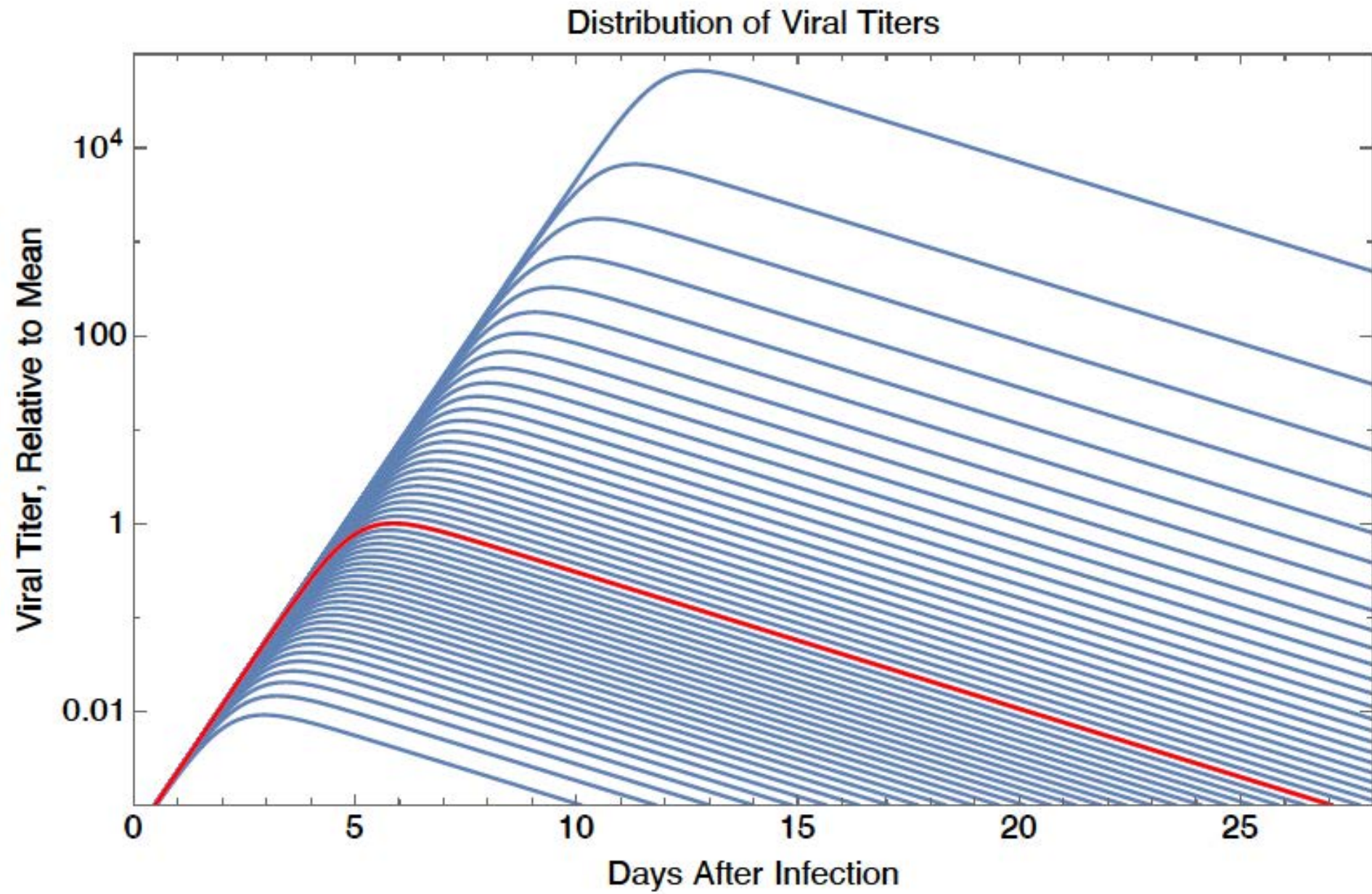


<https://www.cdc.gov/media/releases/2020/s110520-covid-virus.html> - Original data from Terry C. Jones et al., "An Analysis of SARS-CoV-2 Viral Load by Patient Age" (Chow, D., Jones, T., Berlin, n.d.)



