To: Joni Reynolds, Gunnison Public Health
From: Ian Billick (Lead Author) and Erik Niemeyer
Re: Initial Recommendations for Reopening Gunnison County
Date: April 24, 2020

We present this report, which provides recommendations for reopening Gunnison County. We reviewed National and Colorado recommendations, analyzed unique factors about Gunnison which might influence how we open, and also did our best to understand the epidemic that Gunnison experienced, drawing on local data and the best science available from around the world.

To do this analysis, within the context of saving lives we put a focus on not overwhelming the Gunnison health care system. For our purposes, we used 10 simultaneous hospitalizations as a starting point. We emphasize, however, that the Gunnison health care system is the entity best positioned to articulate the appropriate rate and number of hospitalizations. While our conclusions are robust to modifying this number, we expect that the Gunnison health care system will want to refine this number. If further analysis by the local health care system identifies a more precise management goal substantially different than this, we would be happy to update the report.

Additionally, we wish to emphasize that we have deliberately left some ambiguity over the pace of openings, and what will be implemented first. We recognize that you and your team are best placed to make final decisions over implementation, as you receive new information from the community and the state. Given the importance of not moving too quickly, we wanted to create a framework to help you analyze a series of steps Gunnison might take, without suggesting too rigid an approach, especially given how quickly we are learning about the disease and how rapidly the situation on the ground is changing. We recognize that not all these recommendations will, or should be, adopted in the opening phase, and that you and your team may identify ways to safely open the community that we have missed.

Finally, we will highlight that these recommendations are just for the initial round of opening.   We anticipate it will take time to navigate the opening stage, minimizing the chance that transmission jumps again, causing additional loss of life and with further negative impacts. Given how rapidly we are learning about the disease, both within our community and across the world, once we are ready to move beyond reopening, we recommend taking a fresh look at what is known about the virus and updating this analysis accordingly.

Best wishes as you grapple with some serious decisions.

Initial Recommendations for Reopening Gunnison County
April 22, 2020
Ian Billick (Lead Author), Jennifer Hoeting, Jason Hogan, Julie Marshall, Jeff Moffett, Erik Niemeyer,
Mike Pelletier, William Spicer

Executive Overview

We make a series of recommendations concerning potential next steps for the opening of the county. In March 2020, as part of a national outbreak, Gunnison County experienced an epidemic of COVID-19, with one of the highest per capita infection rates in the Country. The virus caused widespread economic disruption as most local businesses were forced to close and tourism ground to a halt. Using travel forecasts from United Airlines we estimate that Gunnison's tourism economy alone will experience a one-third drop in economic activity during 2020, or a loss of $61 million in revenue.

These recommendations are developed with the goal of reopening Gunnison County to maximize social, personal liberty and economic goals while minimizing the probability of overwhelming the health care system (defined as approximately 10 simultaneous hospitalizations for COVID-19).

Major Considerations

1. Tailoring national and state guidelines, with a focus on recommendations by the Colorado Association of Public Health Officials (CALPHO), to Gunnison's unique circumstances.
2. ***The first public health order was highly effective and offers insights moving forward***. A delay of as little as a week could have led to an overwhelmed health care system and many more deaths. The willingness of the public to quickly and dramatically respond was critical to our success in March, and will be important moving forward.
3. Our best estimates are, despite the severity of the initial epidemic, the percentage of individuals who have been infected is still only likely to be 5-10% (see Appendix 1, Estimates of the Number of People Infected in Gunnison County). Little is known about whether all recovered individuals become immune, how long it takes to become immune, and how long immunity lasts. Consequently ***there is strong potential for a second wave of infections of equal or greater severity if the virus is not carefully managed.***
4. CALPHO guidelines indicate that until a vaccine is developed, we cannot expect a return to normal. Our analysis supports the conclusion that ***Gunnison County is unlikely to stop transmission with herd immunity acquired through transmission***.
5. Because the likelihood of an infected at-risk person of developing severe symptoms is so high relative to other groups, ***protecting our at-risk individuals will be critical*** to not overwhelming our health care system (see Appendix 2: Definition of At-Risk Individuals).
6. With a high potential for a dangerous second wave of infections, it will be critical to quickly detect and respond to an increase in transmission rate. The County has multiple ways to monitor changes in transmission, including viral/PCR testing, symptom-based data, and hospitalizations. Because each data stream has its own limitations, ***the county should use all available data, including viral/PCR testing outpatient, self-report data, and emergency room influenza-like illness syndromic surveillance, to quickly detect changes in transmission, with an emphasis on scaling rapid viral/PCR testing as soon as possible***.

<u>Process</u>
To develop our recommendations we used a conceptual model to understand the epidemic in Gunnison County and assess the potential impact and risk of proposed reopening measures on hospitalizations. We established baselines for key parameters using scientific literature and locally-derived data. We have done our best to make our analysis transparent, including documenting assumptions and parameter estimates. Given how rapidly the situation is changing and how much we are learning, this makes it possible to easily incorporate new information and analyses.

<u>Reopening Recommendations</u>
The recommendations incorporate national and state guidelines (Appendix 3, Details of State and National Recommendations for Opening), but are tailored to Gunnison County's unique circumstances. They are meant to be for the early phases of reopening. Because of the dangers of opening too quickly, we recommend that they be implemented sequentially over the next month, proceeding forward if transmission rates stay stable within the County and State, with an initial focus on measures on opening restrictions within Gunnison. Furthermore, as Gunnison County demonstrates that we have effectively implemented these steps, we recommend an analysis of further steps to open the County, incorporating all of the new information, from within Gunnison as well as the emerging science, that will become available. Ultimately, the pace and scale of any opening must depend upon the County's ability to implement changes without triggering a second wave of infection.

