Coronavirus: An Analysis using Complex Dynamic Systems Theory | Yaneer Bar-Yam

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The greatest shortcoming of the human race is our inability to understand the exponential function. — Albert Allen Bartlett

INTRODUCTION

Yaneer Bar-Yam was born in Boston, Massachusetts to a Jewish family in 1959. He received his B.S. degree in 1978 and his Ph.D. degree in 1984, both in physics from the Massachusetts Institute of Technology. He was a Bantrell Postdoctoral Fellow, and a joint postdoctoral fellow at MIT and IBM. In 1991, after a junior faculty appointment at the Weizmann Institute, he became an Associate Professor of Engineering at Boston University. He left Boston University in 1997 to become president of the New England Complex Systems Institute. He is also an Associate of the Department of Molecular and Cellular Biology at Harvard University. He is chairman of the International Conference on Complex Systems and managing editor of InterJournal.

WHY DO I CARE?

I've been trying to find a trusted and communicative guest on Hidden Forces to discuss COVID-19 for some time now. I had been in regular contact with Anthony Fauci's team at NIH since mid-January, but alas, the doctor has been one of the busiest people dealing with this issue. My second choice was former FDA Commissioner Scott Gottlieb, who has been excellent in giving timely updates about the progression of the virus, efforts to contain or mitigate the spread, and early treatment options being experimented with. Again, Scott is a very busy guy and booking him for a 1-2 hour-long conversation proved difficult. A few days ago, however, I was contacted by a friend who recommend a professor Yaneer Bar-Yam to me. He informed me that Yaneer and Nassim Taleb lecture together at the New England Complex Systems Institute, which piqued my interest. As it turns out, Yaneer studies the unified properties of complex systems as a systematic strategy for answering basic questions about the world. His research is focused both on formalizing complex