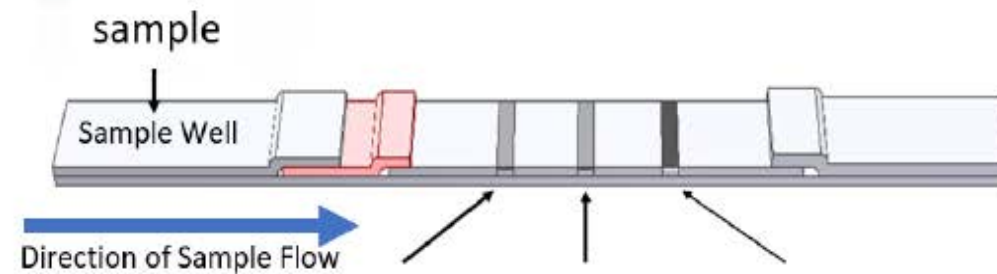
Source: JASON, JSR-20-NS1. <https://fas.org/irp/agency/dod/jason/covid-19.pdf>. - Original data from Terry C. Jones et al., "An Analysis of SARS-CoV-2 Viral Load by Patient Age" (Charité - Universitätsmedizin Berlin, n.d.)





## Test Requirements

- Comfortable
- Accessible at home or place of business
- Extremely inexpensive
- No laboratory required
- Rapid (ideally instant) results



Abbott Laboratory announced 08/26/20<sup>10</sup> its “\$5, 15-minute” BinaxNOW™ COVID-19 Ag Card test not for the virus, but for antigens—Ag-- in the virus, which shows almost 100% detection sensitivity for those infected. A key point is that the "super-titerers" can probably be identified in about one minute, and that the test will probably work as well with saliva input as it does with a nasal swab.

What does this mean?

Germany is reopening its schools with a low ambient Covid incidence, limiting the contact of students to those in a single classroom, without mixing with others during the day. They use an active program of monitoring and contact tracing, and quarantining only those in a classroom, rather than the whole school.

In using the Abbott Ag test to find those with super titers, one has to choose testing frequency and strategy in a particular context. For instance, in a school or a building with many suites occupied by a single corporation, until the virus is eliminated locally the need is to test sufficiently frequently, with consequent isolation of those testing positive, to reduce the  $R_0$  below 1.0. Here [RLG demonstrate] I remind you what reducing  $R_0$  from 2.2 to 0.5 does to an epidemic. As I could have said at the beginning, although perfect protection of oneself against the ambient virus is not possible, absolute protection of oneself by societal response is indeed feasible, as demonstrated by the return of unencumbered social contact in Wuhan in recent weeks, and in the elimination of SARS worldwide. That bears repeating. But as I said in 2006, to remind people that the danger is not far off, but that it can be absolutely conquered by NPI even before an effective vaccine or treatment is available, we need to

**8. Practice these procedures at least one day every two weeks.**

Roughly speaking, if a Covid-19 case spreads the virus by aerosol route for three days of asymptomatic (including pre-symptomatic) breathing and speaking, testing each person each day is likely to catch infected individuals within no more than one day of infection, and isolating them (denying them entry) would thus reduce  $R_0$  by the target factor of three.

But in the longer term-- when for the most part there is no virus present and no infected people in the pod, one can adopt a policy of adaptive sampling, since the next generation of those infected will likely require several days in order to have achieved the titer required for significant transmission in the community. If this seems tentative, you’re right. To say that we lack full understanding of the implications that a tiny fraction of those infected are responsible for essentially all of the aerosol transmission overstates greatly the state of our knowledge.

<sup>10</sup> <https://Abbott.mediaroom.com/press-releases>

To illustrate specifically the human problems of progress in understanding this novel virus, I quote an expert comment<sup>11</sup> on the February 2020 paper regarding the time and mode of Covid-19 transmission.

