

HOW TO CONTROL HAWAII'S CORONAVIRUS EPIDEMIC AND BRING BACK THE ECONOMY: THE NEXT STEPS

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I. INTRODUCTION

In our first policy brief (uhero.hawaii.edu, 25 March 2020), we sketched out a possible plan for control of the novel coronavirus in Hawaii. The plan is loosely based on the successful responses to date in places like Singapore, Hong Kong, and Taiwan and considers the current state of the epidemic in Hawaii and our unique geographical isolation. It has four steps: 1) stem the influx of new infections; 2) rapidly slow the spread of the epidemic in the local population; 3) conduct comprehensive testing of those with symptoms and at elevated risk, proactively trace contacts of all cases, and isolate those who have been exposed or are infected; and 4) based on active monitoring of the testing done, set triggers to reimpose shelter-in-place orders if the epidemic resurges.

Our main goals in this report are to review how the state has implemented steps 1 and 2 and to flesh out steps 3 and 4 more fully. We spell out in more detail how increased testing, comprehensive historical contact tracing, and isolation of exposed and infected individuals can lead to a rapid reduction in new infections and hospitalizations. Once this system has been put in place and has operated successfully for several weeks, we may begin to approach several measurable targets—number of new infections, number of new hospitalizations, capacity of the health care system to treat newly infected or exposed individuals—that would enable Governor Ige to gradually relax his stay-at-home order and for individuals to gradually relax some social distancing restrictions.

II. HAWAII HAS ALREADY TAKEN TWO BIG STEPS

Hawaii has three circumstances that facilitate effective implementation of a coronavirus control plan: Our geographic isolation (2,300 miles to the U.S. West Coast), our small population (1.4 million people), and the very small numbers of governments (4 counties and 1 state government) in the state. These circumstances reduce the costs and raise the benefits to close coordination between governments, private organizations, individuals, and households to both control the epidemic and to minimize economic damage. Have Hawaii governments and organizations taken actions to leverage these circumstances to Hawaii's advantage?

The first step in implementing an effective coronavirus control plan in Hawaii was to restrict travel between Hawaii and overseas destinations and between each of the Hawaiian islands. This has largely been accomplished. Passenger arrivals on international flights began a steep decline on March 1 while arrivals on domestic flights did not begin their steep decline until March 13. By March 22/23, international and domestic arrivals had each fallen by 80-90 percent. As residents became increasingly aware that most people testing positive for the coronavirus had been infected while on overseas/mainland travel, pressure grew for the state government to restrict this travel more tightly. On 23 March 2020, Governor Ige imposed a mandatory 14-day quarantine on all incoming visitors and returning residents from the U.S. mainland and foreign countries. One week later (March 30), Governor Ige imposed a mandatory 14-day quarantine on virtually all interisland travelers, including Hawaii residents, that began on April 1. The interisland quarantine is expected to lead to a sharp decline in the number of daily flights and to eliminate all but essential interisland travel. Both travel quarantines are slated to last until April 30. It would not be surprising to see the overseas quarantine be extended into May given that many of the destinations from which Hawaii receives tourists are unlikely to have their epidemics under control by the end of April.

The quarantine on overseas and mainland travel has contributed to a further decline in daily tourism arrivals at Hawaii airports, from roughly 2,000 people on March 25 to just 121 people on March 30. However, even this level of arrivals places additional burden on public health officials and resources in the state and counties, leading Honolulu Mayor Caldwell to ask President Trump to prohibit all nonessential travel to Hawaii. We expect the number of arrivals to decline further as more potential visitors become aware of the 14-day quarantine, the stay-at-home restrictions that apply to visitors after their quarantine period, the closure of virtually all indoor and outdoor tourist destinations, and the rapidly shrinking daily schedule of flights to and from the Islands.

The state has taken a number of measures to monitor and enforce the travel quarantine. If there are significant violations, monitoring and enforcement measures could be tightened. Current efforts are already straining our existing public health capacity for monitoring and contact tracing and it may be time to begin serious discussion of using electronic means for monitoring compliance and the implementation of social distancing. New arrivals could be monitored during the quarantine by electronic medical bracelets, as is currently done in Hong Kong, phone apps could monitor their location and isolation from other visitors and residents, or an expanded Department of Health monitoring program could ask about their location and their isolation. Publicizing Hawaii's 14-day quarantines in locations continuing to send tourists to Hawaii is an option if significant tourism flows continue from particular cities/countries. Another option to further restrict discretionary travel is for the state to request that airlines and travel booking agencies and websites inform all potential travelers about the state and interisland quarantines prior to travelers booking their itineraries.

Reducing travel to very low levels is important for control of this epidemic because it allows all parties in Hawaii—governments, organizations, individuals, and households—to focus on controlling community transmission. Tracking of Hawaii cases shows community transmission to be a source of 12% of 186 cases classified as travel or community acquired through March 31st, but another 26% of these cases are residents whose source of exposure remains unknown. Community transmission is clearly underway in the Islands. The quarantine on interisland travel should severely reduce the possibility that travelers from islands with a bigger percent of infected residents will bring the virus to islands with a smaller percent of infected residents. Restrictions on interisland travel are also important as they allow state and county governments to impose (and relax) restrictions that are tailored to the state of the epidemic on each island. This is important because it is possible that the state could relax its stay-at-home and social distancing orders faster on islands with fewer cases per capita and which institute effective control measures and strong contact tracing.

