Herd Immunity or Containment through Test and Trace?

Navigating Exit Strategies from Coronavirus Shutdowns and Social Distancing

MARCH 31, 2020

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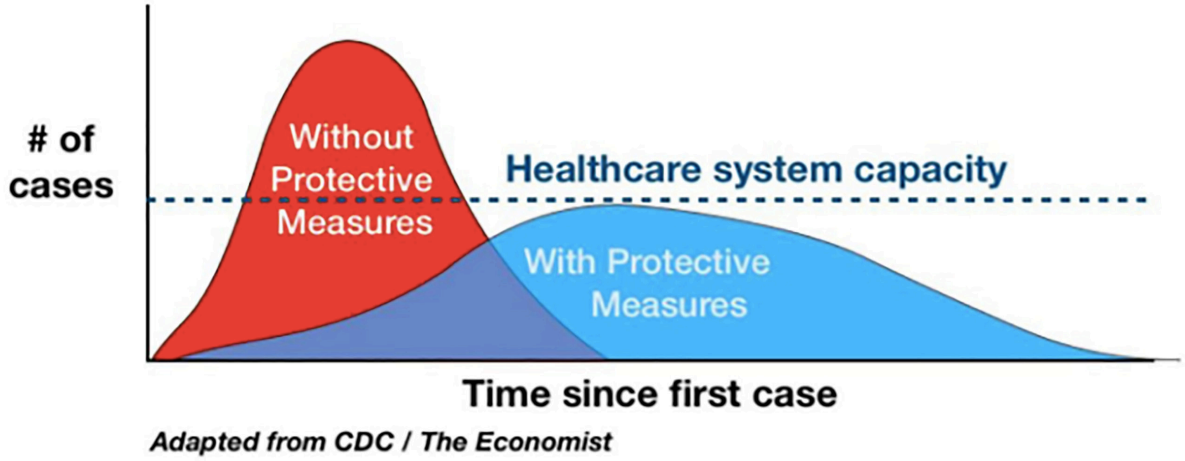
Coronavirus Disease 2019 (COVID-19), a viral disease caused by the virus SARS-CoV-2, has infected well over 600,000 globally and, as of this writing, confirmed cases are growing by about 100,000 per day. It is currently killing about 3000 each day globally, a toll that is growing about 15 percent each day. For comparison, the flu kills about 1000 each day. COVID19 is unusually contagious, and since it is new, none of us are immune. Top health experts have estimated that 40-70 percent of the world's population will be infected. With business as usual, most people will get infected and quickly—over the next four to six months.



Adapted from CDC / The Economist

Introduction

For most, catching the virus is much like catching a common cold; the effects are very minor, and they get over it quickly. Some, however, perhaps 5-10% of the population, mostly consisting of the elderly and/or people with pre-existing health conditions, will get very sick and will be hospitalized. With state-of-the-art care, most of these people will survive too, but many will need intensive care and a ventilator to help them breathe. Since COVID19 is new, some have warned that there might be long-run consequences for those who recover from the disease; but this is unknowable.

The biggest problem with treating COVID19 is that there simply are not enough hospital beds, ventilators, and healthcare workers to care for more than a small fraction of the critically ill under most projections. Even with excellent care, the mortality rate may be one percent of those infected, amounting to tens of millions globally. If we overwhelm the capacity of the healthcare system, three to five times as many could die, potentially hundreds of millions. In addition, many will die because patients with other health problems will not have access to healthcare either. If we apply expert projections to Hawai'i, and assume conservatively that 50% ultimately contract the disease over the next year or two, and 1% mortality with exceptional care, about seven thousand residents of our islands will perish. If our hospitals are overwhelmed and cannot care for the 5%+ who become critically ill, several times this number could die[1].

1 We cannot precisely estimate mortality from outbreaks in other countries because many who have become infected are not tested and confirmed. As a result, observed statistics reporting over 3% mortality of confirmed cases exaggerate true mortality by an unknown amount.

