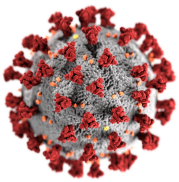

HAWAI'I SARS-COV-2 PANDEMIC

A Plan for Safely Re-Opening Hawai'i: Kaua'i as a Model

Report v1.2

18 June 2020

SARS-COV-2 PANDEMIC

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SECTION 1
Executive Summary

The primary objective of this study is to provide information and recommendations to decision makers on the design and implementation of a plan for screening and quarantining of incoming travelers for the novel coronavirus. The overriding goal is to keep the community safe as we reopen the County of Kaua'i and the State of Hawaii. The intention is to minimize both the risk of a COVID-19 outbreak on Kauai and the duration of quarantine needed to keep the island safe. The report was initiated on 12 May 2020 and was completed 17 June 2020.

Due to the informal nature of the Kaua'i COVID-19 Discussion Group, these recommendations are made without the benefit of organized input from key stakeholders such as the hotels, the visitor industry, the airlines, the State Airports system, the Hawaii State Department of Health (DOH), the police and National Guard. If such a group is not already convened, it is hoped that one will be created soon and that these science-based recommendations will be useful in planning, and implementing a system of testing, quarantine and tracing. Given the economic urgency to reopen, and the desire to do so safely, putting a well-designed protective system in place is likely the state's most important priority for economic recovery.

RECOMMENDATIONS

The Kaua'i COVID-19 Discussion Group has the following recommendations for state and county leadership on how to reopen Kaua'i safely to incoming travelers:

Thermal Screening

RECOMMENDATION: That thermal screening prior to boarding be advocated by state and county officials as a national minimum safety protocol for airlines and cruise ships.

Direct Virus Testing

RECOMMENDATION: That highly sensitive testing for infection with SARS-Cov-2, performed on two separate occasions, 6 days apart, be offered to all incoming travelers as an alternative to the mandatory 14-day quarantine, potentially reducing the quarantine time to 7 or fewer days. If the first test can be done prior to boarding, the two-test strategy would be even more effective.

We emphasize that the performance of two tests separated by 6 days greatly increases the ability to identify arriving passengers capable of spreading the infection and is far more effective than strategies based on a single test. According to our statistical model, and supported by data and experts in public health, testing only once without quarantine means that fully one-third of infected passengers will be allowed to enter our communities undetected (32 for every 10,000 arrivals). At a rate of 1,000 visitors per day, almost 100 positive cases per month will enter Kaua'i unrestrained. Adding a second test after 6 days of quarantine cuts the number by 7-fold to <5 per 10,000 providing an exponential leap in safety.

We emphasize that we view the proposed testing program as an interim step, rather than a long-term solution to the challenges confronting the island. Other options will likely become available in the short- to mid-term that may supplant the approach recommended herein. Importantly, however, the data gained by implementing this program is likely to be valuable for future decision-making. Specifically, the quantitative data on the prevalence of transmissible SARS-Cov-2 among arriving travelers will be generated by proposed testing program, information that is fundamental to future decision-making regarding how best to keep the island safe.

A final point is that the model introduced herein is "flexible" in the sense that it can be applied to predict the risk associated different testing and quarantine options. Thus, while the power of this model is illustrated by predicting the risk associated leaving quarantine after 7 days when viral testing is performed on Days 1 and 6 after arrival, it can also be used to assess the risk associated with testing on earlier or later days. Thus, we view the model as a flexible 'risk assessment tool' for future decision-making. While participation in this testing program is strictly voluntary, we believe it will be viewed favorably by most incoming travelers when compared to the alternative (mandatory 14-day quarantine).

Quarantine Practices

RECOMMENDATION: That, to increase the effectiveness and integrity of the existing quarantine system, all incoming travelers be quarantined in designated hotels except for those visitors and residents who consent to wear tracking bracelets. The proposed personalized quarantine facilites should be approved by the Department of Health.

SECTION 2
Introduction

BACKGROUND

The unprecedented global public health crisis caused by COVID -19 is no longer subject to legitimate debate. As of May 28, 2020, there have been over 1.6 million reported COVID-19 cases in the United States, with over 100,000 deaths from the virus. The worldwide totals as of the same date are more than 5.4 million and 345,000, respectively. Unlike other viral strains, the SARS-CoV-2 virus (which causes COVID-19) manifests itself in completely unpredictable ways. Of those individuals who have been infected by the virus, significant numbers are asymptomatic but still highly contagious, while others may have mild cold-like symptoms, suffer flu-like symptoms, experience organ damage and failure, or perish from the disease. This novel coronavirus has baffled scientists and, understandably, caused considerable fear in the general public.

Quarantines and social distancing have slowed the spread of the virus and continue to be necessary from a public health standpoint, but at a monumental cost to the global economy. In the United States alone, more than 36 million jobs have been lost since states adopted strict stay-at-home measures – wiping out all employment growth created during the past decade. Unemployment is at a scale not seen since the Great Depression. Moreover, GDP in the U.S. is projected to drop nearly 4% in 2020. Countless industries have been particularly hard hit.

Travel and Tourism.

The World Travel & Tourism Council estimates the tourism and travel GDP loss to the global economy at $2.1 trillion this year alone. Airlines are projected to lose more than $50 billion in revenue in the same period. In addition, hotels in the U.S. are losing a staggering $2.8 billion in revenue per week.