The second step in implementing an effective coronavirus control plan in Hawaii was for county mayors and the governor to order all residents and visitors to stay at home and to take social distancing measures when in public places. Such measures, if implemented effectively, can radically reduce community transmission. Between March 4 and March 25, the four county mayors imposed a variety of restrictive orders and voluntary recommendations that varied enormously across the four counties. On March 25, 2020, Governor Ige moved to standardize restrictive measures across the state by imposing a state-wide order to stay at home and to engage in social distancing. The measures were instituted to help achieve two goals: (1) to slow transmission of the virus between individuals and (2) to reduce the burden on the state's health care providers that would result if there were to be a big surge of very ill individuals requiring intensive care.

The governor's stay-at-home order was well received by most state residents and visitors but was pointedly ignored on March 28 by multiple groups of family and friends who gathered at private homes to enjoy the beautiful weather on March 28 and by a very large group who gathered in Waianae, Oahu to watch cock fighting matches (Hawaii News Now, 3/28/2020). Nonetheless by March 31, streets, public areas, and

private yards look increasingly deserted, with most people in nonessential jobs staying home and observing guidelines.

Violations of social distancing have also been observed in grocery stores and in lines outside grocery stores. Long lines of people have been seen outside some grocery stores on Oahu thirty minutes prior to opening. Customers have commented on a lack of social distancing near the check-out areas. Behavioral economics teaches us that “small nudges” can lead to big changes in consumer behavior. Simply putting marks six feet on the floor near grocery checkout stations can remind people to observe social distancing. We urge that these businesses take measures, including small nudges, to ensure that it is possible for customers inside and outside the store to maintain social distancing. Limiting the number of people in the store, placing distance markers on store floors, and taking on-line appointments for times to enter the store are all possible options to make social distancing more feasible. Grocery stores should require staff and customers to wear “do-it-yourself” DIY masks in the store (see discussion below). Expanded delivery services for on-line orders is another important option for reducing crowding inside stores. The State of Hawaii might also consider requesting or paying some grocery stores to stay open for longer hours to ease long lines at store opening.

Strong warnings against such behavior are preferable to heavy-handed enforcement, as it is critical for government to maintain the trust of citizens during a time when its decisions impose such substantial costs on people. Much more needs to be done to educate people how social distancing measures benefit a broad array of people in the community rather than by imposing punishments on those who violate them. The Hawaii state government and private health organizations should consider a massive publicity campaign to publicize the gains from staying at home and social distancing both to the person taking these actions and to others in the community, including the elderly, health workers, and people with compromised immune systems. Professionally produced and informative commercials, social media messaging and news stories could highlight the possibility of asymptomatic transmission locally, make clear that the coronavirus is circulating in our community, and build a sense of social solidarity in protecting our communities, especially our kūpuna.

Targeted publicity around large clusters of virus outbreaks and deaths observed both locally and in other places might help to reduce the number of gatherings in clear violation of both stay-at-home and social distancing orders. Examples of such outbreaks are abundant: the 24 family members who tested positive after a funeral in Albany, Georgia; the 46 choir members who tested positive after a 60-person choir practice in Mount Vernon, Washington; the 25 of 50 guests who tested positive after a 40th birthday party in Westport, Connecticut; and the 80 people who tested positive days after a conference at the biotech firm Biogen in Cambridge, Massachusetts. Reporting local clusters and what links them can also help people to understand their own and their families' risk. The Singapore Ministry of Health routinely reports the clusters they have identified. In their March 27th report, they found clusters centered on workplaces, dinner functions, gyms, churches and preschools. As contact tracing in Hawaii identifies local clusters, DOH officials should report the types of locations, e.g., supermarkets or parties, that give rise to them so that people get a clearer picture of the risk in Hawaii. For legal reasons, they may not be able to name specific locations, but they can inform the public of the general categories of places where clusters are arising to allow people to take steps to protect themselves and their 'ohana.

Another immediate measure that can be taken to reduce transmission is to encourage everyone to use masks when in public settings. Just a few weeks ago CDC and WHO had both recommended against the general public using masks, but recent findings on the COVID-19 virus have called this advice into question. CDC is currently reconsidering its guidance. Extensive testing for coronavirus in the population of Iceland has found that only about 50% of those who test positive are symptomatic at the time of testing. Meanwhile, contact tracing reports from Singapore, Germany and China have documented transmission from

asymptomatic or pre-symptomatic people. In fact, modeling studies of outbreak clusters done for Singapore and Tianjin, China have estimated that almost half of the transmission occurred from pre-symptomatic persons.