*“This virus is transmitted by people sneezing or coughing on you. Masks are for those people who are coughing and sneezing—for them to wear to reduce their coughing or sneezing their virus upon you—not for you to wear when you’re not the one coughing or sneezing. This behavior of everyone wearing masks doesn’t stop the spread; in fact it may increase the potential for warm moist areas for the virus to survive and it promotes unnecessary fear.”*

This represents the faction evidently dominant in the WHO that lacked understanding or acceptance of aerosol transmission, which is the only mode that can account for many examples of community spreading, including the early one choir practice in Washington State 03/10/20<sup>12</sup>; according to the CDC, 87% of the choir members contracted Covid-19 and two died.

To summarize, if super titerers account for almost all the community transmission, then it is only they who need be found and isolated. This reduces the impact on society by perhaps a factor 40 compared with universal lockdown, even while there are a lot of people infected. Just as we were gifted by the fact that SARS is communicated only by those with high body temperature, so there is a fortunate aspect of SARS-CoV-2 in that those with high titers may be detectable much more quickly even with the Abbott test than those infected with normal titers. Perhaps the million-fold super titerer can be detected in real time before entry; but even admitting a person who will test positive after 15 minutes and has already been seated at her workstation, contributes little to  $R_0$  if sent home promptly, compared with having the super-titerer work all day.

That is, even if all were admitted to their workplace, having been sampled on entry, isolating these super titerer after 30 minutes still reduces substantially the communication that can have taken place, although the titer is sometimes so high that even a few minutes of aerosol production may provide a high probability of transmission. This does not have to be all worked out in advance of this talk, but it clearly merits discussion and intensive research.

Without major action by the CDC, other countries can benefit from these perceptions and advances, and it may also happen that states and cities, universities and large corporations may proceed. FDA approval of workplace and home employment of this and analogous tests is essential and might be facilitated by adoption of such an approach abroad.

<sup>11</sup> Richard M Fleming, PhD, MD, JD; Matthew R Fleming, BS, NRP; Tapan K Chaudhuri, MDFHHI-OI-Camelot; FHHI-OI-Camelot; Eastern Virginia Medical School 10 March 2020

<sup>12</sup> <https://www.cnn.com/2020/05/13/us/coronavirus-washington-choir-outbreak-trnd/index.html>

## Two, partial transcripts of: House Oversight and Reform Committee Hearing on Coronavirus Response, March 11, 2020

Derived from C-Span coverage: <https://www.c-span.org/video/?470224-1/dr-fauci-warns-congress-coronavirus-outbreak-worse>

