Assessment of two COVID-19 models to guide community intervention policies in Anchorage and Alaska

Data current as of 25 March 2020

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Executive Summary

On Wednesday, March 19th, 2020, the UAA College of Health, Division of Population Health Sciences and the Institute for Circumpolar Health Studies were tasked with a review of two epidemiologic models: 1) COVID ACT NOW Model[1] and 2) the Imperial College of London model[2] with the intent of assessing their validity and applicability to health policy questions in Anchorage/Mat-Su and Alaska.

This report provides information to answer the following question: *<u>"Based on these models should Anchorage be taking stronger action on social distancing to prevent spread of the outbreak and prevent overwhelming our medical capacity?"</u>*

Based on the results from running one of these models with specific data from Anchorage/Mat-Su and Alaska, we stand by our earlier statement provided to the Municipality of Anchorage on March 20th, 2020, that **both epidemiological models indicate that social distancing measures that are implemented earlier and more completely will reduce the impact on the health care system and decrease fatalities.**

Interventions implemented sooner that delay a sharp increase in cases will allow time to 1) acquire additional hospital supplies and beds, 2) gain additional testing capacity, 3) allow medical providers to return to work after a 14-day post-travel isolation period, and 4) allow Anchorage/Mat-Su and Alaska to prepare more evidence- and data-informed response plans.

Recommendations based on COVID ACT NOW and Imperial College of London models:

- Consider implementing additional community-wide strategies to limit transmission as soon as possible to prevent overwhelming our medical capacity. This may be accomplished by the following measures:
  - Mandated shelter-in-place
  - Narrowing definitions of essential businesses
  - Enforcing non-essential business closures (or work from home)
  - Requiring that non-essential workers work from home
  - Maintaining current school closures
  - Restricting non-essential travel to and within Alaska

  The relative effect of any one of these strategies, by itself, is not known. Therefore, other factors such as social and economic impact should be considered when implementing multiple strategies. As the pandemic continues, we may have additional data on the relative impact of each measure.

- Coordinate state and local protocols for implementing and enforcing quarantine mandates for travelers entering Alaska. Consider harmonizing interventions between Anchorage and the MatSu valley.

- Continue contact tracing and home quarantine of close contacts to provide critical epidemiologic indicators that will inform future response plans.

[1] https://covidactnow.org/
[2] https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf

- Looking forward, we need to consider appropriate and feasible thresholds for triggering policy action, including both implementing and easing restrictions.

Alaska is fortunate in that other states have experienced the pandemic before we have. We can use data from previously affected communities to inform our decisions moving forward. The models reviewed here were built using data from much larger populations than Alaska. Therefore, the assumptions made in these models and the indicators used will need to be re-assessed for their relevance to the Alaskan or Anchorage context. Faculty from the **UAA Division of Population Health and the Institute for Circumpolar Health Studies** are available to help address this and other health policy questions as they arise and we learn more about COVID-19.

COVID ACT NOW MODEL SUMMARY

Source: https://covidactnow.org

SECTION 1: Basic model assumptions and parameters

The COVID ACT NOW model was created by a team of data scientists, engineers, and designers in partnership with epidemiologists, public health officials, and political leaders to help understand how the COVID-19 pandemic will affect each state. **The COVID ACT NOW model is a spreadsheet-based tool that compares three scenarios to "No Action," which assumes unchecked exponential growth of the epidemic.** This model is, in large part, based on the Imperial College model developed to explore the impacts of five interventions to control transmission of COVID-19 in the UK and US. For more information on the Imperial College model, see Appendix A.

The COVID ACT NOW model is open-source and available for adaptation to the local context. We have worked with the model developer, Max Henderson, to download and modify copies of the model that now include data for Anchorage/MatSu (or Alaska) population, age distribution, the number of hospital beds, and the number of reported cases. We have used these modified models to produce the illustrations below.

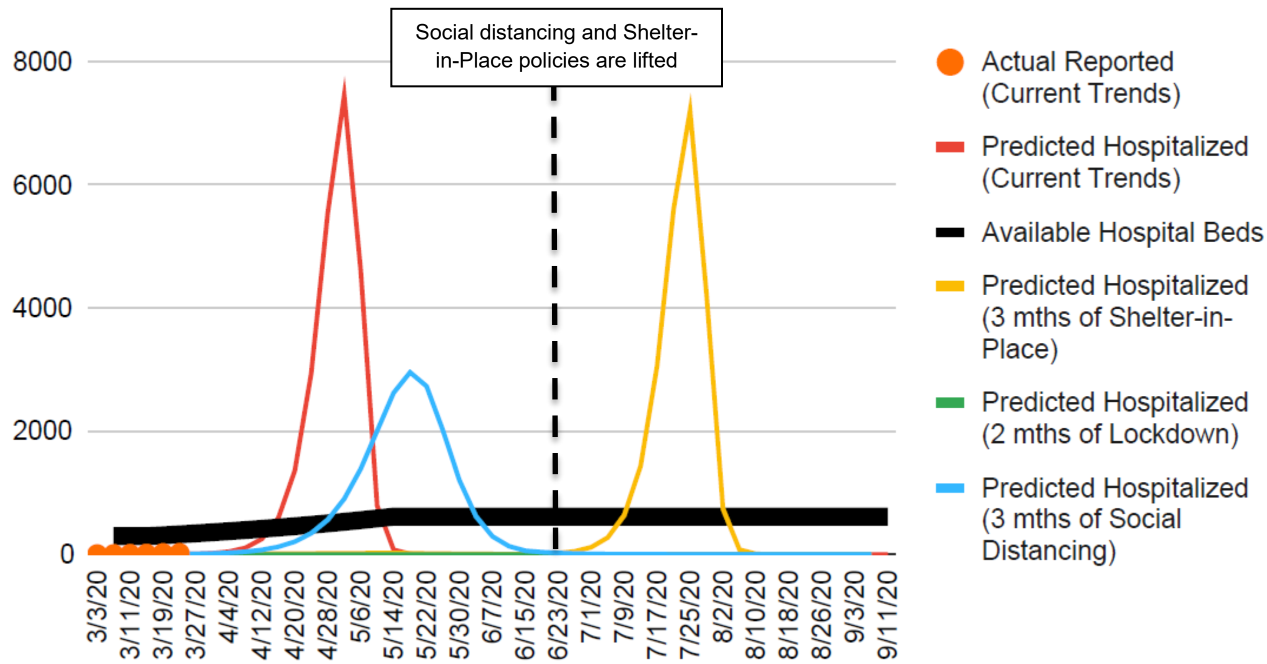
SECTION 2: Strategies considered

The COVID ACT NOW model uses changes to the reproductive number (R0), (the average number of other persons each infected person infects), to predict the potential impact of four different response strategies applied over a three-month period (March 16 - June 23). These strategies include **1) Lockdown, 2) Shelter in Place, 3) Social Distancing, and 4) No Action** (See Figure 2 and Appendix B for summaries of these scenarios). The model predicts the number of cases, hospitalizations, and deaths, and projects those against available hospital beds. The model does not adjust for population density, culturally-determined interaction frequency, environmental factors (humidity, temperature, etc), or differences in spreading rate between individuals. The model does not model the number of ICU beds or ventilators needed. Additional limitations and assumptions are detailed in Appendix B.

SECTION 3: COVID ACT NOW Models adapted to Anchorage/Mat-Su

The following model predicts the number of hospitalized individuals in relation to **1) Lockdown, 2) Shelter in Place, and 3) Social Distancing, and 4) No Action**. The black line indicates the number of available hospital beds, and the orange dots reflect the actual number of reported cases in Anchorage through March 23, 2020. We included both the Municipality of Anchorage and the Matanuska-Susitna Borough in models based on their close proximity and their interconnectedness in terms of travel and economic activities.