Given these findings, use of facemasks for reducing coronavirus spread in the Hawaii community is essential. While the past CDC and WHO guidance has been taken from the viewpoint of preventing infection of the uninfected person using the mask, we would maintain that it should be taken from the viewpoint of protecting other members of the community from asymptomatic and mildly symptomatic individuals who may not even know they are infected. There is no debate about the use of facemasks by those with the flu to reduce transmission to others; they reduce the transfer of droplets containing virus to the environment. Similarly, there should be no debate about the use of facemasks to prevent those with asymptomatic or pre-symptomatic coronavirus transmitting to others. In addition, new studies have shown there is also a protective effect of facemasks worn by those who are not infected. While they do not confer complete protection, which has been the objection to recommending their widespread use, they can significantly reduce an individual's chance of contracting or spreading an infection, especially when combined with social distancing and frequent hand washing. Reviews of numerous studies have shown facemasks to be protective for health care workers against both influenza and SARS, another coronavirus. While those in the public might be less likely to use them as correctly as health workers, they should still confer some protection by reducing exposure to environmental contamination with coronavirus, thereby reducing their risk of infection.

Should the Hawaii state government mandate or strongly recommend mask wearing in public? Most of the places in Asia that had serious outbreaks with the SARS epidemic in the early 2000s were already prepared with ample supplies of masks for both healthcare workers and the public. However, requiring people in Hawaii to wear approved surgical masks or N95 masks in April 2020 would obviously be counter-productive in the short term, as healthcare and other workers facing daily exposure have been unable to obtain adequate supplies of N95 masks and surgical masks. They must clearly be prioritized to receive the masks they need as their risk is the greatest. Numerous scientists argue that even basic DIY masks put together from cut-up T-shirts can be effective in reducing transmission and templates exist online for making them. As such, strongly recommending or requiring the public to wear DIY masks until a greater supply of conventional facemasks can be provided could prove beneficial today while surgical masks are in short supply. Guidelines from the CDC outlining what makes for an effective DIY mask would be useful for home sewers and on-line buyers. However, public messaging on use of masks, whether DIY or surgical, must be done carefully – it must emphasize that use of the mask is in addition to self-isolation, social distancing and frequent handwashing, not a substitute for them. The combined effect of these combined measures should push community transmission close to zero.

Has social distancing been effective in reducing community transmission in past epidemics in the United States? One hundred years ago social distancing saved lives in US cities during the 1918 Spanish Flu epidemic. Required social distancing measures included bans on public gatherings, isolation and quarantine, and school closings. Photos from big US cities in Fall 1918 show crowds of people wearing masks while out in public. Two careful studies found that social distancing was most effective in saving lives when US cities introduced it early in the 1918 epidemic and did not remove it too soon (Bootsma and Ferguson, 2007; Markel et al., 2007). Most importantly, a new (preliminary) study finds that U.S. cities that introduced social distancing measures earlier and more aggressively not only experienced lower mortality during the epidemic but also had stronger economic growth after the epidemic (Correia, 2020).

Has social distancing been effective 100 years later in reducing community transmission of the coronavirus? The San Francisco Bay Area and King County in Washington took some of the earliest and most aggressive social distancing measures. The result? New cases have been rapidly falling. For

the United States as a whole, the best preliminary evidence comes from an app developed by the U.S. technology firm, Kinsa. Kinsa produces “hi-tech” thermometers that send an individual’s temperature information to an app which compiles temperature readings by counties across the United States. (Unfortunately, Hawaii is not included in the Kinsa fever maps.) Kinsa’s fever map shows that “fever clusters” have been declining across the United States during the last two weeks in March, with the largest reductions concentrated in areas that adopted social distancing measures from mid-March (<https://www.kinsahealth.co>). The bigger fever outbreaks are found in Florida, one of the last big population states to adopt a stay-at-home order.

III. APPROACHING THE THIRD STEP: HAWAII’S PLAN FOR TESTING, CONTACT TRACING, AND ISOLATING

The third step to control the coronavirus epidemic is the most challenging and fortunately is already underway. The third step is for the Hawaii state government and private health organizations to expand availability of testing in each of the four counties; routinely test all individuals with respiratory symptoms or fevers for coronavirus; for the Hawaii State Department of Health to proactively trace the contacts of all found infected with coronavirus; and enforce isolation and arrange for or provide care to ill and exposed people until the disease has run its course.

Expanding and Coordinating Testing in Hawaii.

Hawaii is already among the top three states in per capita testing for the coronavirus even though we rank among the lowest ten states for cases per capita. Many of the initial limitations in testing capacity have been remedied and the State is now able to conduct about 1,500 antigen tests per day (Star-Advertiser 3/30/2020) with most of those tests conducted in private labs and positives being reconfirmed in the State lab. To date over 10,000 tests have been conducted and 285 positives detected.

The testing system must serve several essential purposes in building a strong response:

- To improve patient care and allow appropriate precautions to be taken in health care settings to protect health care providers and other patients (antigen tests);
- To identify those health care workers and other essential workers whose jobs require extensive community interaction who have already recovered from coronavirus infection and may have immunity (antibody tests);
- To identify close contacts of all positive cases so that contact tracing can be done to track down and isolate or quarantine those exposed to prevent the infection from spreading further (antigen tests);
- To surveil the number of cases in the community so that trends in the epidemic can be determined and used to guide important decisions on lifting social distancing measures and travel restrictions (both antigen and antibody tests).

What needs to be done in Hawaii to make sure our testing system can fill each of these essential purposes?