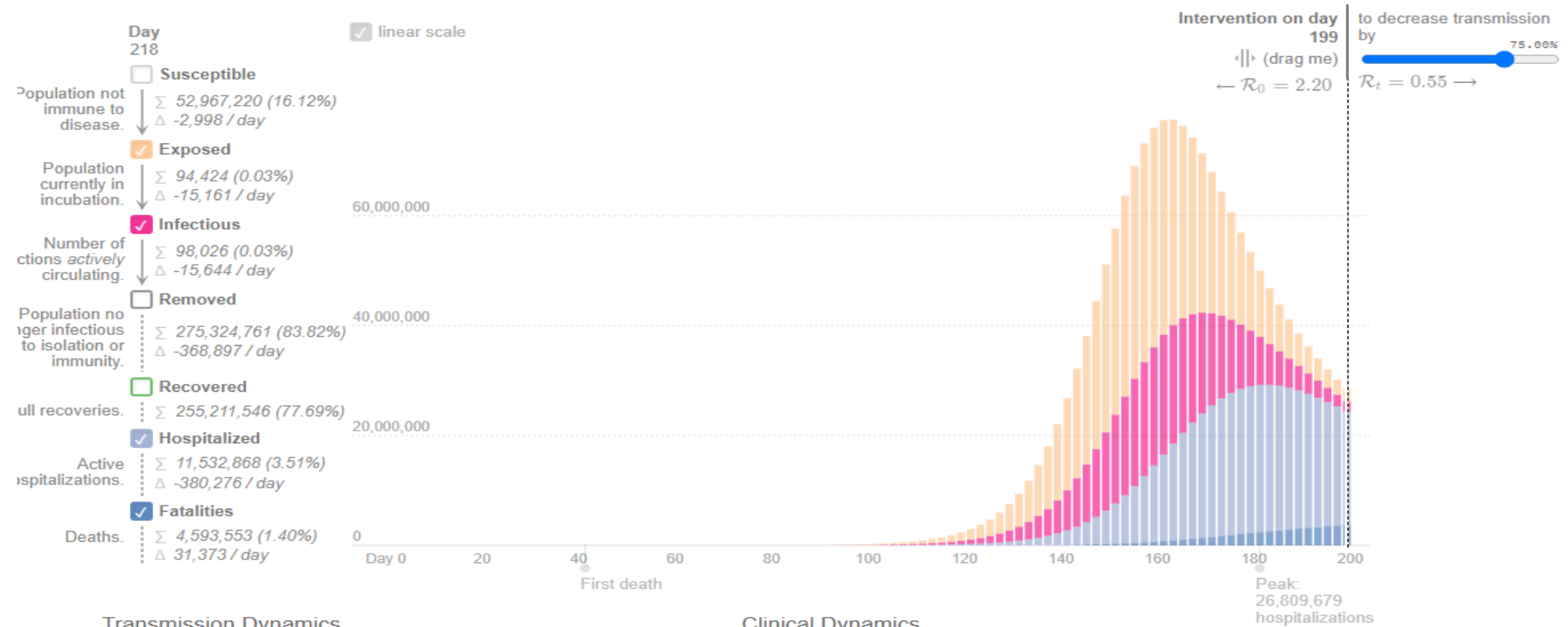
01:00:07 **MR. COOPER**

ARE THERE ANY PLANS TO HAVE DRIVE-THRU TESTING IN AMERICA SO WE DO NOT PANIC EMERGENCY ROOMS WHEN PEOPLE COME IN AND COUGH?

01:00:15 **DR. REDFIELD**

NOT AT THIS TIME. I THINK WE'RE TRYING TO MAINTAIN THE RELATIONSHIP BETWEEN INDIVIDUALS AND THEIR HEALTH CARE PROVIDERS.

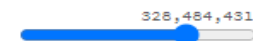
# Epidemic Calculator



## Transmission Dynamics

### Population Inputs

Size of population.



Number of initial infections.



### Basic Reproduction

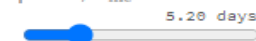
Number  $\mathcal{R}_0$

Measure of contagiousness: the number of secondary infections each infected individual produces.



### Transmission Times

Length of incubation period,  $T_{inc}$ .



Duration patient is infectious,  $T_{inf}$ .



## Clinical Dynamics

### Mortality Statistics

Case fatality rate.



Time from end of incubation to death.