Restaurants and Retail.

Large and small retailers, including such stalwarts as Neiman Marcus and J. Crew, and J.C. Penney have filed for bankruptcy protection, countless restaurants and retailers have permanently closed their doors, and the path towards reopening, let alone long-term survival, for these establishments is less than clear. E-commerce has already greatly expanded its market share at the expense of traditional retailers, and its continued, accelerated growth will only further hasten the demise of traditional retailers unless they can resume normal business activities and volumes well before any potential vaccine is developed.

Concerts, Sporting Events, and Other Large Gatherings.

Professional sports leagues in the U.S. and high-revenue individual sporting events have no realistic safe pathway towards reopening with fans in attendance. The same holds true for the live music industry, with smaller music halls permanently shut down and larger music conglomerates struggling to survive.

Medical Practices.

Practices are down more than 60% in revenue, with elective surgeries and other revenue-generating procedures on hold and patients wary of returning to environments where others may be contagious.

Broader Societal Impacts.

Combined with the devasting health and economic impacts, the broader societal impact has been just as significant. Schools have been shut down indefinitely, and some significant universities, including The University of California, the nation's largest four-year public university system, have canceled on-campus

learning for the fall 2020 semester, with instruction taking place almost exclusively online. Personal travel, family gatherings, community meetings, churches, recovery support groups, and countless other ways in which society comes together have all been placed on hold or significantly modified.

With new "hot spots" materializing daily and with the second and third waves of COVID-19 predicted to hit during the summer and fall, the only way in which society can safety reopen and individuals can get on with life is through accurate, venue-specific, scalable, cost-effective, point-of-diagnosis testing. This is true regardless whether the venue is a university, factory, warehouse, office building, conference center, hotel, sports stadium, concert call, community gathering, or countless other gathering spots. This is especially true when the common-cold season returns, and individuals with any symptoms of a cold – absent rapid, accurate, point-of-venue testing – will not be able to reassure themselves, those around them, or the venues they are attending, that they are not actively contagious with SARS-Cov-2.

These venues simply will not reopen at anywhere close to pre-pandemic levels and most individuals will not want to attend these venues absent some reasonable assurance they are entering a "COVID-Free Zone" or something close to this. As Bill Gates noted, "If in the spring of 2021 people are going to big public events—like a game or concert in a stadium—it will be because we have a miraculous treatment that made people feel confident about going out again. It's hard to know precisely what the threshold is, but I suspect it is something like 95 percent." As of today, all available options fall far short of this standard.

KAUA'I'S GOLDEN WINDOW OF OPPORTUNITY

The absence of new cases of COVID-19 on Kaua'i over the past 9 weeks testifies to the effectiveness of social distancing, masking and other mitigation strategies when combined with sharp limits placed on new arrivals to the island. Once this goal is achieved – referred herein as "the golden window"— island nations and states are uniquely poised to limit the threat posed by the pandemic by limiting the potential for arriving passengers to spread the disease on the island.

Unfortunately, this 'golden window' is bound to be short-lived unless an effective strategy can be developed to protect against the infection returning as more travelers arrive on the island. Given that 0.5% to 1.0% percent of visitors and returning residents will either be actively shedding virus upon arrival or will become infectious in the days following arrival, spread of the disease is inevitable as the number of arrivals increases. Moreover because, individuals carrying the disease may or may not have symptoms, identifying these individuals requires an effective testing strategy.

Currently, the plan for minimizing this risk on Kaua'i is based on a 2-week quarantine period imposed on all visitors and returning residents. While effective in theory, prolonged quarantine can be hard to enforce, and it also places sharp limits on recovery of tourism and associated economic activity. As such, it is a suboptimal solution to a complex challenge. In this proposal, we introduce a plan to safely reduce the duration of quarantine needed to keep the island safe through a carefully timed testing regime to screen for active shedding of the COVID-19 virus.

This proposal is not advocating a reopening of the visitor economy currently. It is proposing improvements to the current system of screening and quarantining incoming travelers in order to keep the community safe right now as well as to prepare for reopening. Tjhe strategy includes quarantining incoming visitors in one hotel to improve the effectiveness and cost-effectiveness of the quarantine system. Almost daily, there are news reports of visitors breaking their quarantine, revealing weaknesses in the present system that could put the community at risk. Now is the best time, while the number of arrivals is small, to perfect the system. If it works, and if it is scalable, it could be used at the proper time to reopen the visitor economy.

The current system of allowing visitors to quarantine in their own hotel rooms or vacation rentals is difficult to enforce, labor intensive and costly. Even with the small numbers of incoming travelers, the system does not appear to be working well. If the numbers increase, the risk to the community will also grow.

OBJECTIVES

The primary objective of this proposal is to offer guidance on the development and implementation of an overall plan for screening, testing and quarantine of incoming travelers to prevent re-entry of the novel coronavirus into Kaua'i and Hawai'i in an effort to minimize both the risk of a COVID-19 outbreak on Kauai and the duration of quarantine needed to keep the island safe.

The island of Kaua'i is in many ways uniquely suited to the implementation of the screening program proposed herein. The absence of active cases on the island speaks to the ability of local officials to implement effective mitigation efforts, and to the ability of island residents to comply with them. In addition, the number of arriving passengers is large enough to permit statistical analysis of the risk posed while being small enough for the proposed testing regime to be feasible with existing resources. Should the program proposed herein prove to be a safe and effective strategy for mitigating the risk posed by passengers arriving on the island, decisions can be made at the State level to determine whether something similar is appropriate for the other islands.