The ramping up of private sector and state testing capabilities has allowed the testing of all symptomatic patients in hospitals and those identified as potential cases by clinicians to be done, but there is still a delay in reporting results. It will be valuable to work toward obtaining rapid point-of-care tests as they become

available to speed diagnoses and improve care. This will also allow contact tracing activities to be initiated more promptly, which will contribute to averting further community transmission.

Because the coronavirus manifests symptoms in most infected individuals within 14 days, testing of those with clinical symptoms can detect many of the infections in the community. Many of those with milder infections are likely to show up in outpatient settings or at doctors' offices. At present, however, only a limited random subset of specimens in the influenza surveillance system are being tested for coronavirus surveillance. If we are to implement strong enough contact tracing to detect most active coronavirus cases in Hawaii and temporarily remove them from the population so they cannot infect others, this testing should be expanded to cover the entire symptomatic population that meets an appropriate clinical definition. Of course, this must be coupled with active contact tracing for all cases. As pointed out earlier, coronavirus infection clusters can be large and grow quickly, so prompt, aggressive action is needed if we are to arrest the spread of the virus in the community. Extensive testing has been a hallmark of the Singapore response, where most cases meeting a symptomatic case definition were tested in primary care, hospital and private care settings. In addition, they now test every contact of a COVID-19 patient. Comprehensive contact tracing has been undertaken for all positives, and, as reported earlier, these efforts have identified many large clusters of infection.

The data system around testing should be enhanced to ensure essential information to guide the response is gathered for every test conducted, whether in the State labs or private labs. This should include important variables such as age, gender, occupation, ethnicity and travel history. For those testing positive, extensive interviews should be done to identify close contacts and others who may have had significant exposures. The goal of this data collection is to provide actionable intelligence about the epidemic. These data can be analyzed regularly to identify whether certain ages or occupational categories are experiencing elevated coronavirus cases, which can trigger stronger public health messaging toward those groups. Coupled with more complete descriptions of clusters as described earlier, this information could keep the public better informed and motivate them to enhance protective measures.

Eventually, cross-sectional application of antibody tests will make it possible to determine what fraction of the population has already had the coronavirus. When these tests become available, this should become an additional component of the coronavirus surveillance system. Knowing the proportion of people in the community who have some immunity to reinfection will guide decisions about stay-at-home and social distancing orders and will also provide a direct measure of how effective they are. It will also determine the susceptibility of the population to a resurgent epidemic if coronavirus is reintroduced at some future date. If new symptomatic cases under an expanded testing regime are under control or the population prevalence of past exposures is low, this population testing can be done less frequently. If antibody testing is made available on a wider basis, it could also help to alleviate people's concerns about their own status or help them determine if it is safe to return to work.

Comprehensive Contact Tracing

Contact tracing is vital to the control of the coronavirus crisis in Hawaii. What does contact tracing normally involve? When a person tests positive for the coronavirus, a public health worker contacts that person by telephone, text, or video conference and asks the person to provide information on all of the people with whom they were in close contact over the last three weeks. These include household members, intimate partner(s), individuals providing care in a household without using recommended infection control precautions, and individuals who had close contact (< 6 feet) for a prolonged period of time. Public health officials then use this information to contact these potentially exposed people. They are asked to report their temperature by phone or to show it to them via video conference, and are asked to self-isolate for

14 days. If they are showing symptoms, they are asked to get tested to determine their own coronavirus status. Self-isolation ensures that potentially exposed people do not themselves expose other people in their households or workplaces while testing can help to confirm positive cases in people already showing symptoms.

How productive can a good contact tracing system be in finding other people infected with COVID-19? Much depends on how rapidly DOH staff can contact people potentially exposed to a particular case, as rapid contact and subsequent isolation of the exposed person reduces the chance that the exposed person will spread the virus to other people. Singapore, which has a very aggressive contact tracing system, tracked down 53 of its first 100 cases via contract tracing. Contact tracing is most productive when the number of cases is a small percent of the population. As the number of cases rises, it becomes much more difficult for a fixed number of contact tracers to do their jobs. Consider that for its first 432 confirmed cases, the Singapore Ministry of Health identified 10,346 close contacts who were all asked to enter into a 14-day quarantine. Once exposed contacts are in quarantine, the Singapore government monitors people in quarantine with a phone app that verifies their location. Quarantined people are required to upload pictures of themselves in their place of quarantine every few hours.

Health ministries in some countries have turned to non-traditional contact tracers as the needs have outpaced their staff capacity for dealing with the crisis. Iceland's National Crisis Coordination Center has turned to several dozen experienced police detectives to conduct in-person contact tracing. Additional staff helped the Center find exposed contacts of new cases incredibly quickly and place them under a 14-day quarantine. Hawaii's caseload has grown more than ten-fold over the last two weeks, growing from 26 cases on March 19 to 285 cases on April 2. Tracing contacts on the new cases has dramatically increased the load on the Disease Outbreak Control Division of the Hawaii DOH. With the number of new cases expected to expand considerably as more testing is conducting, the DOH needs to consider how it might scale up its contact tracing workforce. Perhaps the DOH could follow the lead of Iceland and consider using now underemployed city and county police detectives. (Crime has fallen during the epidemic.) Cooperation between county and state governments and employee unions might facilitate this. Or, if use of police raises civil liberty concerns, perhaps the DOH could look to training teachers from the Hawaii State Dept. of Education to assist. They are currently underutilized, given the suspension of public school instruction.