Figure 1. Model of hospitalizations over time in Anchorage/Mat-Su based on the COVID ACT NOW modeling framework and Anchorage data



If **No Action** is taken, the model predicts that new cases will rapidly overwhelm Anchorage/Mat-Su's medical capacity within weeks and will result in approximately 5,800 deaths in Anchorage. Anchorage/Mat-Su currently has just over 982 hospital beds, and in this scenario, we could need capacity to care for up to 7,400 hospitalizations at the peak of cases.

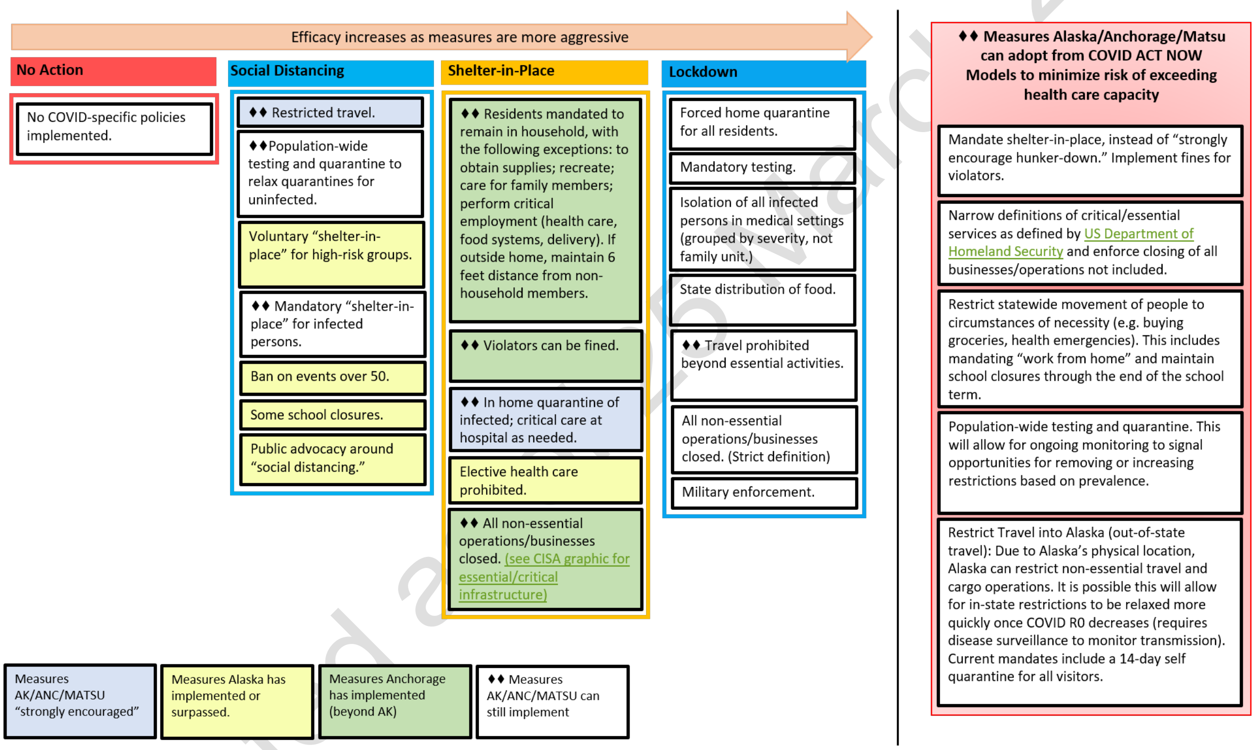
Only the **Lockdown** scenario predicts that hospitalizations will remain below the number of available hospital beds in Anchorage/Mat-Su. The Wuhan-style lockdown is difficult to see in this figure because the case numbers are so low.

The Social Distancing predicts many fewer hospitalizations, compared to No Action, but the number of hospitalizations exceeds hospital bed capacity as early as late April, 2020. Thus, social distancing allows for approximately three to four weeks of preparation from March 25th, 2020.

The **Shelter in Place scenario modeled here is the most similar to the current policies in place in Anchorage.** This scenario predicts very few cases while the response is in place, but shows a rebound in hospitalizations far exceeding capacity within a month after the mandate is removed, with no further measures put in place. This delay in cases and hospitalizations may provide the time necessary for increasing medical capacity in and outside of Anchorage/Mat-Su and Alaska, and may be mitigated by a stepwise decrease in restrictions, rather than an abrupt end to shelter in place.

Figure 2 (below) summarizes the key components of the four scenarios built into the COVID ACT NOW model above. The key indicates those components that relate to steps Anchorage/Mat-Su and/or Alaska has taken (further specifying "strongly encouraged" vs. "mandate") to prevent exceeding medical capacity. Figure 2 also highlights options that Anchorage/Mat-Su and Alaska can still take to adhere to **Shelter in Place** and **Social Distancing**. These options (indicated with ♦♦) are explained in the table on the right side of the graphic.

Figure 2. Summary of COVID ACT NOW Scenarios as related to Anchorage/Alaska[3]



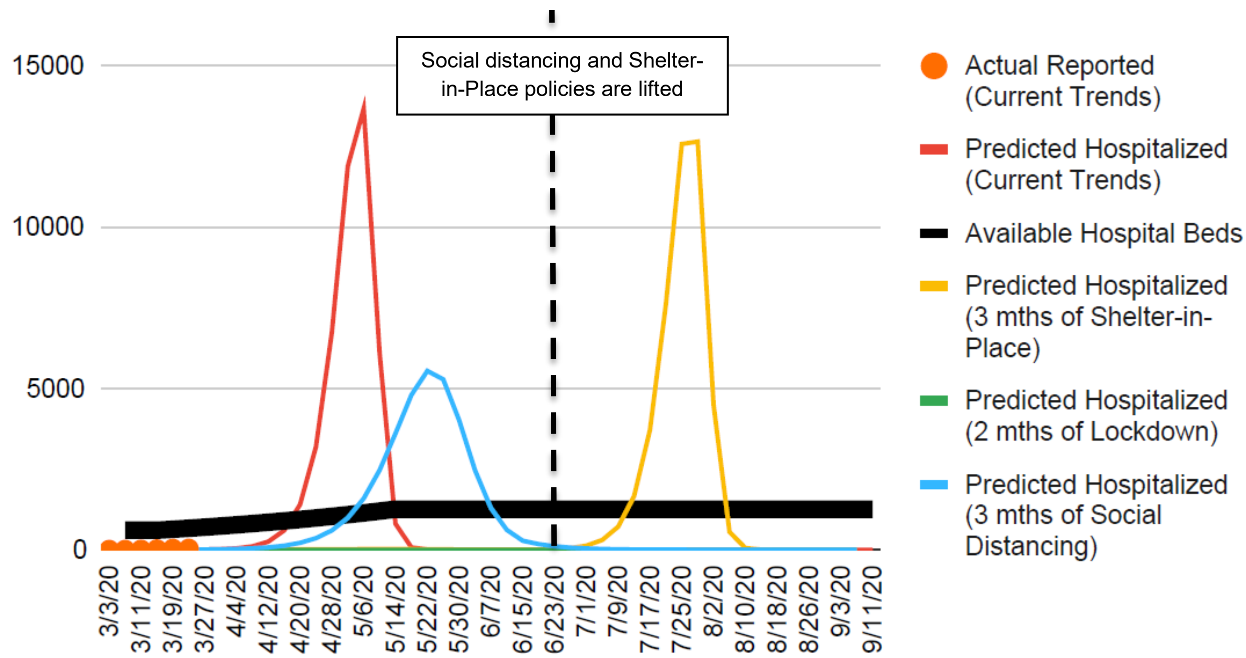
SECTION 4: COVID ACT NOW Models adapted to Alaska

The conclusions from this model are similar to the Anchorage/Mat-Su model for all scenarios. If **No Action** is taken, the model predicts that new cases will rapidly overwhelm Alaska's medical capacity within weeks and will result in approximately 11,000 deaths in the state. Alaska currently has just over 1,500 hospital beds, and in this scenario, we could need capacity to care for up to 13,700 hospitalizations at the peak of cases. Only the Wuhan-style **Lockdown** containment scenario predicts that we will not overwhelm hospital capacity. Similar to the

[3] US Department of Homeland Security list of "essential and critical infrastructure": https://www.cisa.gov/identifying-critical-infrastructure-during-covid-19

Anchorage/Mat-Su model, the Alaska model also predicts a rebound of cases will occur in July, about a month after Shelter in Place is relaxed.