We also anticipate that the information gained by implementing the proposed program will be of value to other stakeholders, including airlines and hotels that serve Hawai'i. In addition, by identifying travelers that are actively shedding the virus upon arrival on Kaua'i, we can spearhead efforts to identify any individuals that may have been exposed while in flight and determine if they, too, were infected.

This proposal is a work in progress and is neither all-encompassing nor complete. A secondary objective of this report is to provide discussion points for larger conversations to be held among all relevant stakeholders during this pandemic.

In the course of the report, the Kaua'i COVID-19 Discussion Group:

- Analyzed and summarized options for managing incoming travelers to Kaua'i;
- Developed a methodology for testing and quarantining incoming travelers to Kaua'i for COVID-19;
- Estimated the likely level of community spread of COVID-19;
- Developed early-stage recommendations for COVID-19 testing and containment.

The study began 12 May 2020 and was completed 17 June 2020. Contributors to this report include Michael Schwartz, MD, John P. Alderete, PhD, MBA, Lee Evslin, MD, Bob Weiner, MD, JoAnn Yukimura, and Jill Lowry, all from Kaua'i, and Paul Pottinger, MD, FACP, FIDSA and Karl Kaiyala, PhD, from the University of Washington (Seattle, WA).

METHODOLOGY

A predictive model was developed to identify a strategically timed testing regime that effectively identifies arriving passengers with the potential to spread the disease, while minimizing the period of quarantine needed to keep the island safe. This model is based on assumptions including the prevalence of COVID-19 among arriving passengers, the sensitivity and specificity of the test used to detect the virus, and the time interval between exposure to the virus and both the onset and offset of active viral shedding.

The predictive model was developed with members of the Kaua'i COVID-19 working group and an expert in biostatistical modeling, Karl Kaiyala, PhD, Research Associate Professor (Emeritus), University of Washington (Seattle, WA).

More information on the predictive testing model is provided in Appendix B.

Use of Subject Matter Experts

Where appropriate, and for the purposes of developing and verifying the assumptions of the testing and quarantine models presented in this report, outside subject matter experts (SMEs) were consulted by the Kaua'i COVID-19 Discussion Group. Notable SMEs include, but are not limited to:

Paul Pottinger, MD, FACP, FIDSA

Dr. Pottinger is a Professor in the University of Washington's (Seattle, WA) Infectious Disease (ID) Division's Clinician-Educator Pathway. He is Director of the ID Training Program. He also co-directs the Antimicrobial Stewardship Program at UWMC, which aims to improve the use of anti-infective medications for the complex patient population there. He also directs the UWMC Tropical Medicine & General ID Clinic.

He attends on the UWMC inpatient General ID Consult Service, Solid Organ Transplantation ID Consult Service, and General Medicine Teaching Service.

He directs and teaches a variety of courses at the School of Medicine and delivers approximately 50 formal lectures per year to students, residents, fellows, and attendings. He collaborates with colleagues at UW, Johns Hopkins, the London School of Hygiene & Tropical Medicine, KCMC in Moshi Tanzania, and Makerere University in Kampala Uganda to bring a comprehensive tropical medicine training course to East Africa.

Dr. Pottinger has been on the frontlines of the University of Washington response to COVID-19 since the outbreak began in Seattle early in March 2020. His work has ranged from managing acutely ill patients to guiding policy decisions regarding COVID-19 preparedness and mitigation, to teaching medical students and house staff to advising local officials and businesses /24/.

Karl Kaiyala, PhD

Dr. Kaiyala is associate professor emeritus in the School of Dentistry at the University of Washington.

Dr. Kiayala has many years of developing and deploying statistical modeling methods for use in clinical science, epidemiology, and biomedical research to help with the analysis of collected data across a wide variety of sources. Dr. Kiayala's work with the Kaua'i COVID-19 Discussion Group was critical in developing diagnostic and prognostic inferences from the developed testing model.

REPORT ORGANIZATION

Section 3 describes screening of incoming travelers to Kaua'i.

Section 4 examines quarantine practices for incoming travelers to Kaua'i.

Section 5 provides conclusions for this report.

SECTION 3
Screening of Incoming Travelers to Kaua'i

Due to both its limited population and its isolation from both mainland US and inter-island travelers, the island of Kaua'i is uniquely suited to the implementation of a screening program to interdict and contain the spread of the COVID-19 virus. The absence of active cases on the island at present speaks to the ability of local officials to implement effective mitigation efforts, and, equally important, to the ability of island residents to comply with them.

These considerations, combined with the relative ease with which a screening program can be implemented here on Kaua'i, create a compelling rationale for establishing such a program before the influx of travelers to the island begins to increase. Should the program proposed herein prove to be successful, decisions can be made at the State level for wider implementation.

How to make travel safe is the multi-billion-dollar question challenging not only the travel industry but the Kaua'i community. Kaua'i must rely on some tourism for its economic recovery.[1] Kaua'i residents also want to be able to travel safely. Kaua'i residents are also a potential source of infection upon returning even as they desire to keep their island home safe. (it seems that at least half of the COVID-19 infections in Hawaii were from returning residents). We anticipate that the information gained by implementing the proposed program will be of value to many stakeholders—including airlines, hotels, the visitor industry as a whole, other visitor destinations around the world, the medical community, many of the small businesses related to tourism, the community that wants above all to be safe, and taxpayers.

