Open Letter on COVID-19

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2am, March 9, 2020

Goal.

This letter aims at convincing the US Governments and the public about the urgent need to **immediately adopt aggressive social distancing policies** to contain the spreading of COVID-19.

Facts.

1. **Once community spread takes hold in a country or region, the number of cases increases exponentially, doubling every 3 days or so, unless aggressive social distancing policies are enforced.**
    a. See, e.g., number of cases outside China, and in France, Germany, Spain, Switzerland, UK, Netherlands, Sweden, Belgium, Norway.
    b. [**Update. March 10.**] Exponential growth occurs because the number of newly infected people is proportional to the number of people already carrying it. In a simplified model, if each person carrying the virus on average transmits to 0.26 persons per day, the total number of patients will be multiplied by 1.26 each day, and will double every 3 days. Starting from 100, it takes 10 days to go to 1000, 20 days to go to 10,000, 30 days to go to 100,000, etc.
    c. [**Update. March 10.**] The spreading of communicative diseases follows the same mathematical models as the spreading of computer worms. See studies on how code-red worm, the SQL slammer worm spreads. Once exponential growth starts, it slows down **only when getting close to saturation** (every target has been infected), **unless intervention stops the growth**.
    See figure.

2. **The US case number has been growing exponentially for over a week.** On Saturday Feb 29, the total number of US cases is 69, including 47 cases originated from the Diamond Princess cruise ship or Wuhan evaluation, and **22 local cases**. By Saturday Mar 7, the number of local cases rose to **388**. **Within 7 days, the number of local cases increased more than 16 folds, doubling more than 4 times.**
3. **When the number of cases reaches thousands, the sheer volume of patients will overwhelm the healthcare system.** Hundreds or more people (mostly older citizens) die, and medical workers will suffer greatly. See reports on this in S. Korea, Italy on Mar 2, Italy on Mar 7, Europe.
    a. A March 6 Testimony of a Surgeon working in Bergamo,Italy uses first-hand experience to explain the stress on hospitals and that COVID-19 is not flu.
    b. [Update. Mar 11.] By locking down Hubei province, China limited the numbers of COVID-19 cases in other provinces to be relatively small. When hospitals in Hubei are overwhelmed, China mobilized the medical resources of the whole country to help.
4. **COVID-19** ~~**has a significantly higher fatality rate than Flu**~~ **appears to be about 20 times as deadly as Flu for every age group.** Flu is estimated to have fatality of 0.1%. Estimation of the fatality rate of COVID-19 varies, some numbers are 2.3% according China's CDCP, 3.4% according to the WHO.
    a. [**Update. Mar 10.**] Comparison of age-based fatality rates of Flu vs. COVID-19.

Flu	0 to 17: 0.01%	18-49: 0.02%	50-64: 0.06%		65+: 0.83%	
COVID-19	10 to 39: 0.2%	40-49: 0.4%	50-59: 1.3%	60-69: 3.6%	70-79: 8%	80+: 14.8%

    b. According to worldometer, among 66,106 closed cases, there are 3828 deaths, translating to a 5.8% fatality rate. This is dominated by data from China. It could be too high, as many people with mild symptoms in China may be self-quarantined and not discovered. On the other hand, this is achieved because China can mobilize medical resources of the whole country to treat patients in Hubei. The rate would be a lot higher otherwise.

c. The numbers from the other countries with more than 5000 cases are worrisome. As of March 5, S. Korea tested 140,000 cases, with 6000 positive cases, and 33 deaths. However, using 33/6000 to claim 0.6% fatality rate is utterly wrong, since the vast majority of the 6000 cases are still active, and the number of deaths will increase. As of March 8, S. Korea has 51 deaths, 166 recovered cases, and 7165 cases being treated. S. Korea's thorough testing means that even patients with mild symptoms are included, yet this yields a tentative fatality rate of 51/(51+166) = 23.5%, which is alarmingly high.

d. Similarly, as of March 8, Italy has 366 deaths, and only 622 recovered cases. Iran has 194 deaths for 2134 recovered cases. These are the most critical numbers to be watched in the next few days. Some scientists claim that there are two strains, with one deadlier, but there is no consensus.

e. Even for a very conservative estimation of fatality rate of 1%, it would mean 5% to 10% of patients need hospital care, which cannot be provided when it is a pandemic. Without adequate medical care, the fatality rate will be higher.

5. **Strong social distancing measures**, taken by S. Korea and China, have **effectively slowed down, and are on path to stop** the spreading of the virus in China and S. Korea.

   a. Italy was forced to close all schools starting Mar 4, quarantine 16 million people starting Mar 8.

   b. **[Update, Mar 9]** Italy finally **lock down the whole country on Mar 9**. **Had Italy taken decisive action one week ago, it could have avoided locking down the whole country,** just as China's locking down Hubei avoided the need for locking down the whole country.

   c. The number of cases in the US is about the same as Italy's numbers 10 days ago. What Italy is doing now, the US is likely to have to follow in 10 days.