Figure 3. Model of hospitalizations over time in Alaska based on the COVID ACT NOW modeling framework



SECTION 5: Recommendations based on COVID ACT NOW and Imperial College models

- Consider implementing additional community-wide strategies to limit transmission as soon as possible to prevent overwhelming medical capacity. This may be accomplished by the following measures:
  - Mandated shelter-in-place
  - Narrowing definitions of essential businesses
  - Enforcing non-essential business closures
  - Requiring that non-essential workers work from home
  - Maintaining current school closures
  - Restricting non-essential travel to and within Alaska

  The relative impact of any of these strategies by themselves is not known. Therefore, other factors such as social and economic impact should be considered when adding other strategies. As the pandemic continues, we may have additional data on the relative impact of each measure.

- Coordinate state and local protocols for implementing and enforcing quarantine mandates for travelers entering Alaska.
- Continue contact tracing and home quarantine of close contacts to provide critical epidemiologic indicators that will inform future response plans.

- Looking forward, we need to consider appropriate and feasible thresholds for triggering policy action, including both implementing and easing restrictions.

Considerations not based on the models: Alaska is in a unique situation because we are much earlier in the progression of the epidemic than many other states, and may still be in a position to prevent overwhelming our medical capacity. Additionally, due to Alaska's geographic location, medical aid from other regions may be limited. However, Alaska's geographic isolation provides an opportunity to significantly restrict travel to the state, thus effectively intervening and limiting additional cases originating from outside of Alaska.

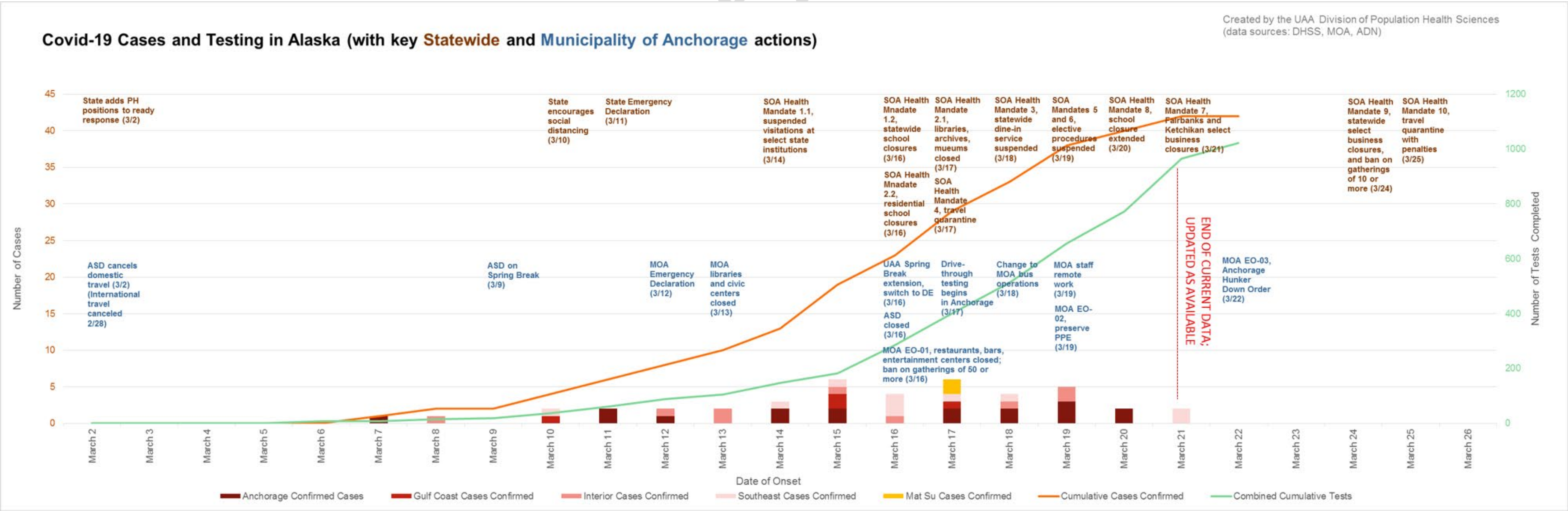
SECTION 6: Additional tools for decision-making

A. COVID-19 timeline in Alaska and Anchorage

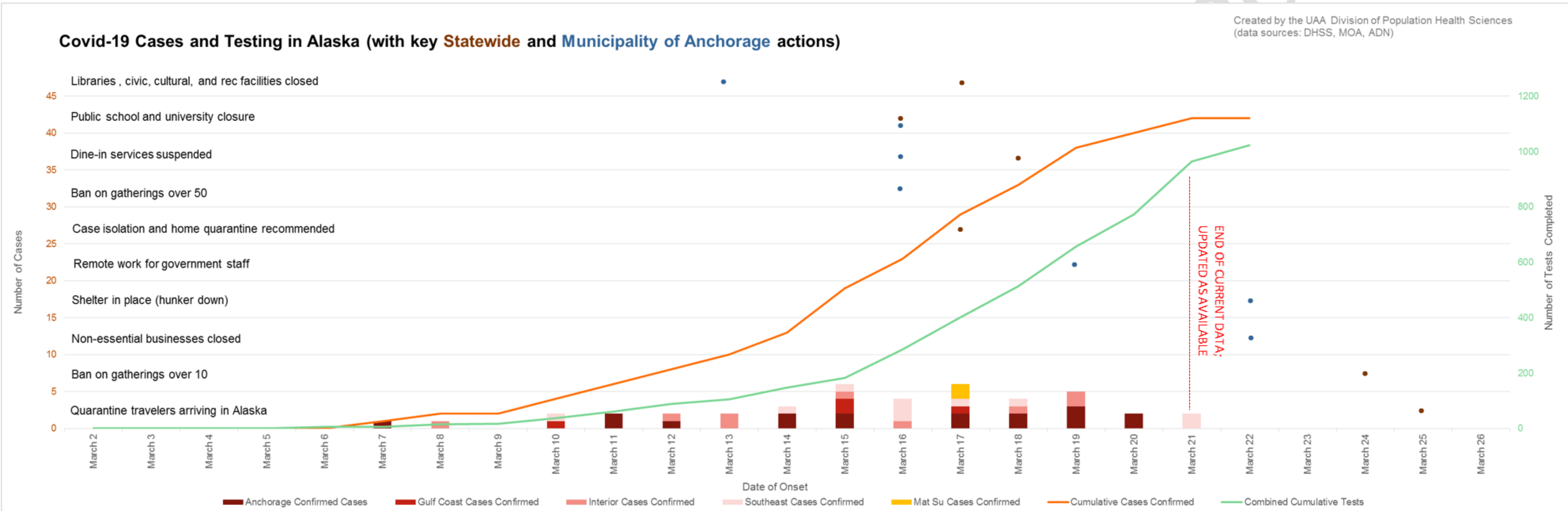
The figures below depict confirmed cases of COVID-19 by region, along with cumulative cases and cumulative tests. Figure 4a also includes the timing of key mitigation measures enacted by the State of Alaska (SOA) and the Municipality of Anchorage (MOA), identified in relevant mandates, orders, health alerts, and announcements. Alternatively, Figure 4b provides a simplified illustration of key categories of social distancing measures enacted by the SOA and MOA. Readers should note that case data are up to date as of March 24, 2020, and represent the timing of the onset of symptoms in confirmed cases. Monitoring and documentation of subsequent cases and actions will continue by the Division of Population Health Sciences to assist in future decisions regarding mitigation measure implementation and removal.