THERMAL SCREENING

RECOMMENDATION: That thermal screening prior to boarding be advocated by state and county officials as a national minimum safety protocol for airlines and cruise ships.

Fever is a common symptom of COVID-19, typically appearing 2-14 days after exposure /1/. Telethermographic systems determine surface skin temperature, which is then used to estimate the temperature at a reference body site (e.g., oral, tympanic membrane). These systems are particularly useful in high throughput areas (e.g., airports, businesses, warehouses, factories) and in settings where other temperature assessment products may be in short supply. [2,3]

Many businesses, social (or religious) groups, and public health officials see temperature checkpoints as a critical tool to prevent those infected from spreading the coronavirus. As the US

[1] The authors want to acknowledge the important public debate about "over tourism" and make it clear that return to the level of pre-COVID-19 tourism is not being advocated here. However, most people would agree that some level of tourism will be important to a healthy economy and recovery.

[2] The available scientific literature supports the use of telethermographic systems in the context of initial human temperature measurement described guidelines for using telethermographic systems for initial temperature assessment for during such a triage process /2/. Additionally, international standards and scientific literature have described guidelines for using telethermographic systems for initial temperature assessment for triage use and best practices for standardized performance testing of such products /3, 4, 5/.

[3] Guidance on containing COVID-19 from the Centers for Disease Control and Prevention says workplaces, health care providers, and assisted living facilities may consider temperature checks. The Food and Drug Administration in April relaxed some regulations on infrared cameras to widen access to the technology. In March, the Equal Employment Opportunity Commission issued new guidance clearing the way for workplace temperature checks, which previously were often precluded by employment laws.

moves to lift quarantine restrictions while trying to suppress the disease, temperature checks are becoming a daily ritual for many.

Thermal screening, however, is not a sufficient screen by itself. Studies have shown that it can miss over 50% of those infected /7/. A person can slip past a temperature check by taking fever-reducing medicine like ibuprofen.

There is some value, however, in the fact that thermal screening can detect a certain percentage of passengers who have the COVID-19 disease. If these contagious travelers are prevented from entering a plane and infecting a planeload of other passengers—and interdicted from entering Kaua'i where they could overload the healthcare system—the value of the screening is maximized. For these reasons, all state and county officials should advocate thermal screening as a minimum national safety standard for boarding of any airline.

While thermal screening has a role to play, its value as a screen must be weighed against the far more accurate polymerase chain reaction (PCR) test as well as other essential components such as quarantine and contact tracing. It is our understanding that the State of Hawai'i has received $50 million for testing, quarantining and contact tracing. Of that money, $36 million is going to the DOT Airport for thermal screening /22/, which as was mentioned earlier has an error rate of over 50%. To our knowledge no funding has been set aside for the testing of visitors and returning residents.

Challenges

A major limitation of screening based on fever or other disease manifestations is that up to 40% of individuals capable of spreading Covid-19 are asymptomatic (or begin shedding virus prior to symptom onset). Combined with the fact that fever is not always present in individuals with active disease, and that even when present fever can be suppressed by commonly used medications such as ibuprofen or Tylenol, a study in February of this concluded that even in a best-case scenario, screening for symptoms like cough or fever, or asking people about possible exposure to the disease, would miss more than half of infected people upon arrival screening/7/. To summarize, a positive test result provides valuable information, but a negative result does not.

The ease with which people shedding coronavirus particles could slip through a temperature checkpoint is one reason major hospital systems do not rely on this technology (like at University of California San Francisco, for example), and it highlights the need for a highly sensitive screening regime if the risk of disease spread is to be minimized. It is for this reason that a 2-week period of quarantine is currently required for all travelers arriving on Kaua'i.

DIRECT VIRUS TESTING

RECOMMENDATION: That highly sensitive testing for infection with SARS-Cov-2, performed on two separate occasions, 6 days apart, be offered to all incoming travelers as an alternative to the mandatory 14-day quarantine, potentially reducing the quarantine time to 7 or fewer days. If the first test can be done prior to boarding this would be even more effective.

We emphasize that the performance of two tests separated by 6 days greatly increases the ability to identify arriving passengers capable of spreading the infection and is far more effective than strategies based on a single test. According to the statistical modeling presented in this report, and supported by data and experts in public health, testing only once without quarantine means that fully one-third of infected passengers will be allowed to enter our communities undetected (32 infected passengers for every 10,000 arrivals). At a rate of 1,000 visitors per day, almost 100 positive cases per month will enter Kaua'i unrestrained. See modeling. Adding a second test after 6 days of quarantine cuts the number by 7-fold to <5 per 10,000 providing an exponential leap in safety.

The Kauai COVID-19 Discussion Group proposes an alternative to a mandatory 14-day quarantine period based on testing for infection with SARS-Cov-2 (the virus that causes COVID-19) on two separate occasions, separated by 6 days. With this approach, our predictive model indicates that quarantine could safely end after 7 days for those who test negative on both Day 1 and Day 6. While participation in this testing program is strictly voluntary, we believe it will be viewed favorably by most incoming travelers when compared to the alternative (mandatory 14-day quarantine).