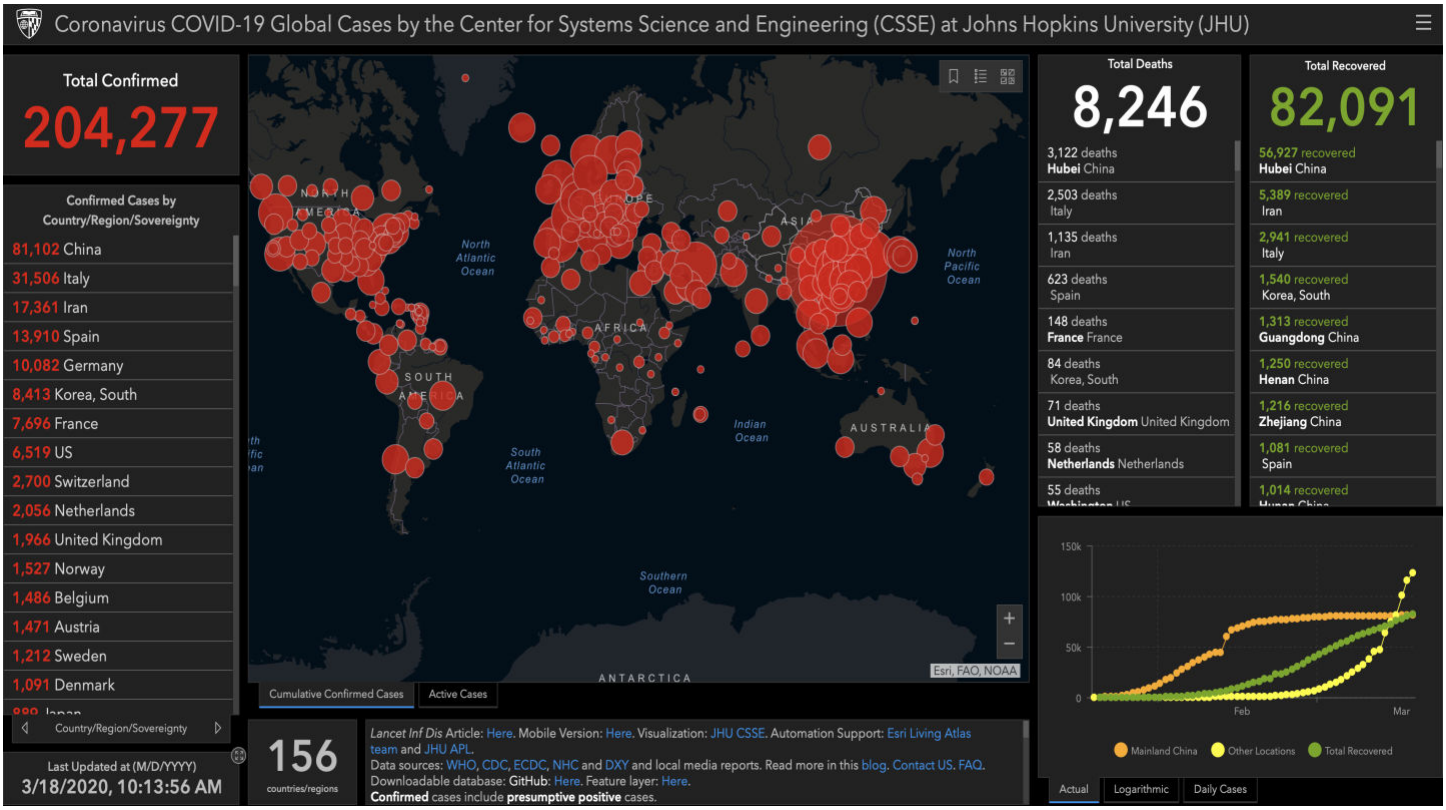


systems concepts and relating them to everyday problems. In particular, he studies the relationship between observations at different scales, formal properties of descriptions of systems, the relationship of structure and function, the representation of information as a physical quantity, and quantitative properties of the complexity of real systems. Applications have been to physical, biological, and social systems. He has applied this background to COVID-19 by not only studying and putting out material and information about the virus, but actually launching endCoronavirus.org, a website built and maintained by NESCI whose "goal is to minimize the impact of COVID-19 by providing useful data and guidelines for action."

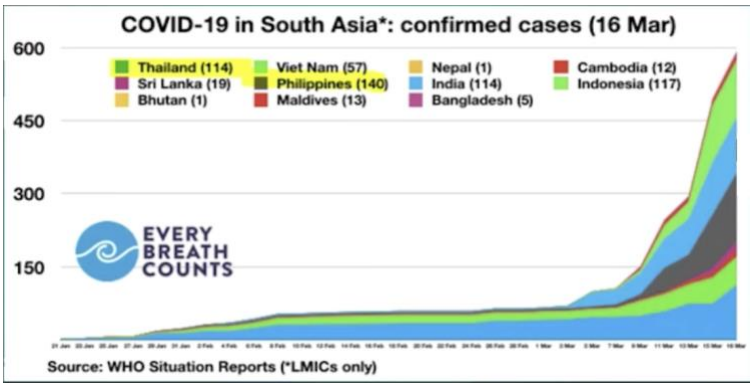
Yaneer and his colleagues have put out more alarming numbers than those often cited by public officials in recent weeks and months. According to Yaneer's research team, which has co-faculty, students and affiliates from MIT, Harvard, Brandeis and other universities, "COVID-19 is a rapidly transmitting disease that evolves in 20% of cases to require extended hospitalizations and roughly 2-4% of cases result in death, with risks increasing rapidly for those over 50 years old. It can transmit even with mild symptoms (coughing, sneezing, or elevated temperature) and perhaps before symptoms appear. Reducing the likelihood of transmission requires everyone to reduce their likelihood of contact not only so they aren't infected but also so that they don't transmit the disease to others. If everyone got tested for COVID-19, we could temporarily separate the infected from the uninfected. This would help reduce the spread of the virus and allow for societies to function normally. For these reasons, universal testing is our highest priority. Aggressive and bold actions are required to reduce transmission by minimizing close-contact interaction in order to reduce vulnerability and risk for individuals, but also to "get ahead" of the outbreak so that it is stopped."