Figure 4. Current status of Alaska cases and mitigation measures at the State and Municipality of Anchorage levels (current as of the morning of 3/25/20). a) Includes all mandates, orders, and recommendations and b) Includes only social distancing interventions.

4a)



4b)

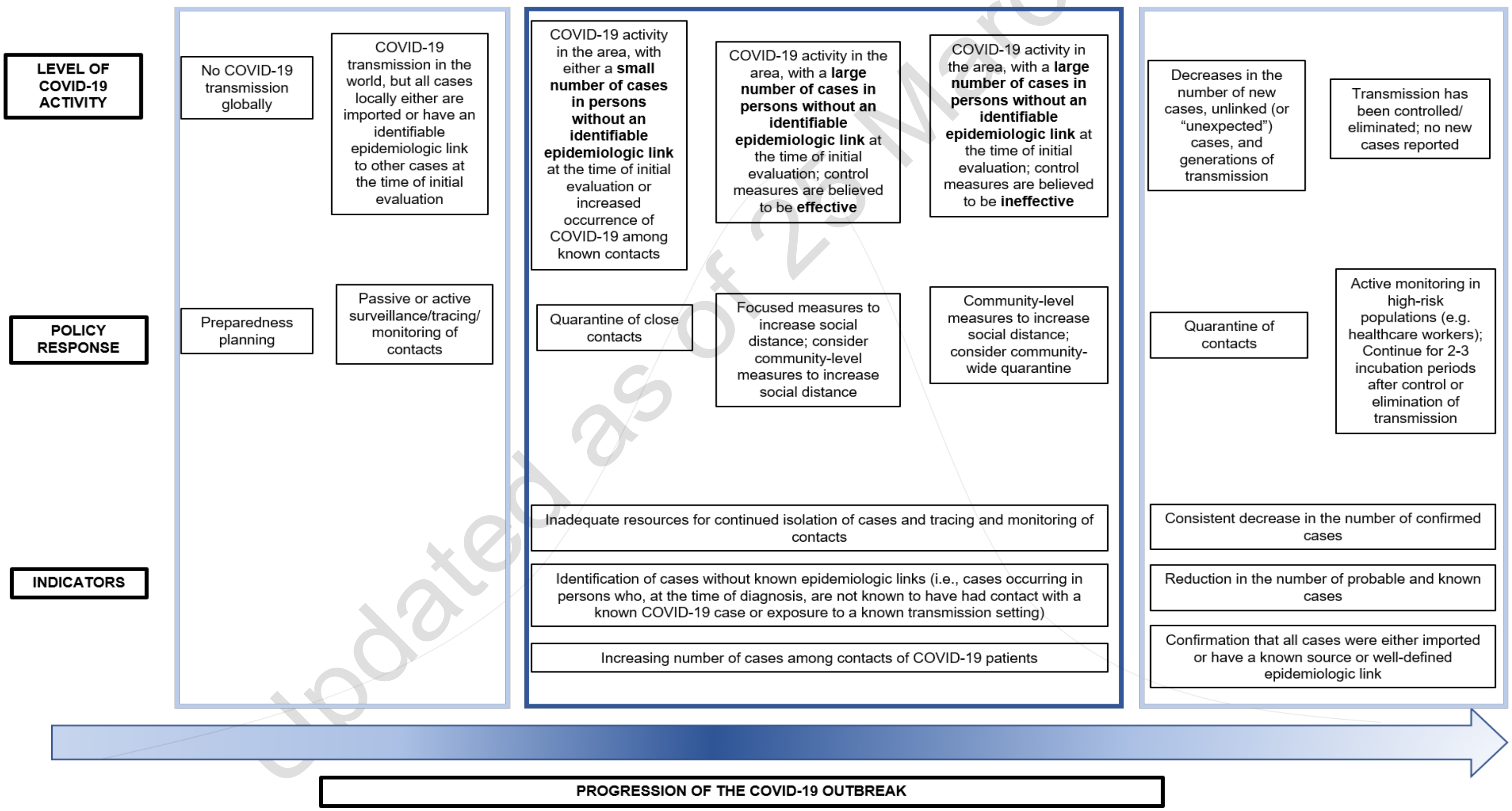


B. Guidelines for community containment measures

Although current recommendations based on mathematical modeling suggest that early and pervasive community-wide containment measures are likely the best way to minimize overload capacity in our area hospitals, we will need to consider appropriate and feasible metrics for rolling back community interventions as well as putting them back in place if necessary. Given that we may not ever reach community-wide testing, we will likely need additional data to support decision-making. The models reviewed here utilized the number of hospitalizations and deaths as indicators, but they were built using data from much larger populations, and therefore, these may not be sensitive indicators in an Alaskan or Anchorage context. The Centers for Disease Control and Prevention guidance for community interventions based on our experience with SARS provide a framework for beginning this discussion (See full guidance here: https://www.cdc.gov/sars/guidance/d-quarantine/community.html). The figure below is adapted from their guidelines and includes epidemiologic indicators for action. Key activities and metrics for tracking include:

- Contact tracing for all cases
- Monitoring of cases and close contacts
- Number of cases without known epidemiologic links
- Number of cases among contacts of COVID-19 patients

Figure 5. COVID-19 response guidelines adapted from the Centers for Disease Control and Prevention



Appendix A. Imperial College Model Definitions and Assumptions (Ferguson Model)

Impact of non-pharmaceutical interventions (NPIs) to reduce COVID19 mortality and healthcare demand

Authors: Neil M Ferguson, Daniel Laydon, Gemma Nedjati-Gilani, Natsuko Imai, Kylie Ainslie, Marc Baguelin, Sangeeta Bhatia, Adhiratha Boonyasiri, Zulma Cucunubá, Gina Cuomo-Dannenburg, Amy Dighe, Ilaria Dorigatti, Han Fu, Katy Gaythorpe, Will Green, Arran Hamlet, Wes Hinsley, Lucy C Okell, Sabine van Elsland, Hayley Thompson, Robert Verity, Erik Volz, Haowei Wang, Yuanrong Wang, Patrick GT Walker, Caroline Walters, Peter Winskill, Charles Whittaker, Christl A Donnelly, Steven Riley, Azra C Ghani.

Source: https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf

Synopsis - Key Points From This Article:
The authors used a modified pandemic influenza planning model with risk profiles and case fatality rates from epidemiology in China, along with expert opinions regarding hospitalization rates and duration by age group, to measure the impact of prevention and control strategies for COVID-19 response.[1-6] The authors explored the impacts of five non pharmaceutical interventions (NPI's) individually and in combination aimed at controlling transmission with measures of contagiousness between R_0 2.0 and 2.6 on predicted deaths and acute bed demand for COVID-19 management in the UK and US.[3-4] The two fundamental strategies assessed were: (1) mitigation and (2) suppression. The authors considered the feasibility and implications of both strategies for COVID-19, including an investigation of what occurs when NPIs are relaxed periodically as specific intervals. Not considered in this article are the ethical or economic implications of either strategy. Their results are applicable to most high-income countries.