We also predict that replacing the current 14-day quarantine with a single screening test performed either prior to or upon arrival will prove inadequate to prevent significant disease spread on Kaua'i. This conclusion is based on 1) our model-based prediction that a single test will only identify a subset (~68%) of individuals who will eventually become infectious, and 2) recent evidence of a major COVID-19 outbreak of occurring where screening was limited to a single test combined with a shortened (5-day) quarantine period, resulting in disturbingly high infection rates. /23/.

Secondary outcomes of this proposal goals are:

- to determine the prevalence rate of individuals arriving on the island who subsequently become capable of transmitting the infection, and
- to facilitate strategies for contact tracing of travelers once they are released from quarantine.

Proposal

This proposal is based on a predictive model developed to estimate the likelihood of a passenger developing transmissible Covid-19 infection after testing negative on both Day 1 and either Day 6 or Day 7 after arrival. As is evident from Figure 3.1, the risk of converting to a positive test decreases exponentially with the passing of each day spent in quarantine, and therefore is quite low after Day 6. Specifically, this model predicts that for every 10,000 arrivals that test negative on Days 1 and 6, only 2 individuals will become infectious after leaving quarantine on Day 7. If the second test is performed on Day 7, instead of Day 6, the risk posed by those with a negative test result drops further to 1 individual per 10,000 (but the test result would not be available until Day 8).

We believe that the risk associated with this approach compares favorably to a mandatory 2-week quarantine with no testing, owing to:

- challenges inherent in enforcement of a prolonged quarantine, and
- a much greater likelihood of voluntary adherence to a shorter quarantine period.
- An added benefit is that we will obtain valuable data regarding the rate at which arriving passengers test positive for the virus over time, which will inform us as to the risk posed by travelers to Kauai more broadly.

Proposal Details

Our proposal calls for all arriving passengers to be asked for their consent to be tested twice for the presence of SARS-Cov-2 by PCR analysis of a specimen obtained by nasopharyngeal swab. The first test will be obtained on the day of arrival (either at the airport or at the hotel where they will be quarantined) and the second will be obtained on Day 6 after arrival. Each sample must be obtained by trained personnel with appropriate personal protective equipment; a sufficient supply of swabs and transport media must also be available. Essential to this model is that test results are made available within 24 hours of when the sample was obtained (see Assumption #2, below).

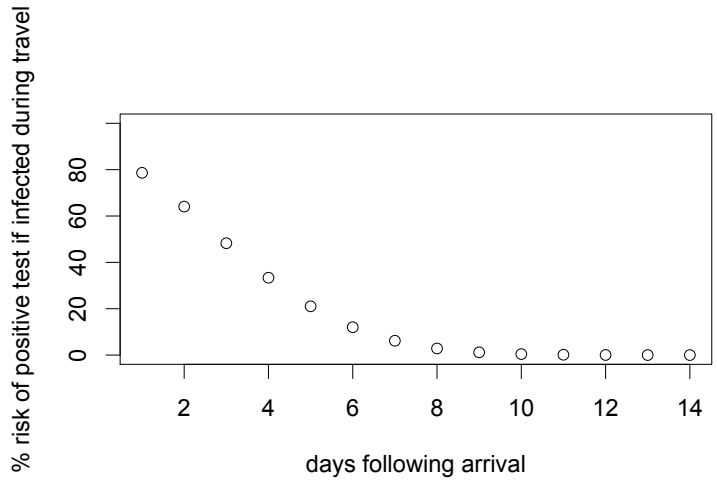
Those testing negative on Day 1 return to quarantine until Day 6 when they are tested again; those that also test negative on Day 6 will be released from quarantine when the test result

becomes available the next day, Day 7. For such individuals, therefore, the duration of quarantine is reduced from 2 weeks to 1 week. In contrast, arriving passengers that opt out of the testing program must be quarantined for the full 14-day period.

In this way, an incentive is created for arriving passengers to participate in the screening program. Even though participation is strictly voluntary, we anticipate that most travelers will prefer this option. We also propose to incorporate cell phone-based contact tracing of all travelers for at least 2 weeks upon their release from quarantine on Day 7, which will enable us to identify contacts for those few individuals that become contagious after they leave quarantine; those contacts must then also be tested.

Any individual testing positive (on either Dy 1 or Day 6) will be placed in isolation for 2 weeks (estimated to be 0.5-1% of arrivals)/14/, and they must test negative before they are released to the community.

Figure 3.1
RISK OF INFECTION OVER TIME



Estimated likelihood of a positive test result over time among all individuals who will test positive after arrival.

Comparison to Other Testing Proposals

To illustrate how the model facilitates comparisons between different screening approaches, let's assume that those capable of transmitting the virus represent 1% of the arriving population, such that there will be 100 such individuals per 10,000 arrivals. As illustrated in the Table 3.1, a single negative PCR test at or before arrival reduces this number by ~2/3rds, to 32 per 10,000 arrivals. Assuming 1,000 incoming travelers per day on Kaua'i, or 10,000 visitors in 10 days, about 32 infected travelers will slip undectected into the community every 10 days—about 100 per month. Kaua'i has seven ICU beds.

Table 3.1
NUMBER OF INFECTED PER 10,000 ARRIVALS THAT ARE RELEASED INTO THE COMMUNITY DEPENDING ON DAY OF SECOND PCR TEST

Day of Second Testing	Number infected per 10,000 arrivals
0 (arrival)	32
1	27
2	23
3	18
4	13
5	8
6	5
7	3

If a second test is performed after a 6-day quarantine period, and if the test result is negative, this number is reduced 7-fold, to 5 per 10,000 arrivals. If the second test is performed Day 4 of quarantine instead of Day 6, however, the number of infected arrivals released into the community increases by more than 2-fold, to 13 per 10,000.