LATEST INFORMATION

According to the latest data available through the WHO and Johns Hopkins websites, we are at about 200,000 confirmed cases worldwide with roughly 8,000 deaths and 80,000 recoveries. The big increases we are seeing among countries reporting confirmed cases are Italy, Iran, and Spain. Testing has been a problem in the United States, so it's hard to really know what the numbers will



be once we reach baseline. South Korea has had the most success combating the virus with a total case fatality of roughly 1% if you divide the 84 confirmed deaths by the 8,413 reported cases (1,540 recovered). Infection fatality rate is undoubtedly lower, even though some of the outstanding reported cases will result in death.



QUESTIONS

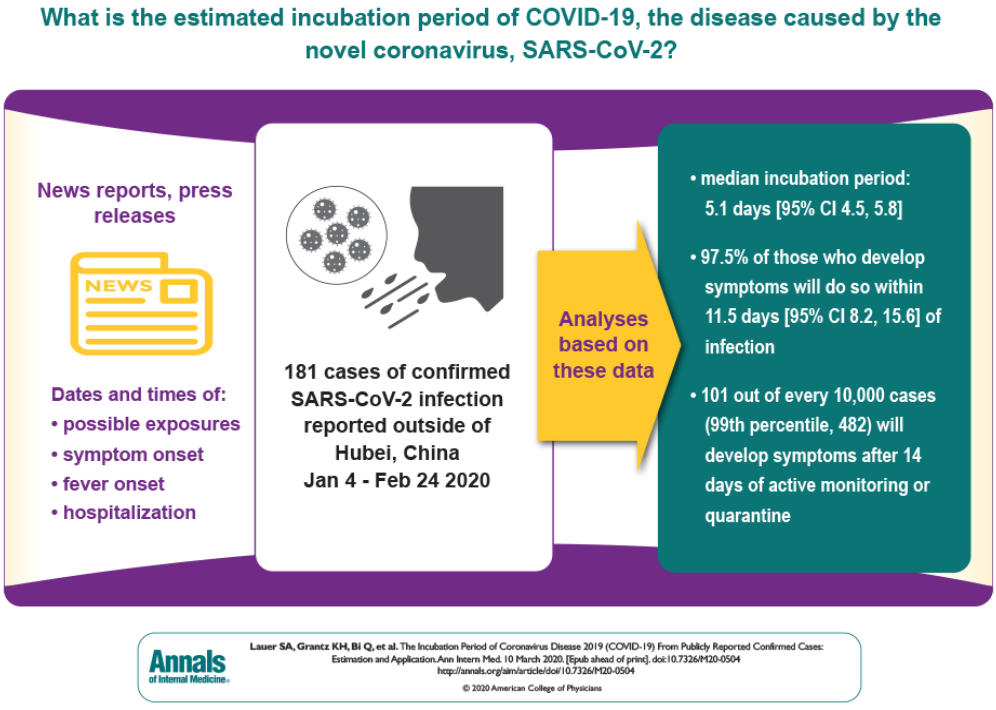
What is COVID-19? — COVID-19 is an infectious disease caused by a virus in the coronavirus family. There are many types of coronaviruses, and these commonly cause mild respiratory illnesses. COVID-19 is caused by a new coronavirus, and it was first discovered in Wuhan, China. **Q:** What is COVID-19? **Q:** What does it mean that this is a "novel" coronavirus? **Q:** Are there a variety of strains and do we know if the vast majority of people develop immunity once exposed? **Q:** Is there any evidence that this virus escaped from a lab in Wuhan or anywhere else, and does it matter either way since we already have the genome sequence?

Origins & Early Signals — From what I have read Chinese authorities first identified a cluster of COVID patients in Wuhan, China in late December 2019. **Q:** What are the origins of this virus and where did it come from? **Q:** When did it begin to pop up in China and how long after did the authorities there begin to take it seriously?

Over-Panic? — Q: Is this virus "the big one" that many epidemiologists have been warning us about or is the fear around this virus among those who are finally paying attention and self-quarantining overdone? (mixed messages from Cuomo)

Current Situation — Q: Where are we at globally with this pandemic at the present moment?