The authors conclude layering of multiple interventions applied simultaneously are most effective and identify suppression as the preferred policy approach.[1] This includes at a minimum social distancing of the entire population, home isolation of cases and household quarantine of their families, supplemented with school and college closures. The authors note a special consideration with school closures in that it could negatively impact the health care system by staff absenteeism.[1] [Reviewers note: This assessment was at a national level, not state, city or community level]

The authors emphasize the more successful suppression measures are at containing transmission and spread of the virus the larger the 'rebound' when those measures are relaxed. Their analysis shows intermittent temporary lifting of NPIs, such as population wide social distancing and school closures (while maintaining case finding, quarantine contacts, and isolating high risk groups), using trends in disease surveillance could limit the large rebound effect if the NPI's could be reinstituted quickly.[1]

The research team cautions that secondary to uncertainties they recommend policy makers use the results to structure their thinking about pandemic response measures and not predictive of precise estimates of individual prevention and control interventions.[1,4]

Basic Assumptions for COVID-19

Incubation Assumption:
- Incubation period of 5.1 days.[3,4] [definition of incubation - time elapsed between exposure to a pathogenic organism and when symptoms and signs are first apparent].

Infectiousness Assumptions:
- For those who are symptomatic - Occur from 12 hours prior to the onset of symptoms.
- For those who are asymptomatic - Occur 4.6 days after infection (in those with an infectiousness profile over time that results in a 6.5-day mean generation time). [asymptomatic - do not show symptoms or signs of disease]

Transmission and Other Assumptions:
- Transmission modeling and parameters based on influenza response plans and social mixing patterns.[1]
- Infection seeded at an exponential rate, doubling every 5 days and calibrated by observations in the UK and US.
- Symptomatic individuals are 50% more infectious than asymptomatic individuals.
- Individual infectiousness is assumed to be variable.
- Typical delay from infection to hospitalization means there is a 2- to 3-week lag between interventions being introduced.
- On recovery from infection, individuals are assumed to be immune to reinfection in the short term.
- Disease progression, infection fatality ratio, hospitalization rates, and requirement of critical care estimated primarily by data from China and adjusted where appropriate based on expert opinion.

Definitions of the two fundamental strategies as possible options:

1) **Mitigation**, which focuses on slowing but not necessarily stopping epidemic spread – reducing peak healthcare demand while protecting those most at risk of severe disease from infection. (R>1), goal is to reduce mortality while herd immunity grows.
2) **Suppression**, which aims to reverse epidemic growth, reducing case numbers to low levels and maintaining that situation indefinitely. (R<1), goal reduce/stop transmission, keep cases low.
   [Reviewers note: There is a continuum between the mitigation and the suppression strategies, not necessarily an 'either/or' approach]

Definitions of NPI interventions considered

Label	Policy	Description
CI	Case isolation in the home	Symptomatic cases stay at home for 7 days, reducing non-household contacts by 75% for this period. Household contacts remain unchanged. Assume 70% of household comply with the policy.
HQ	Voluntary home quarantine	Following identification of a symptomatic case in the household, all household members remain at home for 14 days. Household contact rates double during this quarantine period, contacts in the community reduce by 75%. Assume 50% of households comply with the policy.
SDO	Social distancing of those over 70 years of age	Reduce contacts by 50% in workplaces, increase household contacts by 25% and reduce other contacts by 75%. Assume 75% compliance with policy.
SD	Social distancing of entire population	All households reduce contact outside the household, school or workplace by 75%. School contact rates unchanged, workplace contact rates reduced by 25%. Household contact rates assumed to increase by 25%.
PC	Closure of schools and universities	Closure of all schools, 25% of universities remain open. Household contact rates for student families increase by 50% during closure. Contacts in the community increase by 25% during closure.

*note the authors reflect estimates of noncompliance as a % built into the intervention, and school closure increases both household and community contacts. **case isolation and home quarantine are duties of the public health system and triggered by symptoms. The other three are interventions the city and or/state government can employ.

Mitigation Strategy

This approach focuses on slowing but not necessarily stopping the epidemic spread – reducing peak healthcare demand while protecting those most at risk of severe disease from infection.

Aims:

- Reduce overall deaths.
- Not to interrupt transmission completely, but to reduce the health impact of an epidemic.
- Population immunity builds up through the epidemic, leading to an eventual rapid decline in case numbers and transmission dropping to low levels.
- Early supplies of vaccine would be targeted at individuals with pre-existing medical conditions that put them at risk of more severe disease.[4]

Impact of Mitigation Policies/Outcomes:

- Might reduce peak healthcare demand by 2/3 and deaths by half.
- Majority of the effect of this strategy can be achieved by targeting interventions in a three-month window around the peak of the epidemic.
- Optimal mitigation would still overwhelm surge capacity at peak demand many times over.
- Health care systems will be overwhelmed after only a few weeks.

Challenges:

- Hundreds of thousands of deaths and health systems (most notably intensive care units) being overwhelmed many times over. [In context, this is at a national level]
- There is a risk that surge capacity may be exceeded under this policy option.
- The impact of many of the nonpharmaceutical interventions (NPIs) detailed in this article depends critically on how people respond to the introduction of these, which is highly likely to vary between communities and countries.
- Mitigation will never be able to completely protect those at risk from severe disease or death and the resulting mortality may therefore still be high.
- Once interventions are relaxed, infections may begin to rise, resulting in a predicted peak epidemic later in the year.
- The more successful a strategy is at temporary suppression, the larger the later epidemic is predicted to be in the absence of vaccination, due to lesser build-up of herd immunity.

Primary Mitigation Finding:

Optimal combination of NPIs for the mitigation strategy applied over 3 months was, case isolation, home quarantine of household contacts, and social distancing of the elderly >70 would possibly reduce health system demand by 2/3 and deaths by half, yet overwhelm critical care beds at peak demand by 8 fold over surge capacity.[1]

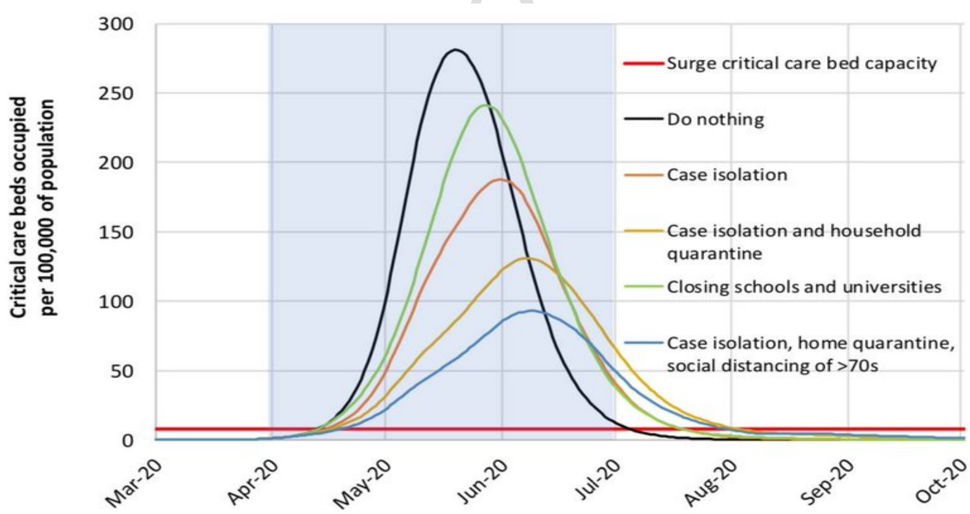


Figure 2: Mitigation strategy scenarios for GB showing critical care (ICU) bed requirements. The black line shows the unmitigated epidemic. The green line shows a mitigation strategy incorporating closure of schools and universities; orange line shows case isolation; yellow line shows case isolation and household quarantine; and the blue line shows case isolation, home quarantine and social distancing of those aged over 70. The blue shading shows the 3-month period in which these interventions are assumed to remain in place.