Screening passengers with a negative PCR test result prior to boarding the aircraft is a powerful way to minimize the number of infected individuals that arrive on the island. In the absence of a second test and/or quarantine, however, this approach will still release 32 infected travelers per 10,000 arrivals into the community. If combined with quarantine for 4-6 days upon arrival, followed by a second negative PCR test, however, this becomes a highly effective screening strategy.

Testing Requirements

Of paramount importance is the accuracy of the screening test – failure to detect travelers who carry the disease will cause the testing strategy to fail and hence pose a significant risk to the health of the island. The current gold standard test for detecting SARS-Cov-2 uses a method known as polymerase chain reaction (PCR) to amplify and detect genetic material from the virus in samples obtained from a nasopharyngeal swab. When performed properly, the sensitivity of this test is 99%; i.e., for every 100 positive individuals, only 1 will test negative. No other currently available test comes close to this level of accuracy. Obtaining this high level of sensitivity, however, is dependent on obtaining an adequate sample.

Model Assumptions

The design of the testing regime proposed herein is based on a predictive model developed to assess the risk that a traveler to Kauai will become positive for SARS-Cov-2 viral infection after arriving on the island. This model (Figure 3.1) is based on the following assumptions, derived from published data:

1. Prevalence of transmissible COVID-19 in the population arriving on Kauai is in the range of 0.5% - 1.0% /8/.
2. Sensitivity and specificity of the PCR test to detect SARS-Cov-2 viral infection is 99% for both; turnaround time <24h /9/.
3. Time from viral exposure to onset of viral shedding (which typically precedes symptom onset by 2-3 days) peaks around Day 4 after exposure; >97% of those who will shed virus do so by Day 10 /11/.

4. Consequently, if we assume duration of viral shedding to be no longer than 12 days and that onset of viral shedding occurs as early as 4 days after exposure, approximately 67% of individuals who are going to test positive will do so by Day 1; i.e., only a minority of individuals destined to test positive will have tested negative on Day 1. (A key exception to this assumption applies to individuals who exposed during travel to Kaua'i, discussed below.)
5. Travelers will not be exposed to the SARS-Cov-2 while in quarantine.

Challenges

One consideration pertains to airport screening and the possibility that some arriving passengers will have been exposed to COVID-19 during flight. This scenario poses a significant challenge to efforts to shorten the duration of quarantine, owing to the possibility of individuals being exposed just prior to arriving on the island and hence being among the most likely convert to testing positive after being released from quarantine. Yet even most of these individuals will have converted by Day 6 (see Assumption #4, Appendix B). For this reason having the first test done prior to boarding in combination with a follow up test on island would be desirable.

A significant and ongoing issue worldwide is the lack of access to testing supplies, namely nasopharyngeal swabs, reagents and personal protective equipment. Shortages in testing supplies mean that hospitals and health departments will continue to prioritize people who can get tests.

While it appears that supplies are presently enough in Hawai'i, we know of no calculation of need based on viral testing of incoming travelers. Assuming a conservative number of incoming arrivals to Kaua'i, say 1000 per day, 14,000 test kits a week or 56,000 tests per month will be required assuming every arrival is tested twice. While that may seem like a lot of tests by American standards, such a volume of tests does not seem to be a problem in many Asian countries such as South Korea The Kauai COVID Discussion Group has identified a reliable source of test kits. The cost of such kits (about $150 per test) could be paid for by the visitor, the airlines or visitor industry, state or county government—or a combination thereof.

Processing of test samples is another potential limitation. Local Hawai'i laboratory capacity would need to be assessed and expanded, if necessary. Should there be insufficient capacity, the test itself can be performed within a matter of hours by a laboratory at the University of Washington Medical Center, with a 24-hour turnaround time, compatible with the goals of the screening program. In discussions with those who run the Virology Laboratory at the University of Washington, it was noted that they have the capacity to perform all the testing needed for this proposed program to succeed, should that be an attractive option.

SECTION 4
Quarantine Practices for Incoming Travelers to Kaua'i

RECOMMENDATION: That, to increase the effectiveness and integrity of the existing quarantine system, all incoming travelers be quarantined in designated hotels except for those visitors and residents who consent to wear tracking bracelets. The proposed personalized quarantine facilites should be approved by the Department of Health.

This section describes a quarantine system that would complement the testing protocol proposed in Section 3. Together, the proposed testing and quarantine protocols could reduce the quarantine time from a mandated 14 days to 6 days with release on the 7th day.

Quarantine is an age-old method for stopping the spread of infectious disease. Today, validated by science, it is an effective, legally sanctioned method for containing SARS-Cov-2. The emergency proclamation by Governor David Ige imposing a 14-day quarantine on all incoming travelers as of March 31, 2020, was likely a major factor in the State's success in controlling the virus thus far. It was effective in two ways: 1. By requiring the incoming traveler to remain in a hotel room or home, it limited the potential virus carrier from interacting with, and thus exposing, members of the community to the virus. 2. It strongly discouraged visitors from coming to Hawai'i.