6. **The risk to each individual at this time (i.e., Mar 9) remains low.** Even if one million people within US are infected, the chance that one person gets it is 1 out of a few hundreds. ~~Also, the fatality rates for young people are known to be low.~~ [Correction on Mar 10: see the updated fatality analysis earlier.] However, the risk to everyone **increases exponentially over time** as the number of cases rises, and **the risk to society is very high.**

Prediction and Justifications.

Without new decisive containment efforts, the number of confirmed cases in US will increase at least 10 folds in 10 days, to 4000 or more (and possibly as high as 10,000) by Mar 17.

1. Every region with cases reaching 400 has been on exponential growth until reaching 4000. To go from around 400 to 4000, it took China 6 days, S. Korea 8 days, Italy 9 days, Iran 7 days.
2. In 3 days (from Mar 5 to Mar 8), France case number grows from 423 to 1126, and Germany grows from 349 to 847, both significantly more than doubling.
3. So far, the number of persons tested in the US is low. According to the Atlantic, less than 2000 persons were tested as of Mar 6, with 10% positive rate. On the Grand Princess cruise ship, out of the first group of 46 tested, 21 were positive. These indicate that many people with the virus have not been tested.
4. The virus is highly contagious. In New York, one patient leads to dozens of cases. Out of 3700 passengers and crew members quarantined on Diamond Princess, the number of confirmed cases grew from 10 on Feb 4 to 542 on Feb 18.
5. The situation will be dire by the end of March, before warm weather arrives in the northern part of the country. And experts say the expectation that COVID-19 will disappear in summer like flu is false hope.

[UPDATE, added 9pm on 3/9] US case number watch, using only non-repatriated cases. Prediction starts from number on 3/7, and is based on 27% daily growth, which results in slightly more than doubling every 3 days. (The wiki page lowered the number for 3/7 from 388 to 352 after I entered the predictions; I am keeping the original predictions based on starting from 388.)

Date	3/7	3/8	3/9	3/10	3/11	3/12	3/13	3/14	3/15	3/16	3/17	3/18
Prediction	388	493	626	795	1009	1282	1628	2068	2626	3335	4235	5379
Actual	352	495	640	926								

The Paths Ahead.

Path A. The US government takes decisive and proactive actions today and leads all countries fighting the potential devastation by COVID-19 in a coordinated effort to enforce aggressive social distancing measures to contain the spread. Looking at situations in China, this should be able to contain the virus in 4 to 6 weeks. **Life should be able to return to normal by June or July.** Economy should be able to quickly recover in a few months after that. Total number of cases in the US may be in the tens of thousands, with hundreds of deaths. There will be economic and other kinds of pains and suffering, but these are **unavoidable**.

Path B. Continue the current course of action. **In no more than two weeks (by Mar 22), the number of confirmed cases will top 10 thousands.** Health care systems in states starting with Washington, California, New York will be strained like Northern Italy today. **US government may have to adopt drastic social distancing measures similar to locking down entire cities.**

- The best case scenario is that the spreading can still be contained by these measures to be about 10 to 50 times the size as under Path A, i.e., with hundreds of thousands or a few millions of people infected, and thousands or more deaths. It will take longer for the lockdown effort to be effective because of the scale of spreading. It may be August or September before life can return to normal. And the economic damage will be a lot higher than Path A.
- Worst-case scenario is that spreading cannot be contained, and we are looking at situations predicted by some experts, with up to 70% of the population infected. Local communities will still try any conceivable containment method. Economic and social activities will be greatly disrupted. At least 20% of the population over the age of 70, as well as significant fractions of other age groups, will die while waiting for medical care, with family members desperately looking

on. The situation looks to be at least as bad as the Spanish flu. We may be looking at the worst humanity and economic disaster since World War 2. The remaining hope after the devastation is that either virus mutates to a milder form, or effective vaccines can be developed before the next wave hits.

The Choice.

It appears that US officials have admitted failure in containment and moved to mitigation; however, it is unclear what is the mitigation strategy. **The only rational choice is Path A.** While this brings the disruption to the broader society earlier, the magnitude of the disruption will be less and it will pass quicker. **Without decisive and aggressive actions now, the government will have to take these or even more drastic measures later,** when the virus is much more widespread, which leads to thousands of preventable deaths, health care systems straining to the point of breaking, longer disruption of social and economic activities, and bigger scale of damage to the society and the economy.

Every day of delaying means more people die in the end.

Any measure (economic or otherwise) not curbing the exponential spreading of the virus is like treating gangrene with band-aid.

[Update on Mar 10] Is it Too Late Already?