Even in the best scenario, the situation looks grim. The cost of saving up to tens of thousands more, through shutdowns, quarantines, and shelter-at-home orders, will be the most severe recession we've ever seen, albeit hopefully a brief one. About 12 percent of Hawai'i's non-farm employees (80,000 of 670,000) have already lost their jobs. Tens of thousands more will surely lose their jobs in the coming weeks.

What comes next? How long will we need to stay at home; quarantine visitors; home-school our children; and close parks, restaurants and stores? Our leaders and health professionals, understandably, have no clear answers yet. Flattening the curve as fast as we can is the most critical issue.

Despite the tough trade-offs that we face, we believe it is important to begin to think about a longer-run strategy. Is the situation really so grim? Might containment be possible, at least here in Hawai'i, aided by our isolation? How do we manage the crisis after the shutdown? Sketching out alternatives and possibilities, as crudely as we understand them now, might help our leaders to make better decisions. And it may help the rest of us begin to plan and contemplate our own futures, find hope, and perhaps better manage our own anxieties.

Two Exit Strategies: Herd Immunity or Containment with Test and Trace

A vibrant if somewhat chaotic literature has rapidly emerged about COVID-19. Much of the research is not yet peer reviewed and cobbles together data from disparate and crowd-sourced data that scientists are sharing with remarkable openness. Some ideas here are drawn from online conversations with other scholars and experts. This literature points to two general exit strategies, one considerably more optimistic than the other. While there is nothing particularly new in what we describe here, these two approaches can get muddled with "flatten the curve" in popular discourse, the media, and sometimes even among experts. But to be sure: these two strategies are very different and have very different implications.

Both strategies begin with flattening the curve as depicted in the figure — use shutdowns, social distancing, quarantines, and whatever else it takes to stem exponential growth of infections and keep the number of critically ill at any point in time within the capacity of the healthcare system. That's where we are at right now. However, after infections peak, the two strategies differ markedly.

Herd Immunity

Herd immunity starts with the presumption that containment or eradication of the virus is impossible once it has spread as widely as it has, which leading health experts claim is likely. Flattening the curve doesn't necessarily mean that fewer people will contract the disease; it simply means that we do what we can to sufficiently delay the inevitable. As more people gradually get sick and recover, their bodies, armed with new coronavirus antibodies, likely become immune. As the "herd" of recovered and immune grows, the virus loses its virulence. Experts indicate that this happens when about 50-60 percent of the population is immune. Herd immunity will happen whether we flatten the curve or not. It's just that by flattening the curve, we save more lives through better healthcare, especially of those who become critically ill.

The more slowly we build immunity, the longer we must live with restrictions on our activities, limiting economic activity and increasing economic cost. So, ideally, we try to grow the herd as fast as possible subject to the healthcare capacity constraint. As perverse as it may seem, we actually want people to get sick sooner than later, so long as not too many get too sick at once. Ideally, those who catch the virus first would be the young and healthy, for very few of them require critical care, they tend to recover quickly, and can comprise a large share of the herd of immune who would then reduce risk for everyone else. Thus, once the curve is flattened, a policy that first eases restrictions on the young and healthy would be more efficient: more could get to work sooner, and we could build the immune population faster. As the young and healthy recover from their infections, restrictions could be gradually lifted on more susceptible segments of the population, when the prevailing risk is lower from herd immunity.