Will Hawaii still need a large contact tracing group once the epidemic becomes more under control later this year? Once Governor Ige decides to relax the stay-at-home order and people begin to interact with each other more often, the probability increases of a sporadic outbreak of new coronavirus cases. Such an outbreak would occur at a time when Hawaii has likely been successful in shielding most of the population from becoming infected. The large pool of uninfected people provides a fertile environment for a few new cases to quickly explode into large clusters of new cases. This could be prevented if the Hawaii DOH had large numbers of experienced employees in its contact tracing system who could quickly react to the new cases by identifying exposed contacts and moving to isolate them quickly. Such actions have great potential for containing any sporadic outbreak and keeping the number of new cases from rising to a level that might necessitate imposition of a new stay-at-home order and other restrictive measures.

Local Isolation and Quarantine.

Testing and contact tracing are only effective when people with the virus isolate themselves until the disease has run its course and people exposed to the virus isolate until they obtain test results. Isolation is facilitated when there are facilities to which people with the virus or exposed to the virus can turn. The Gottlieb Report (p. 6) recommends that “[c]omfortable, free facilities should be provided for cases and their contacts who prefer local isolation, quarantine, and treatment away from home. For example, a member of a large household may wish to recover in a hotel room that has been repurposed rather than risk infecting

family members. Isolation and quarantine away from home should not be mandatory or compelled by force.” In Hawaii, where many families live in small apartments or condominiums, isolation or quarantine within the home is difficult and poses a risk to other family members.

The State of Hawaii needs to identify facilities on each island where exposed people can be isolated and cared for. Potential candidates include hotels in tourist districts and neighborhoods or vacant military housing, such as Kilauea Military Camp. The state might focus first on state- and county-owned facilities where it does not need to negotiate with private owners for their use. That said, the state is already negotiating with hotel operators to use their hotels as quarantine facilities for people exposed to the coronavirus or as treatment facilities for people infected with the virus.

Use of technology to improve tracking, isolation and quarantine

Given the high burden that contact tracing is imposing on the DOH, closer consideration should be given to using digital technology to assist these essential efforts. Mobile phones can assist in several ways. In Singapore, a voluntarily downloaded mobile app called TraceTogether uses Bluetooth to log other phones that have been in close proximity for some duration, collecting only their mobile number. If someone with this app tests positive, public health workers can use this data to rapidly identify and call close contacts. In several countries that have seen slow epidemic growth, mobile phones are being used to track compliance with isolation and quarantine orders. If the person under a quarantine order departs their quarantine location, they are contacted by public health workers to improve compliance. In addition, as maps in the New York Times on April 2 showed on a nationwide basis, anonymous data from cell towers can be used to monitor population compliance with stay-at-home requirements over time. This same approach could be easily applied in a state setting, providing valuable intelligence on the effectiveness of this important policy. Comparing this with the trend in reported cases could provide one more indicator of expanding community transmission. Obviously, in adopting any of these approaches in the United States, consideration needs to be given to privacy needs and legal requirements; but even privacy-conscious Europe is now considering adopting some of them (New York Times, 3/30/2020).

IV. GRADUALLY RELAXING STATE-IMPOSED RESTRICTIONS: BASIC PRINCIPLES

The fourth step in controlling the coronavirus epidemic is for the state to gradually relax stay-at-home and social distancing recommendations and orders and allow some economic activities that involve groups clustered in a location, e.g., a workplace, to resume. However, this must be done with extreme caution. Both modeling work on COVID-19 and the experience with the 1918 flu have demonstrated that once social distancing measures are discontinued, there is a serious risk of virus resurgence, that is, the epidemic rapidly begins again. A successful shelter-in-place order plus practicing social distancing when leaving home to obtain food or supplies is extremely effective at protecting people from contracting the coronavirus. However, it still leaves them susceptible to the virus, creating the potential for the epidemic to resurge should people return to their old ways of congregating in groups. Therefore, there are two important requirements for relaxing restrictions: 1) they should only be lifted once we have a strong monitoring system in place that can rapidly detect a resurgence in the epidemic; and 2) restrictions must be released gradually and the effect of removing them monitored to insure the epidemic remains contained. If the epidemic resurges, we must be prepared to reimpose restrictions immediately. An effective and widely distributed vaccine will make restrictions unnecessary, but as Dr. Anthony Fauci has pointed out that is 12-18 months out in an optimistic scenario.

Until an effective treatment or vaccine is developed or antigen and antibody testing become cheap, accurate, fast and widely available, some economic activities will not resume. This section focuses on

activities that could restart once they have been reorganized in ways that increase the safety of providers and customers.

When will the Hawaii epidemic have declined sufficiently to relax some government restrictions? The Gottlieb Report (p. 6) presents four measures of epidemic severity that could be used as criteria by the State of Hawaii to identify when conditions warrant a gradual lifting of stay-at-home orders. The Gottlieb Report's criteria, edited a bit to fit Hawaii's specific circumstances, follow:

- When the State of Hawaii reports a sustained reduction in the number of new cases for at least 14 days i.e., one incubation period;
- hospitals in each county are safely able to treat all patients requiring hospitalization (for both COVID-19 and other serious medical conditions) without resorting to crisis standards of care and use of overflow facilities, such as arenas and convention centers, to provide hospital care to patients;
- the State of Hawaii identifies sufficient public and private capacity to test all people with coronavirus symptoms;
- the Hawaii State Department of Health has the capacity to conduct active monitoring of all people with coronavirus symptoms, who should remain quarantined, and to trace close contacts of virus carriers.