Some argued that it is already too late to try to contain the spread COVID-19. I believe that this is wrong because **at any point during the spreading of the virus before saturation (i.e., around 50% of the population infected), the total cost of aggressive social distancing will be much lower than the alternative**. This is true no matter 0.001%, 0.01%, 0.1%, 1%, or 10% of the population have already been infected. The cost of total social distancing is largely fixed, but the cost of letting the virus spread will increase proportionally with the size of the infected population. The benefit of preventing the infection percentage to go from 10% to 20%, based on 5%

fatality rate (which is very conservative because the vast majority of patients can receive no medical care at that point), means saving the life of 1.65 million people in the US (330M * 0.1 * 0.05).

My estimate is that currently between 0.001% and 0.01% of the population carry COVID-19, while 0.0002% has been tested positive. When the number of confirmed cases reaches 0.01% (33,000), which should happen in 3 to 4 weeks if no strong social distancing action is taken, the government and most of the society will realize that the cost of letting the virus spread is not what the society can bear. Drastic social distancing is the only way to go. My hope is to wake up the Administration and the public before we reach that point. (If one disagrees with my 3 to 4 weeks time estimation, feel free to replace it with 1 to 2 months. It doesn't change the need to act earlier rather than later.)

[Q/A. Added Mar 11]

Question. What is the end game? If 1% of the population are infected, why would social distancing/lockdown work? Wouldn't COVID-19 be with us forever, like flu does?

Answer. Each patient has a period of time during which s/he is contagious. Assume that it is 2 weeks for COVID-19. Suppose that intervention measures can reduce the average number of new patients infected by one existing patient to 0.02 person, which means on average 1 patient infecting 0.28 new patients. After one cycle of 14 days, the original patient is no longer a patient (either recovered or dead), and the patient population size is 0.28 that of the original.
This is when exponential growth (or shrinking) is our brightest hope, instead of our worst fear. Starting from a infected population of 3.3 million, see the following table:

Time	Day 0	Day 14	Day 28	Day 42	Day 56	Day 70	Day 84	Day 96
Infected popul. size	3,300,000	924,000	259,000	72,000	20,000	5769	1590	445

Somewhere around Day 60, when there are less than 20000 patients, if people at risk are thoroughly tested, and the public can clearly identify almost all patients, then only the patients

need to be isolated, the rest of the public can go back to normal life. After Day 96, it would take 3 more cycles for the number of patients to be in single digits. But very few people's life needs to be affected in that phase.

If we start now, assuming that the true number of virus carriers is 72,000, it would take 2 to 3 cycles, e.g., 4 to 6 weeks for the spreading in the US to be contained. If we wait, the period of containment will be longer.

Note that seasonal flu can be eliminated in the same fashion, but the fatality rate and hospitalization rate for flu are too low to compensate for the huge cost of the required social distancing efforts. And depending on how prevalent flu viruses are with animals, flu can easily come back to humans.

COVID-19, with about 20 times higher fatality rate, is very different. If hospitals can become strained to handle a bad flu season, imagine how it can deal with demand that is 20 times larger. When patients cannot receive hospital care, they die at much higher rate.

Question. US has lower population density than the other countries hardest hit by COVID-19, and relies less than mass transportation. Many organizations are already practicing social distancing. Wouldn't that be enough?

Answer. It is a very interesting question. [To be finished later when I can find time.]

Who is the Author and Why is He Writing This?

I am a Professor of Computer Science at Purdue University. My research area is Security and Privacy. I am no medical expert, but I am familiar with the literature on the spreading of computer viruses (the mathematical modelling of which is similar to that of biological viruses), and I have worked with numbers a lot.

I started looking at COVID-19 numbers on Feb 27 because my son signed up for his school's Spring break (Mar 14 to 21) trip to Orlando, FL, and I needed to decide whether I would allow him to go. While the numbers were low then, the exponential growth of COVID-19 case numbers was obvious. While I easily convinced my son that he should not go (he understands the power of exponential growth), I was worried about the trend, and has been following it since. Over the last week, my worst-case

predictions on the case numbers have been met, and I have seen exponential growths in more and more countries. I have also been discussing these trends with others, and found that few people saw the same things as I did. I have resigned to simply sit back and watch the situation develop. However, after reading Testimony of a Surgeon working in Bergamo, I was deeply saddened by the suffering described there. The doctor's first-person account turned the abstract numbers in my mind into vivid human suffering. I shared my frustration with my friends: "I am watching a train wreck going to happen, yet can do nothing to help." Then I realized maybe there is something I could do. If this open letter achieves its goal, thousands of people do not have to die. Thus, even if the chance of having any impact is very low, I have to try.

Acknowledgements.

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Minor edits were made throughout after the above time. Major edits are marked with [Update].