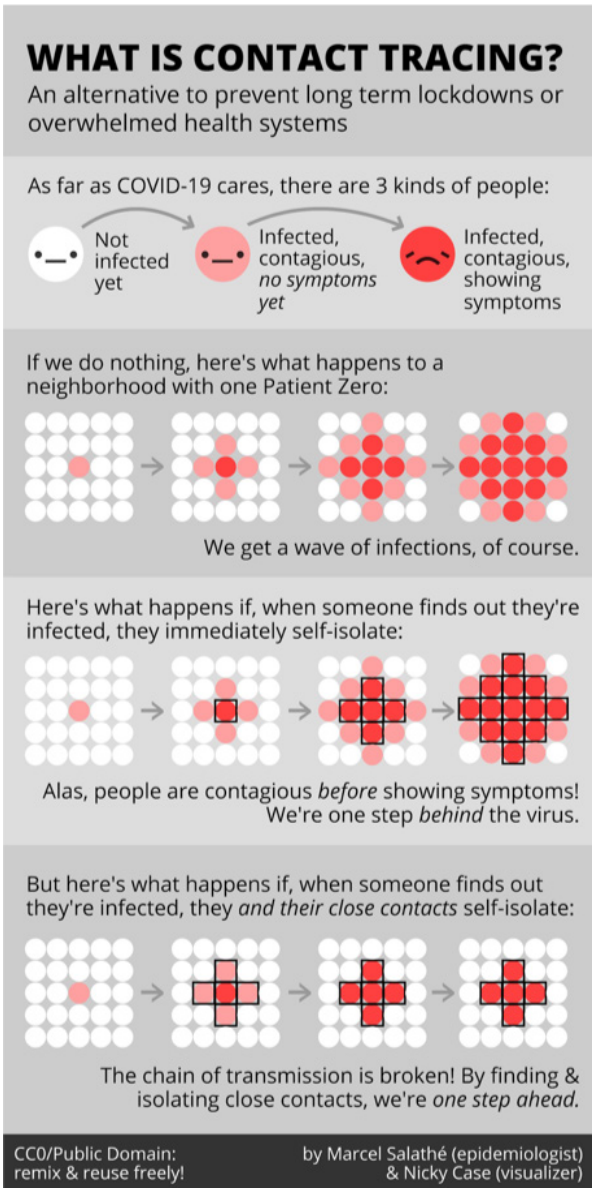
There are, of course, huge social challenges with this approach. The first is the delicate calibration of how much to relax restrictions to keep the virus spreading, but not too fast. A second challenge would involve keeping the elderly and otherwise vulnerable isolated while the young and healthy go about their daily lives and expose themselves. In the early phases, perhaps lasting months or even longer, there would need to be absolute separation between the groups. This will be especially difficult for many of Hawai'i's multigenerational and lower-income families. Mingling could occur only gradually as young and healthy recover from the infection and gain immunity. And there would still be a large share of the population (the elderly and those with compromised health) that would not be able to work or attend school, which would create ongoing economic challenges for a fairly substantial share of the population.

Worst of all, of course, would be the devastating loss of life: eventually, on the order of one percent of the 40-70 percent infected, would still perish, even with exceptional care. And these are only very rough estimates; given how little we still know about the virus, mortality rates could be higher or lower. Moreover, immunity is unlikely to last indefinitely. While it's unlikely that COVID-19 would ever be as virulent as it is now, the virus is already mutating, thereby diminishing immunity. It may reinfect people regularly, possibly increasing mortality in general, and likely increasing the health risks associated with smoking, obesity, air pollution, and other behaviors and environmental factors associated with health. We might be able to develop an annual vaccine, a bit like the flu shot, that provides full or partial immunity. The total impacts to life and health could be altered significantly and indefinitely.

Containment Using Test and Trace

The unusual challenge with COVID-19 is that it has a very long incubation period and it spreads very easily. People can be infected for days, show no symptoms, and still be contagious. This makes the disease especially challenging to contain, especially after it has spread as widely as it has. But there is a possible compensating factor: technology. Today, almost everyone has a cell phone with GPS tracking. With the right software, it is easy to trace all the people who may have recently come into contact with someone who has recently tested positive. While someone may need to be showing COVID-19 symptoms to test positive, we can conceivably isolate both those who test positive and all those who came in contact with them. This is precisely how South Korea, China, Singapore, and Hong Kong have, so far, successfully contained the virus, even after significant community spread. Implementing this strategy requires the ability to test all those presenting themselves with symptoms of the virus, plus a sufficiently low infection rate, presumably achieved with shutdowns and social distancing. The first requirement may very well be the primary hurdle, unless we abandon FDA requirements and buy test kits from South Korea. The second hurdle may be easier in Hawaii than other places, as we discuss below.