Once the four criteria have been achieved, Governor Ige can consider removing the stay-at-home and social distancing orders in a phased manner. The first phase is to remove the stay-at-home order for those not at high risk for serious COVID-19 outcomes, while maintaining or strongly recommending the more vulnerable (older individuals or those with pre-existing conditions that expose them to higher COVID risk) remain at home or only return to work if workplace social distancing can be guaranteed. As the stay-at-home order is lifted, additional regulations to maintain social distancing in public and workplace settings to the extent possible should be put into place. Singapore, for example, is marking every other seat in restaurants and cafes as off limits to increase social distancing in these settings. Hong Kong is requiring restaurants to operate at no more than half capacity with no more than 4 people per table and a guaranteed 1.5m spacing between tables. Depending on the workplace setting, different regulations might be adopted to sustain social distancing protocols to the extent possible. Everyone should still be asked to wash hands frequently and to maintain their distance from others, even in the workplace. All businesses and workplaces should be required to provide hand sanitizers in heavily trafficked areas. In short, every conceivable means to reduce the presence of highly contagious coronavirus in the environment should be taken.

Housing facilities with vulnerable populations may want to relax restrictions on visitors and resident mobility within facilities more slowly. The Gottlieb Report (p. 8) recommends that “[s]pecial attention should be paid to long-term-care facilities and nursing homes. These facilities will need to maintain high levels of infection prevention and control efforts and limit visitors to prevent outbreaks.” Vulnerable populations “should continue to engage in physical distancing as much as possible until a vaccine is available, an effective treatment is available, or there is no longer community transmission.” These cautionary notes apply strongly to Hawaii where more than 18 percent of the 2018 population was 65 years or older.

In addition, as these orders are modified, the Governor might want to consider tightening the state's recommendation to wear masks in public and extend it for several more months. If our recommendations provided above are implemented, all Hawaii residents will have been wearing DIY basic masks in public since early April 2020. However, once supply constraints on surgical masks have been relieved AND the state's stay-at-home order is removed, then it will become even more important for everyone to use more

effective surgical masks in public spaces to compensate for the additional risk that comes with more social interactions. As more people leave their homes more frequently, there will be increasing infringements on social distancing and higher potential for a surge in new infections, albeit in an environment with a lower percent of coronavirus infected people than today. Requiring people to wear surgical masks in public spaces for several months after stay-at-home orders are relaxed could help to prevent asymptomatic transmission, reduce the amount of coronavirus in the air and on surfaces, and ensure that the epidemic does not quickly reemerge.

Restarting the Non-Tourism Economy

Let's consider reopening Hawaii's non-tourism economy first. Reopening the non-tourism economy is critically important, as it accounts for 77 percent of Hawaii's GDP. Once the Governor's stay-at-home order is lifted, which closed or partially shut-down businesses will resume operations and how will they reorganize to facilitate social distancing? One temporary measure that businesses should take (until a vaccine is developed) is to find employees with positive coronavirus antibody tests to take jobs that require close contact with other workers or customers. The Gottlieb Report (p. 9) suggests that people with positive antibody tests could "return to work, serve in high-risk roles such as those at the front lines of the health care system, and serve in roles that support community functioning for people who are still physically distancing." Emanuel (2020) suggests that antibody-positive people could staff and manage retail stores and restaurants. All that said, there are ongoing concerns regarding the strength of immunity protection provided by the coronavirus antibody and the period of time for which the protection lasts (WSJ, 4/2/2020). Research in this area must be monitored closely and policies changed as needed.

We anticipate that almost all businesses will reorganize operations at least to some extent to increase the safety of customers and employees. The Gottlieb report (p. 8) agrees, arguing that "general physical distancing precautions would still be the norm after stay-at-home precautions are relaxed, including teleworking (as much as possible), maintaining hand hygiene and respiratory etiquette, wearing a mask in public, regularly disinfecting high-touch surfaces, and initially limiting social gatherings to fewer than 50 people." The capability for businesses to reorganize to accommodate worker and customer safety demands varies tremendously. Some will radically reorganize their entire operations, many will make changes to ensure social distancing, and others will find such changes untenable and close their doors. Industries with a high cost of providing customer safety will decline in size if consumers can easily find substitute products (think movie theaters and large lecture classes), but could expand in size if customers find the industry's products to be essential and are willing to pay the high costs required for workers to produce these goods and services safely for consumers (think home construction). Other industries with a low cost of providing additional customer and worker safety will expand and thrive (think online services). At the end of the day, the demand for additional safety measures by workers and consumers will be a drag on the Hawaii economy that could persist for several years, while in the longer run the changed circumstances of firms, customers, and workers will encourage waves of innovation that will place the economy and society onto paths unknowable today.