Having successfully contained and possibly eliminated the virus from the island, Kaua'i must now address the severe economic sacrifice that was required to achieve this goal. In order to revive the economy Kaua'i must find a way to allow travelers to enter the island without allowing the virus to enter the community. It must also establish a system of detection, contact tracing and quarantining as a second line of defense to rapidly interdict and stop the spread of any virus that eludes the first screen and gets into the community. Until a reliable "rapid response" or "point of care" diagnostic test is available, quarantining will be crucial for both the screening of incoming travelers and the system of interdiction and contact tracing in the community.

QUARANTINE PROPOSAL

The proposal is to quarantine all visitors in one place, logically a hotel where rooms and meals are available, and employees are trained in COVID-19 protocols. In contracting with an existing hotel, the state would be investing in the economy and helping to save a business from potential demise, just as was done after Hurricane 'Iniki when tour buses were contracted by the Federal Emergency Management Agency (FEMA) to provide emergency public transportation. It is likely that the occupancy of a quarantine hotel will be higher than if it were just serving a regular hotel function at this time.

Visitors could be allowed to quarantine at the resort where they have reservations, if those hotels are certified by the Department of Health (DOH) as having the protocols to handle quarantined guests and the visitors consent to wear tracking bracelets as are used in South Korea /12/.

Likewise, returning residents and intended residents would be quarantined at a hotel as well, but it may better at a separate hotel as the needs and functioning of such guests would be different from the visitor.

Returning residents could be allowed to return home provided there were no others living in the home and they agreed to wear tracking bracelets. Where there are other householders in the

home, returning residents would need to demonstrate accommodations that meet quarantine requirements such as a bedroom with separate bathroom. This would require inspection and instructions about safe quarantining at home. Consent and commitment to wearing a tracking bracelet would also be required.

Proposal Details

A quarantine hotel set aside specifically for visitors (including returning residents) would have the opportunity on to focus on providing exemplary service and engagement to mitigate the inconvenience and stigma associated with a forced quarantine. Such a quarantine hotel for visitors could set a goal to provide such a memorable experience for the guests that they would be comfortable and inspired to book rooms in the future when the COVID-19 period is just a memory. A second facility for returning residents, students, and local business commuters would focus more on digital-communication access for family and business needs.

Incentives

Properties could potentially be incentivized with compensation via state contract, or in conjunction with reduced taxes, or special marketing program via HLTA/HTA, or other considerations. And until the State and County are ready for visitors, visitors could be made to pay a fee as is required in South Korea.

Keiki

There should be a special program for adults traveling with keiki. Keiki get bored easily and will need special attention, as well as patience, remembering that they are likely to be wound up because they are traveling, out of their environment, and potentially have stressed adults accompanying them. Daily bundles with projects, games, puzzles, art materials etc. based on age, could be delivered to the rooms each morning. Parents will be appreciative of this level of awareness and attention (kids hopefully will look forward to the delivery). Security measures and immediate response should be planned for if any child decides to go exploring. The response plan and expectations should be explained to the parents upon arrival.

CHALLENGES

There are several challenges to setting up a mandated quarantine policy for incoming travelers to Kaua'i. This will include managing legal and ethical issues, managing County or State liability issues, finding appropriate quarantine facilities and building out the appropriate infrastructure, having a properly trained workforce with sufficient personal protect equipment, and medical management and testing logistics at the quarantine facility.

A major component of effective quarantining will be enforcement. The County and State will have to determine how best to manage enforcement among a broad range of stakeholders, from the hotel to police and even the National Guard. Managing the infrastructure will be one of the biggest challenges and shifting as much of the burden from current law enforcement and military involvement will be necessary over the long haul as more travelers arrive on island Higher-level enforcement could default to local authorities and/or the National Guard, but lower level security, organizational, statistical, and technological tasks could boost the local economy and save businesses.

A handbook should be provided to each traveler or family that lists expectations, the level of enforcement and responsible parties, and potential penalties that are associated with infraction depending on State and County rules/laws.

County and state officials will also need to consider how best to manage or expand penalties for law breakers.

SECTION 5
Conclusions

We all rejoice at the lack of new COVID-19 cases on Kaua'i for the past 9 weeks and the gradual lifting of restrictions.

Our efforts will be for naught, however, if we reopen without a solid plan in place to prevent the COVID-19 virus from re-entering our county and state as the number of incoming travelers, both visitors and returning residents, increase.

There have been over 2.1 million infections in the United States, with 116,977 deaths at the time this report was written. The risk to our communities is real: without proper screening of incoming travelers, the virus could re-infect and spread in Hawai'i again, with devastating public health and economic consequences.

Kaua'i's and Hawai'i's chances for a sustained economic recovery depend on putting in place a science-based screening and quarantine system for incoming travelers — as well as a system of detection and containment (through testing, contact tracing and appropriate quarantining and isolation) when reinfection of the community occurs.

This report, channeling experts in medicine, science, and epidemiology, focuses on the screening and quarantine system for incoming travelers. It proposes a system whereby incoming travelers to Kaua'i will be offered the opportunity to reduce the 14-day quarantine to 6 days if they volunteer to take a pcr test on both Day 1 and Day 6 of arrival. If both tests result in negative readings, the quarantine will be lifted on Day 7. If the first test can be done prior to boarding this would be even more effective.