<u>Suppression Strategy, (similar to what CDC refers to as Containment)</u>
This approach aims to reverse epidemic growth, reducing case numbers to low levels and maintaining that situation indefinitely.

<u>Aims:</u>

- To reduce the reproduction number (the average number of secondary cases each case generates); R, to below 1 and hence to reduce case numbers to low levels or (as for SARS or Ebola) eliminate human-to-human transmission.
- Early action is important, and interventions need to be in place well before healthcare capacity is overwhelmed.

<u>Impact of Suppression Policies/Outcomes:</u>

- A combination of case isolation, population wide social distancing and either household quarantine or school/university closure reduced R close to or below 1.
- All four NPIs had the largest effect on transmission.
- Peak critical care demand occurred about 3 weeks after initiation and continued to decline.
- This combination of NPI’s likely to assure critical care bed demand stays within surge capacity.

<u>Challenges</u>:

- Suppression policies may need to be maintained for many months.
- NPIs (and drugs, if available) need to be maintained – at least intermittently - for as long as the virus is circulating in the human population, or until a vaccine becomes available.
- In the case of COVID-19, it will be at least 12-18 months before a vaccine is available. Furthermore, there is no guarantee that initial vaccines will have high efficacy.
- Suppression, while successful to date in China and South Korea, carries with it enormous social and economic costs which may themselves have significant impact on health and well-being in the short and longer-term.

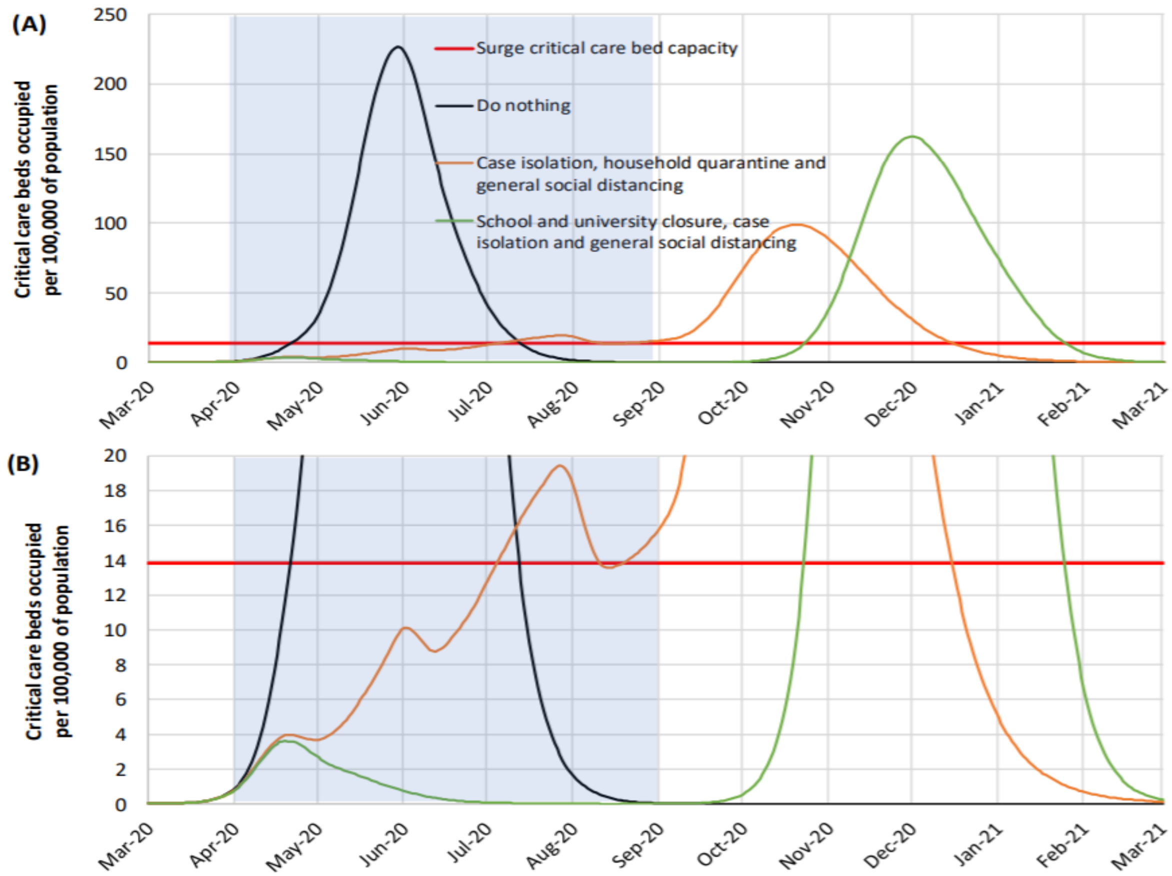


Figure 1: (A) Suppression strategy scenarios for US showing ICU bed requirements. The black line shows the unmitigated epidemic. Green shows a suppression strategy incorporating closure of schools and universities, case isolation and population-wide social distancing beginning in late March 2020. The orange line shows a containment strategy incorporating case isolation, household quarantine and population-wide social distancing. The red line is the estimated surge ICU bed capacity in the US. The blue shading shows the 5-month period in which these interventions are assumed to remain in place. (B) shows the same data as in panel (A) but zoomed in on the lower levels of the graph.[1]

Primary Suppression Strategy Finding:
Over the period of five months to reduce R to 1 or below required a minimum of 1) case isolation, 2) social distancing of the entire population, 3) and either household quarantine OR 4) school and university closer.[1]
School and university closure was predicted to be more effective than household quarantine in achieving suppression. All four interventions were predicted to have the greatest impact.

Adaptive Suppression Strategy:
The authors explored relaxing two of the four primary suppression strategies, namely population wide social distancing and school/university closure if used. The on and off trigger for relaxing these two NPIs was ICU cases. For example, if ICU cases were 100 all 4 NPI’s were applied and if cases fell to 50 two of the NPIs were lifted.[1] Without a vaccine and in order to avoid a large rebound in cases adaptive suppression could be an option for regional use, although there

are obvious uncertainties. They estimate all four suppression NPIs would need to be in force at least 2/3 of the 18 month duration while awaiting vaccine.

Discussion
An important point is that it is necessary to layer multiple interventions, regardless of whether suppression or mitigation is the overarching policy goal. Combining all four interventions (social distancing of the entire population, case isolation, household quarantine, and school and university closure) is predicted to have the largest impact, short of a complete lockdown which additionally prevents people going to work. The suppression approach will require the layering of more intensive and socially disruptive measures than mitigation. The choice of interventions ultimately depends on the relative feasibility of their implementation and their likely effectiveness in different social contexts.[1]

A minimum policy for effective suppression is therefore population-wide social distancing combined with home isolation of cases and school and university closure. Population-wide social distancing applied to the population as a whole would have the largest impact. And in combination with other interventions – notably home isolation of cases and school and university closure – has the potential to suppress transmission below the threshold of R=1 required to rapidly reduce case incidence. If long term supression isn't an option the authors' results show that the alternative relatively short-term (3-month) mitigation policy option might reduce deaths seen in the epidemic by up to half, and peak healthcare demand by two-thirds, although risk of overwhelming the health care system is likely.

They predict that school and university closure will have an impact on the epidemic, under the assumption that children do transmit as much as adults, even if they rarely experience severe disease.[2,6] School and university closure is a more effective strategy to support epidemic suppression than mitigation. In combination with population-wide social distancing, the effect of school closure is to further increase the halting of social contacts between households and suppress transmission, though insufficient to mitigate (or suppress) an epidemic alone.
If intensive NPI packages for suppression are not maintained, the authors' analysis suggested that transmission will rapidly rebound, potentially producing an epidemic comparable in scale to what would have been seen had no interventions been adopted.