Test and trace may also come at a cost to privacy and civil liberties, and perhaps some challenges with enforcement. There are a number of software programs



available to accomplish contact tracing, possibly in a manner that is not too invasive to privacy, but it will clearly be a delicate issue to navigate both legally and politically in the United States and in other places like Germany that have a recent history of state surveillance. But, there would be precious little time to do so. Contact tracing can also be done more crudely, through interviews and broader announcements about where infected people have been, but it may be more costly and less effective.

Finally, an important and non-trivial concern with test and trace methods is that the United States has extensive laws governing protected health information. Tracing procedures implemented by Hawaii would have to be compliant with existing federal law. Consulting legal experts on the implementation of test and trace methods is of paramount importance.

If we want to return our economy full steam by lifting the quarantine for travelers and tourists, we'd need a mechanism in place to screen test and trace them, too. The cost and logistics of establishing such a system could be even more complex.

If a large enough sample of tests are available and a tracing mechanism is set up quickly, we will be able to restart our economy more quickly while saving innumerable lives. It is difficult to attach numbers to human lives (although we often do, at least implicitly), or to civil liberties. Regardless, these are stark tradeoffs, even if we cannot quantify them precisely.

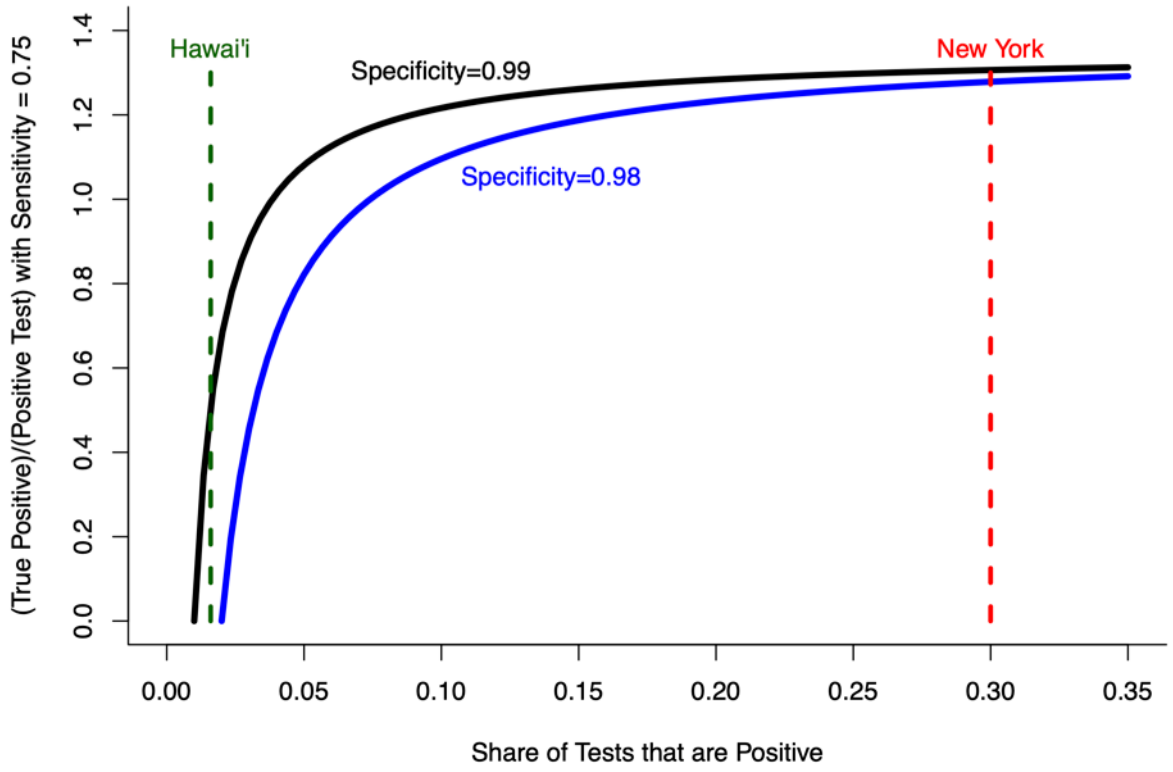
Is Hawai'i a Special Case?