When the stay-at-home order is ended, businesses that rely on large numbers of people gathering together in crowded spaces will have to rethink their business model until the Hawaii population is vaccinated. Examples include bars, clubs, some restaurants, conventions, conferences, large university lecture classes, sports events, concerts, theatre performances, and museums. One option for these venues is to allow fewer people into their space, thereby allowing all customers to practice social distancing. Consider now how a restaurant might react to the stay-at-home orders being lifted. Let's assume that the requisite extra space between customers can be achieved by removing half of the restaurant's tables. This will cut some of the restaurant's costs that vary with the number of customers, such as waiters, busboys,

cooks, and food costs, but will still leave restaurants grappling with how to pay the rent and other fixed costs with fewer customers. Two federal programs have been set up to aid restaurant owners and workers through spring 2020.

It is hard to imagine how events involving large crowds, such as a UH football game or a UH Wahine volleyball game could be safely held until a vaccine is developed. It is easier to image 50,000 fans staring at a television in their home, watching a football or volleyball game played without fans in the stands. For this to happen, player and staff safety issues would need to be resolved. Consider that when the National Basketball Association (NBA) learned that one star player, Rudy Gobert of the Utah Jazz, had tested positive, it immediately shut down its season. Similar issues will haunt any attempt to play the NFL or college football seasons. Or UH Wahine volleyball.

We may see large conventions—which rely on many people engaged in events in crowded hotel or convention center spaces—moving to an online model with online plenary sessions, online small-group sessions, and even online cocktail parties. Unfortunately, such online conferences will offer little comfort to the large number of workers in Hawaii who provide lodging, meals, and entertainment to convention visitors who no longer actually visit.

There are many businesses and occupations that rely on close personal contact—hair salons, massage, dentistry, optometry services, health services—and others where customers repeatedly use the same equipment, such as gyms. Whether these businesses will be able to restart successfully before a vaccine becomes available is an open question and is likely to depend on the particular circumstances of each business and their clientele. Businesses could consider monitoring the daily temperature of workers who have contact with multiple customers.

What about K-12 schools? It is very likely that Governor Ige's stay-at-home order will be in effect long enough to prevent the completion of the 2019-2020 school year for public and private K-12 students. If the stay-at-home order is lifted in late spring or early summer, the state could consider working with the Hawaii State Teachers Association to find a way to finish up the current school year during the summer. Ensuring that children do not fall behind in their instruction should be a priority of the state and teachers. When public and private schools restart in-person instruction, administrators would need to make provisions for immune-compromised children and for older teachers and other staff who would be especially vulnerable to a new outbreak of the epidemic among their younger students. One option to minimize exposure for older vulnerable teachers is to temporarily assign them to teach on-line classes and to temporarily assign younger less vulnerable teachers to in-person classes. In the absence of a vaccine, there could be virus outbreaks within a school. To minimize their impact requires that all staff, teachers, and students maintain social distancing, that ill students are kept at home, and that any cases are followed up with aggressive contact tracing and testing. Virus outbreaks within schools might be reduced if school staff took the temperature of each student and teacher daily.

How will social distancing be maintained in the crowded classrooms found in Hawaii's public and private schools? One idea is to hold twice-a-day sessions with half of the students attending in the morning and half in the afternoon. This will allow for increased seat spacing between students, albeit at the cost of less in-person class-time with the instructor. Lost in-person instruction time could be partially made up with on-line instruction time during the other half of the day. Lack of access by students from low-income families to home computers and home internet connections will need to be remedied for this plan to work. Wearing of masks for various activities within particular schools is another option to reduce the chances of an infection outbreak.

Should the University of Hawaii and the state's private universities restart in-person classes once the stay-at-home order is lifted? From early March in the spring 2020 semester, the University of Hawaii

required its faculty and students to transition from in-person classes to on-line classes. UH recently decided to offer all 2020 summer session classes on-line, a decision made easier by increasing percentages of students choosing to take on-line summer session classes over the last decade. UH administrators will need to decide by early June 2020 whether to offer Fall semester classes entirely on-line. Moving all classes for the Fall semester online is a risky decision. Out-of-state undergraduate students could balk at paying UH-Manoa's high non-resident tuition for an exclusively online instructional program. Graduate students in most fields will likely balk at an exclusively on-line program, as in-person mentoring, laboratory work, and peer interactions are big components of most graduate programs. In the Arts, many classes involve one-on-one instruction or small ensembles of 10 or less students. It is worth remembering that we are in the midst of a global pandemic and that universities throughout the world are facing the same issues.

How risky is it be for UH or private universities to offer in-person instruction in the Fall 2020 semester? If the State of Hawaii implements the right policy measures to control the epidemic, then by mid-summer Hawaii could be one of the safest places for undergraduate and graduate students to be educated. Students are, of course, making their enrollment decisions during the month of April. Committing UH to in-person instruction in the Fall semester involves its own risks, the main one being whether the epidemic is brought sufficiently under control by August to allow in-person instruction to proceed. Students from foreign countries and the U.S. mainland will surely need certified antigen/antibody test results or have completed the state's 14-day visitor arrival quarantine to be enrolled at UH. Older more vulnerable faculty might prefer to teach online. If UH offers in-person instruction, it should require that all staff, teachers, and students maintain social distancing, self-isolate and test if becoming ill, and that all coronavirus cases are followed up with aggressive contact tracing and testing.