### Recovery Times

Length of hospital stay



Recovery time for mild cases



### Care statistics

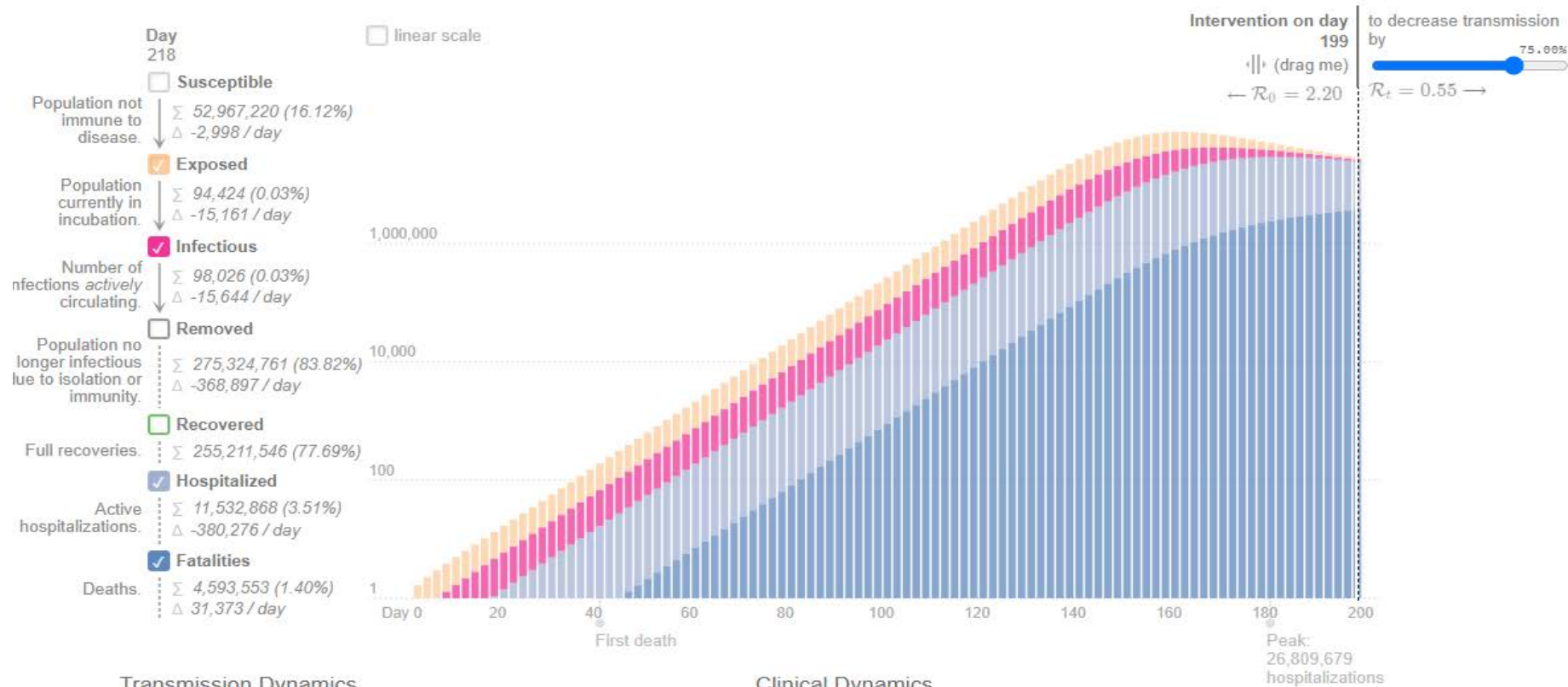
Hospitalization rate.



Time to hospitalization.



# Epidemic Calculator



## Transmission Dynamics

### Population Inputs

Size of population.

328,484,431

Number of initial infections.

1

### Basic Reproduction Number $\mathcal{R}_0$

Measure of contagiousness: the number of secondary infections each infected individual produces.

2.2

### Transmission Times

Length of incubation period,  $T_{inc}$ .

5.20 days

Duration patient is infectious,  $T_{inf}$ .

2.9 Days

## Clinical Dynamics

### Mortality Statistics

Case fatality rate.

2.00 %

Time from end of incubation to death.