Without the quarantine and second test, we stress that for every 10,000 incoming travelers, approximately 32 unidentified infected travelers will be admitted into Kaua'i. At 1,000 visitors per day, that would mean about 100 infected travelers would enter Kaua'i undetected per month. This number would quickly overwhelm health care resources on Kaua'i, potentially leading to a second economic shutdown.

It is our hope that the State of Hawai'i's Department of Health has test kits, personal protective equipment and test processing capacity to implement the proposed testing and quarantine process for the expected number of incoming travelers. If that is a problem, this study has identified sources of test supplies and test processing capacity that Hawai'i could utilize.

Upon arrival to Hawai'i, incoming travelers will not be allowed to rent cars and will be shuttled to a designated quarantine hotel where management and workers are trained in protocols approved by the state Department of Health. Police or the National Guard will provide 24/7 support for hotel security.

A visitor may choose to stay at another hotel of his or her choice (approved by the DOH for hosting quarantined guests) but he or she must agree to wear a tracking bracelet. Our enforcement personnel currently have their hands full with just a trickle of visitors. It will become impossible — and extremely expensive — to enforce the quarantine as visitor numbers grow unless we use smart technology as well as good system design.

Because a substantial percentage of past infections were caused by residents returning to Hawai'i, the policy of home quarantining of returning residents needs to be upgraded. Because other householders have been infected in the past, quarantining (and isolation) henceforth should be done outside the home, unless the home is occupied only by returning residents.

As described in this report, the 14-day quarantine could be reduced significantly with enough testing capacity. If that works on Kaua‘i, Kaua‘i could become a model for the state.

Making travel to, or back to, Hawaii safe is the key to successful and sustained economic recovery. It will allow businesses to open safely and people to go back to work. It is the most important thing our leaders can secure for us now.

APPENDIX A
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APPENDIX B
Predictive Model Assumptions and Methodology

METHOD

This model is based on widely accepted Bayesian conditional probability concepts that are routinely employed in disease epidemiology /13/. Conditional probability estimates (a.k.a. model assumptions) are based on values derived from the literature relevant to the latency to viral shedding following infection, and on the sensitivity and specificity values for PCR-based detection of SARS-Cov-2 when performed by the Department of Virology at the University of Washington. The disease prevalence value is based on /8/. The model is structured as a 'tree structure', with conditional probabilities governing the percentage of people that will ultimately prove to be either true positives or false positives when tested on Day 1 or Day 6.

ASSUMPTIONS

1. Test sensitivity and specificity are both 1.0
2. CoVID-19 disease prevalence is 0.75% = 0.0075.
3. Infectivity occurs 4d after infection with CoVID-19.
4. Conversion to testing positive corresponds to the onset of infectivity.
5. Cessation of infectivity occurs 12d after infection.
6. Conversion to testing negative corresponds to the cessation of infectivity.
7. The flight to Kauai corresponds to d0.
8. Test 1 occurs on d0, the first day of quarantine.
9. Test 2 occurs on d6 of the quarantine.
10. All who test positive on Test 1 are quarantined for 14d.
11. Some passengers are infected on the flight (d0). Specifically, each infective passenger generates 0.72 new cases (based on updated information), i.e., the effective reproduction rate (Re) is 0.72.

Expected test outcomes on Test 1 and Test 2, and expected impact on the decision to release following a negative test on both Test 1 and Test 2 based on the assumptions listed above are listed in Table B.1.

ACCOUNTING FOR RISK OF INFECTION DURING FLIGHT

1. Passengers infected on d-12 or before are noninfectious on d0 and cannot transmit disease on the flight (d0) (Line 1 of Table B1).
2. Passengers infected on d-11 to d-4 are infectious and can transmit disease on the flight. Passengers infected on d-3 to d-1 are not yet infectious and cannot transmit disease. Thus 8 of 11 (72.7%) infected passengers can generate new cases on the flight.
3. Given a disease prevalence (P(D)) of 0.0075, an Re of 0.72 (https://www.news-medical.net/news/20200510/Reproduction-number-of-COVID-19-and-how-it-relates-to-public-health-measures.aspx), and given that the proportion of uninfected passengers prior to flight is estimated to be (1 – P(D)), we expect the rate of new cases generated on the flight to be 0.0075*0.727*0.072/(1-0.0075)=0.0004, i.e., ~0.04% of the previously uninfected passengers will become infected on the flight. However, these will test positive on Test 2 and thus be quarantined for the entire 14d.

LIMITATIONS

Deviation from predicted outcomes can result from random variation in the inputs to the model that deviate from model assumptions. A more realistic predictive model can be generated using

Monte Carlo simulations that acknowledge the uncertainties in input estimates (using published values where possible).

CONCLUSION

Despite these caveats, we anticipate that if implemented, the proposed screening protocol would reduce the number of infected passengers that are released from quarantine to less than 3 per 10,000 arriving passengers.

Table B.1
EXPECTED TEST OUTCOMES

day infected	day infectious	day noninfectious	test pos onT1 (d0)?	test pos on T2 (d6)?	released?
-12	-8	0	N	N	Y
-11	-7	1	Y	N	N
-10	-6	2	Y	N	N
-9	-5	3	Y	N	N
-8	-4	4	Y	N	N
-7	-3	5	Y	N	N
-6	-2	6	Y	N	N
-5	-1	7	Y	Y	N
-4	0	8	Y	Y	N
-3	1	9	N	Y	N
-2	2	10	N	Y	N
-1	3	11	N	Y	N
0	4	12	N	Y	N