To avoid a rebound in transmission, these policies will need to be maintained until large stocks of vaccine are available to immunize the population – which could be 18 months or more. Adaptive hospital surveillance-based triggers for managing the population-wide social distancing and school closure offer greater robustness to uncertainty than fixed duration interventions and can be adapted for state-level. Future decisions on when and for how long to relax policies will need to be informed by ongoing surveillance. Given local epidemics are not perfectly synchronized, local policies are more efficient and can achieve comparable levels of suppression to national policies while being implemented for a slightly shorter amount of the time. However, in the case of the national policy for Great Britain, the authors stated social distancing would need to be applied for at least 2/3 of the time, until a vaccine was available.

Conclusion
Overall, the authors conclude population-wide social distancing would have the largest impact; and adding home isolation of cases plus school and university closure – have the potential to suppress transmission below the threshold of R=1, required to rapidly reduce case incidence.

The social and economic effects of the measures which are needed to achieve this policy goal will be profound. The authors emphasized that it is not at all certain that suppression will succeed long term; no public health intervention with such disruptive effects on society has been previously attempted for such a long duration of time. How populations and societies will respond remains unclear.

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Appendix B. COVID Act Now Model Definitions and Assumptions (Henderson Model)

Model Summary

The COVID ACTNOW model is a compartmental, deterministic model that is based on assuming exponential growth of the epidemic within a population. The model is compartmental, meaning that it places people in groups of susceptible, infected and recovered persons. How people move from one category to the next is described by a series of mathematical equations. The model is deterministic because it does not account for random variations in how the virus may spread. The COVID ACTNOW model is based on a publication from the Imperial College in London, a leading modeling group, who predicted possible scenarios in the US and UK at the national level. ACTNOW uses assumptions for hospitalization, ICU use and case fatality based on the Imperial College paper.

We have worked with the ACTNOW model developer, Max Henderson, to download and modify copies of the model that now include data for Anch/MatSu (or Alaska) population, age distribution, and the number of hospital beds here. The model uses changes to the reproductive number (R0), (the average number of other persons each infected person infects), to predict the potential impact of different response strategies on the number of cases, hospitalizations, and deaths and projects those against available hospital beds .

Intervention Definitions & Assumptions

Source for COVID ACT NOW Model Scenarios:
https://docs.google.com/document/d/1ETeXAfYOvArfLvlxExE0_xrO5M4ITC0_Am38CRusCko/preview#heading=h.6qtmfecxjzwo

See actual state current policies here: https://www.aei.org/covid-2019-action-tracker/

*Listed from most to least aggressive suppression practices

Definitions:

- R0 (Reproduction number): Indicates how infectious a disease is. R0 tells you the average number of people who will catch a disease from one contagious person. For example, a 1.3 R0 means that 1.3 people will become infected for every person who is already infected.
- Assumption: These are the parameters that the model is built upon. For example, one assumption of the model is that the hospitalization rate of infected individuals will be 7.3%.
- After-effects: Measures taken after the containment measures outlined in the model.

Table 1: Containment scenario R0 assumptions and limitations in COVID Act Now model and related considerations for Alaska

Method	R0 Assumptions and Limitations	After-effects	Considerations for Alaska
Wuhan-style Containment Goal: Fully and permanently contain disease until vaccine is developed Duration: 2 months (8 weeks) Measures: Treat everyone as infected. Forced home quarantine for everyone, shutdown all businesses, close borders, actively monitor the spread and containment, mandatory testing of *everyone* and aggressive quarantine. Isolated sick people in hospitals. Public aid relief bill.	R0 assumptions: Week 1: 1.3 Weeks 2-6: 0.3 Week 7: 0.2 Week 8: 0.035 Limitations: Based on early reported Wuhan numbers for the first 6 weeks, and extrapolations from these numbers for the remaining 2 weeks. *Note: There is some speculation that these numbers under-represent the number of actual cases experienced in the region.	Once ended, long-term implementation of border quarantines (14 days), active monitoring, and potential for repeat of containment measures to ensure containment.	*AK not currently following Opportunities for Alaska: Due to Alaska's physical location, Alaska has the ability to shut down its borders to any non-essential travel and cargo operations. This would significantly reduce the number of infections coming from outside of Alaska, and also any that may travel from Alaska to other parts of the US.

California-style “Shelter-in-place” Containment/Delay Goal: Fully contain disease until vaccine is developed, or at least delay spread until healthcare capacity can be built and therapeutic treatments become available Duration: 3 months (12 weeks) Measures: Mandatory “shelter-in-place” home quarantine (especially firm for high-risk groups) for everyone, shutdown of non-essential businesses, close schools, ban events over 10 people, passive monitoring, public advocacy around social distancing and enhanced hygiene. Public aid relief bill.	R0 assumptions: Weeks 1-4: 1.3 Weeks 5-8: 1.1 Weeks 9-12: 0.8 Limitations: Based on conjecture and extrapolation from Wuhan data above to a less ideal/strict containment scenario.	If contained, long-term implementation of border quarantines (14 days), active monitoring, and potential for repeat of measures above to ensure containment. If not contained, measures likely to be extended for 12-18 months in order to fully #flattenthecurve, with testing making quarantines more targeted.	*AK not currently following Opportunities for Alaska: Implement a *mandatory* “shelter-in-place” for all residents, and *mandatory* banning of events over 10 people. Mandate that non-essential state employees work from home if possible. Clearer delineation between essential and non-essential employees is likely needed. Provide clearer messaging about what is considered “non-essential businesses” and enforce closures.
Texas-style Delay/Distancing Goal: Delay the overloading of the healthcares system to minimize unnecessary deaths, while minimizing damage to the economy Duration: 3 months (12 weeks) Measures: Voluntary “shelter-in-place” for high-risk groups, ban on events over 50 people, public advocacy around “social distancing” and enhanced hygiene, possible school closures, restricted travel, and passive monitoring. Roll-out of population-wide testing and quarantine, so that quarantines can be relaxed for those who are not infected.	R0 assumptions: Week 1-12: 1.7 Limitations: Based on rough extrapolation of reducing 50% of overall transmission opportunities in society, thus cutting a worst-cases R0 of ~3.2 to roughly 1.7.	Measures likely to be extended for 12-18 months in order to fully #flattenthecurve	*AK not currently following Alaska measures currently surpass Texas-style delay/distancing as included in this model in the following way: -Alaska schools and universities are closed

Do Nothing: current historical trends continue	R0 assumptions: Actual data where available, 2.4 for all forward-looking periods.		*AK not currently following

Additional discussion on Anchorage/Mat-Su and Alaska COVID ACT NOW Models
Spread of COVID-19 and resulting hospitalizations in Anchorage and Alaska may be slightly less severe than those modeled using the Texas-style social distancing scenario because Alaska has closed all schools and universities, while the social distancing model does not include that measure.

Hospitalization rate, case fatality rate, and fatality rate increase if hospitals are overloaded may be *higher* in Anchorage and/or Alaska since cases coming from underserved areas (eg. rural Alaska, pop. 239,319) may be more severe once treatment is sought/provided. However, these rates may be *lower* in the California-style ‘Stay-in-place’ model, given the lesser number of older adults in Alaska (12.5% of total pop.) compared to California (14.3% of total pop.). Age distribution may be less of an issue, however, when interpreting the Texas-style ‘Social Distancing’ given a similar percentage of adults 65+ in Texas (12.6%) as Alaska.

ANCHORAGE: Given current restrictions in place and the assumptions of the model, the R0 in Anchorage can be expected to lie between California Shelter-in-Place (1.3) and Texas Social Distancing (1.7) estimates for weeks 1-4.