32 Days

### Recovery Times

Length of hospital stay

28.6 Days

Recovery time for mild cases

11.1 Days

### Care statistics

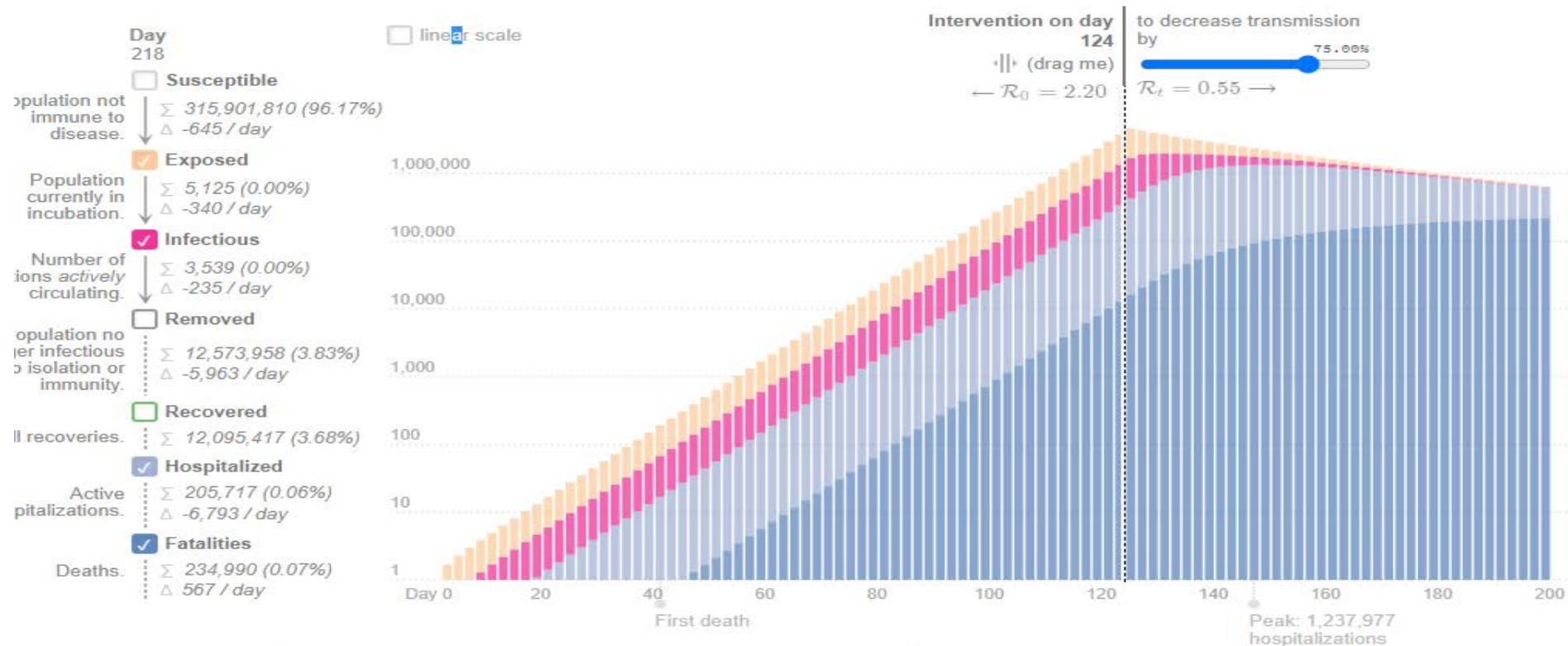
Hospitalization rate.

20.00 %

Time to hospitalization.

5 Days

# Epidemic Calculator



## Transmission Dynamics

### Population Inputs

Size of population.

328,484,431

Number of initial infections.

### Basic Reproduction Number $\mathcal{R}_0$

Measure of contagiousness: the number of secondary infections each infected individual produces.

2.2

### Transmission Times

Length of incubation period,  $T_{inc}$ .

5.20 days

Duration patient is infectious,  $T_{inf}$ .

2.9 Days

## Clinical Dynamics

### Mortality Statistics

Case fatality rate.

2.00 %

Time from end of incubation to death.