Restarting the Tourism Economy

The tourism economy will take longer to restart than the non-tourism economy. This is because tourism from overseas will only resume when either (1) a vaccine is developed or (2) the coronavirus epidemic is brought completely under control in areas sending tourists to Hawaii or (3) rapid, same-day antigen tests become available to pre-screen potential visitors at their doctor's office, an urgent care facility or home airport within a day of leaving for Hawaii. A pessimistic forecast for the resumption of substantial tourism flows from overseas is 12-18 months, the time likely to be required for vaccine testing, production, and widespread vaccination of the Hawaii population to occur.

So, if 12-18 months is the pessimistic forecast for tourism to restart, what is the most optimistic forecast? Tourism could resume quickly if two necessary conditions are met: (1) Potential tourists perceive Hawaii to be a safe place to visit and (2) Hawaii residents can be assured tourists are free of the coronavirus. The first condition could be satisfied sometime this summer if Hawaii builds on its already considerable achievements by moving ahead with the testing, contact tracing, isolation, and mask policies recommended in this report. The second condition could also be satisfied this summer if rapid antigen and antibody tests become readily available to people wanting to vacation in Hawaii. Travelers will take a rapid antigen test within a day of boarding their flight to confirm that they do not carry the coronavirus. A second antigen test might be required in Hawaii within a day of the passenger's flight home. With a positive antibody test, a traveler would not need to take the antigen tests. New antigen and antibody tests are being rapidly developed, and it is possible that an antigen test capable of detecting the virus in asymptomatic carriers will become available over the next few months with a relatively narrow window period, i.e., the period during which a person with the virus still tests negative. Abbott labs is currently rolling out an antigen test that provides results within 5-15 minutes; this test could potentially be used at airports sending passengers to Hawaii. In the best-case scenario, when the state lifts its stay-at-home order later this spring or early this summer, it will also waive its 14-day travel quarantine for visitors with a certified antigen test or with a

positive antibody test. It is possible, but far from certain, that Hawaii will become particularly attractive as a vacation destination later this year if it is one of the first global visitor destinations to have its epidemic under control.

There are numerous factors that could and probably will dampen the optimistic scenario. Many potential tourists, particularly ones from vulnerable populations, may decide to postpone taking a vacation until a vaccine becomes available. Why take an unnecessary risk? Others may decide to substitute cheaper vacations closer to home to save money or may decide not to take a vacation due to declines in household income and wealth. Some may continue to perceive long-distance travel itself to be potentially dangerous. Others may find that the destination is less attractive because it does not allow large gatherings, e.g., big conventions. In this intermediate scenario, we could see only a limited resumption of tourism until US and foreign populations are vaccinated. Finally, Japanese tourism has typically restarted very slowly after other political and economic crises. A slow return of Japanese and other foreign tourists would weigh heavily on Hawaii's tourism-oriented businesses as these tourists tend to spend more than U.S. tourists.

Could cruise ships resume cruises between the Hawaiian Islands if all passengers and crew members on the ship presented certified antigen or antibody test results at boarding? The documented rapid spread of coronavirus on cruise ships leaves this in doubt. Concerns will remain that one or more passengers or crew will inadvertently slip through the testing screen and that the crowded environment of a cruise ship will amplify coronavirus transmission. Residents in Hawaii cruise destinations (Hilo, Kahului, Lihue, and Honolulu) could also be worried about the health status of disembarking passengers and crew even if they have been certified to be free of the virus. In sum, it is difficult to envision cruise ships resuming service between the islands or between Hawaii and overseas destinations until a vaccine is developed and all passengers and crew have been vaccinated.

When could inter-island travel restrictions be relaxed or lifted? Travel restrictions between any pair of islands could be relaxed when both islands have met the four conditions (set out above) for relaxing county/state stay-at-home orders. We note that islands with smaller populations, such as Kauai, might be more worried about a surge in visitors from an island with a much larger population, such as Oahu. Inter-island travel by residents for vacations or family visits is also likely to be somewhat limited due to big reductions in incomes and wealth for most Hawaii households.

VI. CONCLUSION

Increased antigen and antibody testing, comprehensive historical contact tracing, mandated mask use, and isolation of exposed and infected individuals are the most vital measures that the state can take to control the coronavirus epidemic. Once several measurable targets are achieved, we expect that Governor Ige will be able to lift his stay-at-home order and this will facilitate the reopening of much of the state's non-tourism economy. Unfortunately, reopening the state's tourism industry depends on two factors mostly outside our control: The speed with which a vaccine can be developed, produced, and distributed and the speed with which rapid-response antigen and antibody tests can be deployed at foreign and domestic airports sending visitors to Hawaii. What's important is that we focus on the measures that are under our control—travel quarantines, social distancing, testing, contact tracing, and isolation. Implementation of these measures is entirely feasible with the cooperation of the public, businesses and non-profit organizations, and our state and county governments. What is needed for the state to control the epidemic is the will to move quickly on testing and contact tracing and to undertake a strong and sustained public relations campaign communicating to the public the essential principles for controlling an epidemic. In an epidemic that has brought the economy to a standstill, moving quickly and decisively to contain the virus is the fastest path to economic recovery.

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