ALASKA: Rates of transmission, infection, and hospitalizations will likely be heterogeneous across Alaska, given the implications of the model. Communities restricting travel (eg. rural villages), and formally encouraging social distancing (eg. Anchorage), will likely experience the lowest transmission/infection rates (R0=1.3-1.7). Communities with no restrictions may face higher transmission/infection rates more reflective of the Texas-style and “do nothing” scenarios (R0=1.7-2.4 or higher) if historical trends continue.

Table 2: Estimated containment scenario R0 assumptions and limitations in for Anchorage and Alaska

Method	R0 Assumptions and Limitations	After-effects	Considerations for future measures
Anchorage-style “hunker Down” (3/22/2020) Bus transportation limited to 9 riders (3/18/2020) Public and private schools are closed to students through May 1, 2020. Residential school programs will send students to their families and home	Weeks 1-4: Given current restrictions in place and the assumptions of the model, the R0 can be expected to lie between California (1.3) and Texas (1.7) estimates, according to the model.	Information not available at this time	Mandatory quarantine for visitors from out of state. Restrictions on travel to Anchorage within state Further restrict and clarify definitions of essential services and businesses.

communities by March 27. Bars, breweries, restaurants, food and beverage kiosks or trucks, and other establishments are banned from serving food or beverages for public dine-in service. Take-out and delivery is permitted. Closed state operated libraries, archives, museums, and penal institutions to the public through March 31, 2020. Recommended self-quarantine for visitors and residents who traveled outside of Alaska. Health care workers who have traveled are not permitted to work for 14 days. All elective medical procedures are postponed. Oral health procedures postponed for one month. Medical procedures postponed for three months. No evictions are permitted through March 31. Utilities cannot be discontinued due to insufficient payment.			
Alaska-style: **Confirmed cases as of 3/22/2020: 21** Recommend ceasing all non-essential travel. Public and private schools are closed to students through May 1, 2020. Residential school programs will send students to their families and home communities by March 27. Bars, breweries, restaurants, food and beverage kiosks or trucks, and other establishments are banned from serving food or beverages for public dine-in	*Not included in model Weeks 1-4: Given current restrictions in place and the assumptions of the model, the R0 can be expected to lie between California (1.3) and Texas (1.7) estimates. Transmission and infection rates will be heterogeneous across Alaska. Communities restricting travel (eg. rural villages), and formally encouraging		Require non-essential state workers to work from home. Mandatory quarantine for visitors Restrictions on geographical travel within state (though rural communities are implementing individual measures) Restrictions on commercial travel into Alaska Activation of the national guard Closure of non-essential businesses Imposed or recommended

service. Take-out and delivery is permitted. Closed state operated libraries, archives, museums, and penal institutions to the public through March 31, 2020. Recommended self-quarantine for visitors and residents who traveled outside of Alaska. Health care workers who have traveled are not permitted to work for 14 days. All elective medical procedures are postponed. Oral health procedures postponed for one month. Medical procedures postponed for three months.	social distancing (eg. Anchorage), will experience the lowest transmission/infection rates (R0=1.3-1.7). Communities with no restrictions will face higher transmission/infection rates more reflective of the Texas-style and “do nothing” scenarios (R0=1.7-2.4 or higher) if historical trends continue.		curfew State-wide limit of gatherings Relaxed medical licensure

Core Variable Assumptions

There are a few core variables that drive the model. These are listed below.

Table 3: Assumptions for the Covid Act Now model and considerations for Alaska

Metric	Default Assumption	Explanation	Source Data	Considerations for Alaska
Estimated Initial R0	2.4	R0 determines how fast the disease spreads each period. The model uses actual data as reported by JHU. When none is present, this default is used.	Range provided by Imperial College paper.	Given the limited data available for Alaska, the estimated initial R0 should be assumed for AK.

Hospitalization Rate	7.3%	This is the rate at which infected people are hospitalized. Our best estimates vary quite a bit by age.	Range provided by Imperial College paper, weighted by actual USA demographics as reported by statistica here.	May be higher since cases coming from underserved areas may be more severe once treatment is sought/provided. May be lower in some areas given the lower number of older adults in Alaska compared to US. We used hospitalization rates of 6.2% for Anchorage/Mat-Su and 6.4% for Alaska in the models presented here.
Case Fatality Rate	1.1%	This is the rate at which infected people die, assuming they can access treatment. Our best estimates vary quite a bit by age.	Range provided by Imperial College paper, weighted by actual USA demographics as reported by statistica here.	May be higher since cases coming from underserved areas may be more severe once treatment is sought/provided. May be lower in some areas given the lower number of older adults in Alaska compared to US. We used a CFR of 0.8% in the models presented here.

Fatality Rate Increase If Hospitals Overloaded	1.0%	This is the additional rate at which infected people die, assuming they cannot access treatment. It is the number of infected cases requiring at least ICU care.	Range provided by Imperial College paper, weighted by actual USA demographics as reported by statistica here.	May be higher since cases coming from underserved areas may be more severe once treatment is sought/provided. May be lower in some areas given the lower number of older adults in Alaska compared to US. We used a CFR if hospitals are overloaded of 0.8% in the models presented here.
Population	Varies by state	The population of each state.	Wikipedia here	731,007
Hospital Beds	Varies by state	The number of hospital beds in each state.	KFF here, somewhat outdated.	
Hospital Bed Utilization	60%	The number of beds unavailable for CoVid cases due to being occupied.	Guess based on discussions with experts.	
Emergency Bed Capacity Build	207.9% in 2 months	The number of additional beds made available by emergency preparation. Roughly equivalent to clearing out fully half of all other hospital bed occupants.	Guess based on discussions with experts.	May be lower since traveling nurses are no longer available in Alaska, and medical professionals who have traveled have been asked to stay at home for 14 days post travel

Additional information:

Italian-style "National Quarantine" Goal: Eliminate infection transmission. Duration: April 3, 2020. Measures: Ban on all travel that is not an emergency. All public gatherings banned. Schools closed. Only supermarkets and factories producing essential goods will remain open (3/22/2020) As of 3/11/2020: All schools and universities are closed, all social gatherings are forbidden, movement of people restricted to circumstances of necessity (eg. buying groceries, health emergencies) - enforced by law enforcement. All retail trade is suspended, but essential services (banks, post offices, financial services) remain open. All sports, cultural events, and religious ceremonies (including funerals) are not allowed to take place. *Violations to these provisions are considered criminal offences.	*Not included in model, but see: https://www.nytimes.com/2020/03/20/health/coronavirus-data-logarithm-chart.html	Information not available at this time	*AK not currently following Opportunities for Alaska: Decrease number of businesses and services open to public to narrowly-defined "essential" operations. Ban all non-emergency travel Ban all public gatherings. Restrict movement of people to circumstances of necessity (eg. buying groceries, health emergencies).

Data Notes and Resources for Alaska Changes to the COVID-19 Act Now Model

Column & Row	Description	SOA	ANC MatSuData Used	Data Reference
B7	Population	731,545	398,283	Alaska Bureau of Labor & Statistics 2019
B8	Hospital Beds	1514	982	DHSS (2020) http://dhss.alaska.gov/dhcs/Documents/hflc/PDF/HFLC_Facility_List_WebsiteList.pdf
B9	Hospital Bed Utilization	60%	70%	ADN: https://www.adn.com/alaska-news/2020/03/17/are-alaskas-hospitals-equipped-to-handle-the-coronavirus/
J18-J23	Actual Reported Infections	0.04...36	0...19	from State of Alaska, http://dhss.alaska.gov/dph/Epi/id/Pages/COVID-19/monitoring.aspx
K2-K10	Demographics	14%...2%	14%...2%	Alaska Bureau of Labor & Statistics 2019

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