Hawai'i is unique in so many ways. It also appears to be unique with regard to COVID-19. For one, we're naturally isolated, which will make it easier to contain the virus, something that the herd immunity approach essentially rules out. And so far, it also appears as if we have a low incidence of spread, which is surprising given the large number of travelers from highly infected areas. The vast majority of those who have tested positive here (>80%) have been travelers, but the travelers appear to have infected very few others. There are eight documented cases of so-called "community spread" among the 120 confirmed cases (at this writing). While cases have grown over the last few days, this may have happened because testing has increased. Reporting on negative test outcomes stopped after March 24, but before then indicated rapid acceleration to over 500 tests per day. Reporting from Civil Beat indicates that as of Saturday March 28 they are now up to 1000 tests per day.

On a per-capita basis, testing in Hawai'i is quite high relative to other states, so our unusually low number of confirmed cases is not simply due to insufficient testing. For example, we have roughly seven times the number of completed tests per capita as California, and one of the highest per-capita testing rates in the nation. (An important caveat: there is a longer time lag required for tests sent to private labs on the mainland—up to ten days.) Hawaii has also astutely used local state labs to take a random sample of 268 people presenting with flu symptoms, all of which have tested negative for COVID-19, and many of these tests are more recent. This is the clearest evidence we have that COVID-19 remains rare in Hawaii. Looking across all tests, Hawai'i also appears to have the lowest positive/negative test ratio in the nation (at least until they stopped reporting negatives).

One pattern in the data, evident in reporting by Civil Beat: tests from Hawai'i's State Laboratories (~20% positive) show a much higher positive rate than the considerably more prevalent tests from private labs do (~1-2% positive). This likely stems from State labs having much more stringent criteria for testing than private labs. If we want to maximize the value of each test to society, ideally the same screening criteria would be used for all tests. The State, however, presumably has little control over the private labs and their criteria for testing. Efficient use of limited testing resources will be critical to implementing a test and trace approach, so it would be worth the effort to better coordinate testing between public and private labs.

Another concern with the low ratio of positive to negative test outcomes from private labs, which comprise a large majority of tests, is that many of the positives could be false positives. Two factors determine the false positive rate: (1) the so-called specificity of the test, which gives the probability of a negative result when someone does not have the disease, and (2) the prevailing incidence of the disease. We know that the test has high specificity, probably 98% or greater, which may seem really good. But only 99% specificity could imply that most positive results from private labs are false positives, since only around 1-2% are positive in the first place. This testing issue is opposite the challenge with most regions of the country, which have a higher share of positive tests. We know that the COVID-19 tests have low sensitivity, which is the probability of a negative result when a test subject actually has the disease. This fact means that in other parts of the country we are vastly undercounting the number infected, both because they tend to have higher positive to negative test outcome ratio and because they are testing less on a per-capita basis than Hawaii.