32 Days

### Recovery Times

Length of hospital stay

28.6 Days

Recovery time for mild cases

11.1 Days

### Care statistics

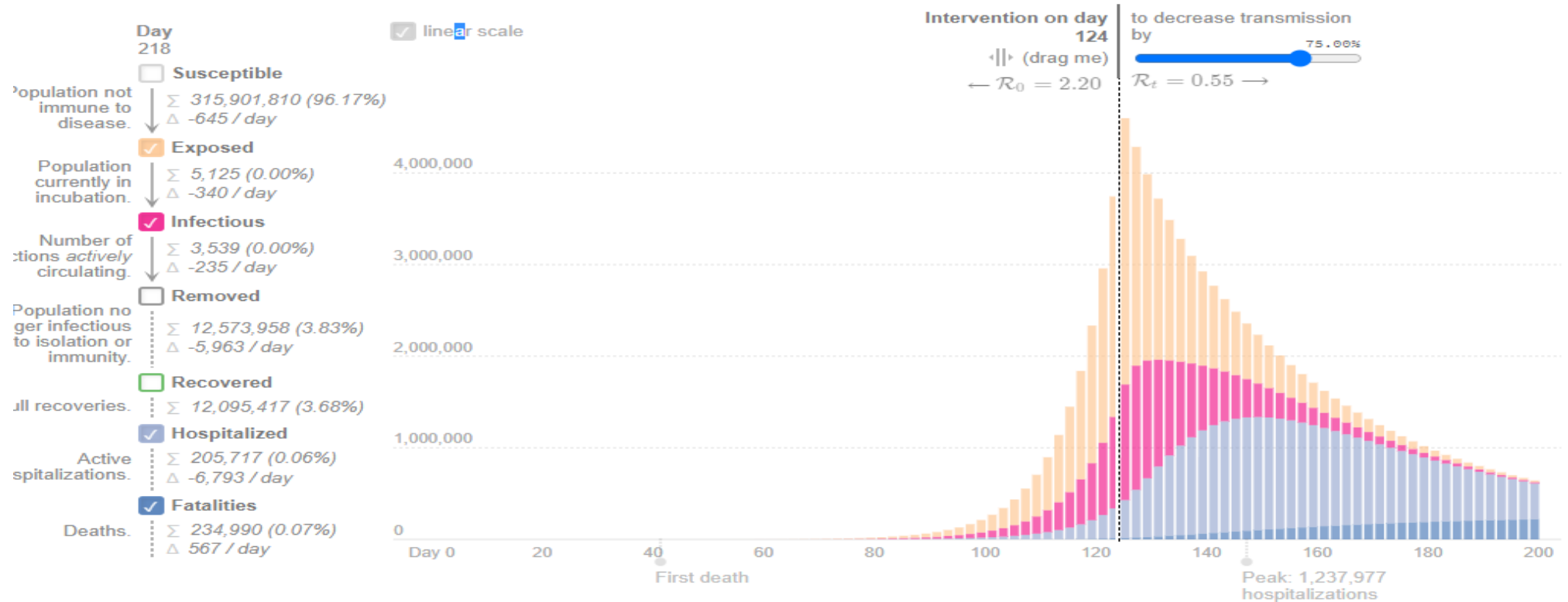
Hospitalization rate.

20.00 %

Time to hospitalization.

5 Days

# Epidemic Calculator



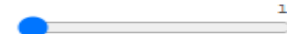
## Transmission Dynamics

### Population Inputs

Size of population.



Number of initial infections.



### Basic Reproduction Number $\mathcal{R}_0$

Measure of contagiousness: the number of secondary infections each infected individual produces.

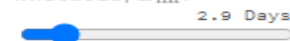


### Transmission Times

Length of incubation period,  $T_{inc}$ .



Duration patient is infectious,  $T_{inf}$ .



## Clinical Dynamics

### Mortality Statistics

Case fatality rate.



Time from end of incubation to death.



### Recovery Times

Length of hospital stay



Recovery time for mild cases



### Care statistics

Hospitalization rate.



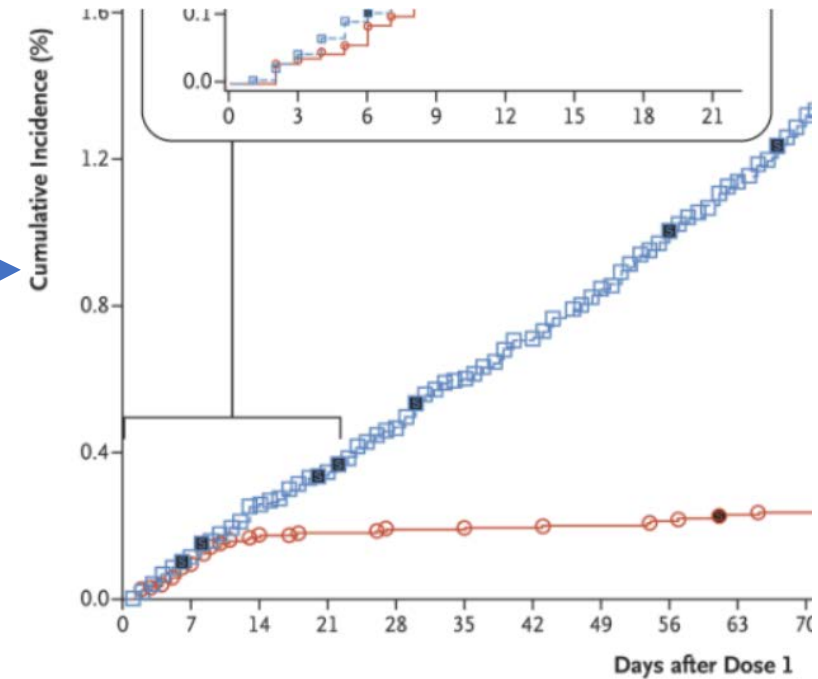
Time to hospitalization.