Good Information — According to your team, Coronavirus causes about 20% severe cases and 2% deaths. This is about 20 times higher than the flu. A typical incubation period is 3 days, but it may extend to 14 days, and reports exist of 24 and 27 days. It is highly contagious with an increase from day to day of 50% in new cases (infection rate R0 of about 3-4) unless extraordinary interventions are made. **Q:** What is the best resource for people who want the most accurate numbers for how many people have been diagnosed in their area and the mortality rate? **Q:** How do you take that data and then extrapolate a value for where we are now?



Case Fatality Rate vs. Infection Fatality Rate — **Q:** How are we measuring fatality for this virus? **Q:** Is it fair to divide total deaths by total cases or do we need to only count those cases that are officially recovered? **Q:** How does this help us understand what the fatality rate is across the entire population or what it will be when all is said and done?

Exponential Function — **Q:** What is it that people don't understand about exponential growth curves? **Q:** Why, when you have an exponential growth does a "small" reaction not do anything? **Q:** What is the doubling rate of this virus?

Growth Rate — **Q:** We were at about 10K cases outside china 2 weeks ago. We are over 100k today. **Q:** Does that mean we should expect to see 1 million in two weeks from now (or that we actually at 1 million today)? **Q:** What are important terms? (RN 3-4) **Q:** How solid is this number?

Mitigation vs. Suppression — **Q:** What does it take to stop the contagion? **Q:** What is the correct approach? **Q:** Who is doing it right and who is doing it wrong?

What is the Situation in Italy — **Q:** What is the situation in Italy? **Q:** Are measures having an effect? **Q:** What is the UK and other countries doing?

Social Distancing — **Q:** What is social distancing and why is it six feet the recommendation for "social distancing?" **Q:** Where does that number come from? **Q:** How do family members deal with the fact that people in the home will infect one another?

Asymptomatic Contagion — **Q:** How long can someone contagious while also being symptomatic, and how contagious can someone be without having symptoms? (i.e. the more symptomatic, the more contagious?)

Incubation Period — According to a study published a week ago (Annals of Internal Medicine), there were 181 confirmed cases with identifiable exposure and symptom onset windows to estimate the incubation period of COVID-19. The median incubation period was estimated to be 5.1 days (95% CI, 4.5 to 5.8 days), and 97.5% of those who develop symptoms will do so within 11.5 days (CI, 8.2 to 15.6 days) of infection. These estimates imply that, under conservative assumptions, 101 out of every 10 000 cases (99th percentile, 482) will develop symptoms after 14 days of active



monitoring or quarantine. **Q:** What do we know about the incubation period for this illness, how does this compare to the flu, and what does this mean for the spread of the virus?

Symptoms — According to your team, symptoms of COVID-19 commonly include fever, coughing, and tiredness. Some patients also experience aching, nasal congestion, runny nose, sore throat, or diarrhea. Most people recover from this virus without needing special treatment, but some may become seriously ill and develop difficulty breathing. Older people, and those with existing medical problems like heart problems, high blood pressure, or diabetes, are more likely to develop severe symptoms. **Q:** What are the common symptoms? **Q:** How long does the disease last on average (and median duration)? **Q:** How mild is "mild" and what percentage have mild symptoms? **Q:** How severe is "severe" and what percentage have those symptoms? **Q:** How long does the disease last in this case, and do all these people require hospitalization? **Q:** How many of these require ventilation and ICU?

Strained Hospitals — **Q:** What are we looking at in terms of demand vs. supply of hospital beds and ICU facilities at what we can conservatively estimate will be the peak of this epidemic? **Q:** How many people who don't have coronavirus will die or suffer because of the strained hospitals?

Essential Services — **Q:** How are essential services going to be provided for people who self-quarantine and/or are unable to provide for their families as a result of their businesses shutting down, being laid off, electing not to go to work?

Second, Third, etc. Waves — **Q:** What is the risk that a second wave of infections will be seen once interventions are lifted? I've heard arguments opposite to those made by you which is that mitigation will only make things worse in the long run because we need to develop herd immunity.

Total Infections in the End — **Q:** How many people are going to get this?

Treatments — **Q:** What sorts of treatments are being currently used or experimented with both in the US and abroad?