This graph shows the relationship between actual incidence of COVID-19 infection among those tested (true positive) in relation to the share who test positive. The horizontal axis gives the share that test positive; the vertical axis gives the ratio of true positives over tested positives. These differ because no test is perfectly accurate. Test accuracy is measured by specificity and sensitivity. Sensitivity is the probability of a positive test conditional on being infected; specificity is the probability of a negative result conditional on not being infected. The tests used to date have relatively poor sensitivity (reportedly 0.6 to 0.85; 0.75 is assumed in the graph). Specificity is reportedly very high, and probably 0.98 or higher, but we could not find quantitative estimates; 0.98 and 0.99 are depicted. Hawai'i's true positives are likely much fewer than tests indicate; in New York, true positives are greater than tests indicate. Positive rates for Hawai'i (1.6%) and New York (30%) are inferred from recent aggregate data collected by The COVID Tracking Project.

Hawai'i's Choice

We need a little more time to be sure, but it looks as if Hawai'i, with its strict shutdown and social distancing policies, low case count, and reasonably high rate of testing, is ahead of the curve. Our leaders certainly deserve credit for this. It may also have something to do with our climate. Correlative evidence in a recent, unpublished paper suggests that COVID-19 is markedly less contagious in the tropics.

Given Hawai'i's unusual circumstances, which exit strategy makes the most sense for us? At this time, it is premature and probably unnecessary to make a hard decision. We will learn much more about the opportunities and tradeoffs in the coming days and weeks of shelter-in-place. New antibody tests will soon be available to determine if someone has ever been infected, recovered, and is now immune, not just whether they have the disease currently. These tests promise to be faster and cheaper, too. Antibody tests may enhance the ability to test and trace our way to containment. They will also help to identify those who are immune and may safely go back to work, school and social life. With new technology and information, there may be new options to consider and the costs and benefits of different strategies hopefully will be clearer.

Soon, however, we will have difficult choices to make. If and when it becomes clear enough that Hawaii has a low rate of infection and our hospitals can handle many more critically ill, we may want to begin growing herd immunity by relaxing restrictions on young and healthy people sooner than later. Sweden is attempting this approach. This will have economic benefits of allowing our economy to restart and our children to go back to school. This will require a sensible set of rules to separate the more vulnerable among us as the virus resumes its spread. We may need to be ready to reimpose shelter-in-place and physical distancing rules if the virus spreads more quickly than anticipated and risks overwhelming our hospitals. This strategy, however, essentially takes the view that containment is impossible and in the long run, most will get infected, with all of the associated mortality and indefinite implications for health that this choice is likely to entail.

Obviously, we cannot both *rapidly* grow herd immunity and implement an effort to contain the disease using test and trace. Although, we might consider a test and trace strategy that starts with relaxed restrictions on young and healthy first. This may require less testing ability, and if test and trace fails, at least we would be building low-risk immunity among the young and healthy. Thus, it would be prudent for Hawai'i to begin to prepare sensible rules that could be used to implement either approach, begin to navigate the sensitive issues around civil liberties, and begin to prepare the public by informing them about the possibilities and difficult tradeoffs.

It does appear that Hawai'i will be in a position to at least attempt the test and trace strategy long before other states, due to our isolation, our low infection rate, and relatively high amount of testing. At least so far, we appear to be successfully flattening the curve. Our testing capacity, both public and private, would need to be better coordinated to serve this purpose, however, if not expanded. Other states and regions might learn from our efforts. If test and trace is viable at minimal cost to civil liberties, it is the obvious choice. If we deem the cost to civil liberties too severe, but the approach is otherwise viable, we might consider a temporary sacrifice of those liberties to serve the larger social cause.

Regardless of the path we ultimately choose, there is little time to prepare contingency plans if we want to minimize the impact of COVID-19 on our economy and our health. The stakes are immense and more pressing than anything we have personally contemplated. The issues raised for any exit strategy are complex and involve unprecedented tradeoffs between life, health, social disruption, and potential compromises to civil liberties. Hopefully this brief will help the public and our leaders contemplate these tradeoffs, for the more quickly we face and contend with them, the less lives and prosperity will be negatively impacted by this crisis.

The views expressed in this article are those of the authors and do not represent the views of the University of Hawaii.

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