# Examples of Research Needed in the Context of Quenching the Pandemic and Avoiding an Additional Million U.S. Deaths

## Pharmaceutical Interventions (examples)

- Continue assessment of existing Pfizer and Moderna mRNA vaccines
  - Against variants of concern – VOC
  - Growth of immunity by day (Pfizer): ----->
  - Loss of immunity by week or month
  - Look for long-term effects of mRNA vaccine in general
  - Rapid assessment of early treatment with inexpensive widely used drugs.



## Non-Pharmaceutical Interventions (examples)

- Assessing and reducing contagion and effort required to avoid it
  1. Amount of virus on mail, newspapers, vegetables, packages. How to wash N95 mask while maintaining its filtration efficacy.
  2. Contact time necessary/sufficient to inactivate SARS-CoV-2 on surfaces, gloves, and hands, by the use of augmented weak bleach:  
500 g water, 5 g of 5% chlorine laundry bleach, 5 g white vinegar, 3 g detergent
- Home care for people ill with COVID-19
  1. What at various stages of the disease?
  2. Utility of consumer Pulse Oximeters, Infrared Fever Thermometers.
  3. Improving blood oxygen level by lying prone (chest down).
  4. How and when to use supplemental oxygen, e.g. in the form of an at-home oxygen concentrator as used for those with emphysema.

# Personal Comment On the Past and the Future

In February and March, 2020, I was dismayed with the lack of attention in the U.S. Government to the pandemic and with the non-use of the Defense Production Act simply to order large amounts of PPE on speculation, to fill stocks for the Veterans Administration and for the care of the Armed Forces at home and abroad, and their families, which is the responsibility of the Department of Defense. The Administration designed and funded Operation Warp Speed to develop and produce vaccines against COVID-19, which succeeded spectacularly, but without the design, creation, or funding of programs to administer the vaccine.

I recalled dimly the mobilization for World War II, organizing for Scientific Research and Development in support of the war effort, the Office of Production Mobilization, the later 1950 Defense Mobilization Act, and the like. There seems to be nobody within the government whose job it is to prepare for sudden nation-wide mobilization as also was the case for WWII, when the military arsenals and development organizations were (probably fortunately) transparently inadequate to do the job of providing a peak production rate of 200 combat airplanes per day, of a total of 200,000 during the war, and the like.

As a member of all three National Academies of Science, Engineering, and Medicine, I tried to interest officials to lead or urge the creation of such organizations (or in creating such capabilities from the large government departments and agencies that we have— e.g. the NRDC formed in 1940 and the OSRD— Office of Scientific Research and Development under Vannevar Bush) but there was no resonance or, so far as I could see, understanding that the future of the United States and even of civilization was in peril and might be rescued by such mobilization against the pandemic. Pretty soon I had found no route to persuasion, and so I knowingly retreated to trying to do something about the pandemic itself.

I totally missed some aspects of the pandemic, that a few minutes of discussion in a collegial or adversarial environment would have brought to light— the critical shortage of funeral homes in New York City, and of burial and cremation facilities. I did understand the poor state of the American public health non-system that I had been trying to remedy since the mid-1960s, but that is another story.

Utility of consumer-type PAPR mask— powered air purifying respirator

For the future, we need to dig our way out of the pandemic disease. In the post-pandemic era we can will make use of the new tools that we perforce have had to adopt at enormous human cost, that might be highly beneficial to the society for the future, such as telemedicine and work from home, and enhanced teleconferencing as is familiar to us from Zoom and similar apps, If we survive this pandemic as a society, we will need to learn how to survive decades of peace and stability, and still be ready for a new pandemic, for a major asteroid impact, for an out-of-control cyber attack.

You, my audience, younger and more vigorous, have the opportunity to address these problems and to solve them.