These recommendations focus on steps which will limit the transmission of the data, as well as limit the transmission of the disease to individuals who are at risk of death or severe health problems. The primary mechanisms for limiting transmission of the disease involve minimizing the introduction of disease to Gunnison County from communities with higher rates of infection (***movement***), reducing contact between infected and non-infected individuals within the community (***social distancing***), using ***hygiene*** to reduce the likelihood of transmission of disease when an infected individual comes into contact with a non-infected individual, and ***protecting at-risk individuals*** who have a much greater likelihood of death or severe health problems if infected.

Because minimizing contact between infected and non-infected individuals is at the heart of all these measures, the sooner we can effectively deploy contact tracing and testing, the sooner we will be able to move away from broad-brush restrictions affecting everybody to control transmission.

Movement: We recommend following state guidelines concerning movement into Gunnison County from within and outside the state, but considering stronger restrictions if introduction from other communities threatens our capacity to manage transmission. We also suggest the County allow non at-risk individuals to move to the county to live with their family, to work, and to spend time at second homes. Tailoring national and state guidelines to Gunnison County, we recommend:

1. ***Residents:*** Allow statewide travel for specialty retail and non-urgent medical treatment without requiring 7 days of self-isolation upon return. Upon return to the County, individuals should self monitor for symptoms and self-isolate if they do exhibit symptoms.

2. ***Residents***: Once movement within the State is allowed by the State, allow people to leave the County for other locations in the State and return without being subject to 7 days of self-isolation.
3. ***Colorado non-residents***: Allow travel to Gunnison by individuals living outside Gunnison County but in the State of Colorado, as such movement is allowed by the State of Colorado, reserving the right to enact more strict restrictions should circumstances require it.
4. ***Non-residents from outside Colorado***: Allow movement to Gunnison from outside the State as such movement is allowed by the State of Colorado, reserving the right to enact more strict restrictions should circumstances require it.
5. ***All non-residents***: Because of job loss and economic distress, allow non at-risk asymptomatic individuals to return to the county to live with residents and non-residents, if they isolate themselves from at-risk individuals within their household for 7 days, subject to Colorado restrictions on movement.
6. ***Nonresident local homeowners***: Allow non at-risk asymptomatic nonresident local homeowners to return to the county if they isolate themselves from at-risk individuals within their household for 7 days, subject to Colorado restrictions on movement.

Distancing: Social distancing is important because asymptomatic or pre-symptomatic individuals are capable of transmitting the virus. By reducing their contact with others, we can reduce transmission rates. Following national and state guidelines we have included a recommendation concerning group size because even if it is possible to maintain an average distance of six feet or less, there is typically some inadvertent mixing. Furthermore, in some instances transmission may still occur at distances further than six feet. Most importantly, a single instance of one highly infective individual interacting with a large group of people could lead to rapid imposition of potentially prolonged closures for the entire county. Consequently, we recommend being highly cautious around group size until we know more about transmission, and have greater capacity to implement contact tracking. With these things in mind we make the following recommendations:
1. Indoor group/event sizes should be 10 or less individuals.
2. Because of the potential to organize outside events (e.g., a race) while minimizing contacts, we recommend outside groups/events of more than 10 individuals be considered to be allowed if there is a strong plan for ensuring that the six feet social distancing requirement is maintained and that any one individual is realistically not coming within the range of 6 feet of more than 10 individuals.
3. Social distancing of six feet should be maintained for individuals of separate households.
4. Non-essential services that cannot maintain social distancing should not be allowed, unless they involve professionals who can implement appropriate protections or have received an exemption from the County by demonstrating they are appropriately managing risk.
5. If social distancing of six feet cannot be maintained for an essential service or an allowed professional service, face masks should be worn.

Hygiene: The measures listed below are the primary recommendations that have emerged from the state and federal government. However, as appropriate we recommend that the County consider providing additional guidance beyond the recommendations below:

1. Face masks should be worn when people are in settings, such as retail stores, where distancing of less than 6 feet between individuals of separate households is likely.
2. Businesses should structure their business to minimize the items that multiple people come in contact with and disinfect surfaces contacted regularly by the general public.
3. Everyone should practice proper hand washing and avoid touching their faces when in public settings.
4. Proper sneeze/cough hygiene.

Activities and Businesses: Tailoring national and state guidelines to Gunnison County, we recommend:
1. Businesses that are able to maintain social distancing and hygiene requirements, except for those prohibited below, are encouraged to open because of the need to get the economy moving again.
2. We suggest that businesses that do not meet the guidelines be allowed to request exemptions, which will be reviewed on a case by case basis to evaluate the risk of increased transmission versus economic and social benefits.
3. Religious organizations that can develop plans for hosting groups larger than 10 but not larger than 25 while meeting social distancing and hygiene standards are encouraged to request an exemption, with special attention paid to protecting at-risk individuals.
4. Outdoor recreation, with social distancing, is encouraged because of the mental and physical benefits.
5. Restaurants are encouraged to provide delivery or take-out. If they can meet other requirements while serving clients in their establishment, they should be allowed to file an opening plan.
6. Bars should remain closed.
7. Construction is encouraged to continue [as has been encouraged with the 7th public health order].
8. Opt-in child care and children's day programs are encouraged to start, though they should be subject to a maximum group size of 10, group compositions should be fairly stable to limit mixing and transmission between groups, at risk individuals not work directly with children, and families strongly consider not sending children if they have at-risk individuals living with the children.
9. Overnight children's programs such as summer camps should not be allowed.
10. Special events should not be allowed, unless they meet the standards for group size, social distancing and hygiene.
11. Socializing that meets hygiene and social distancing standards is encouraged. It is highly recommended that at-risk individuals limit the number of people they socialize with, be excessively cautious about practicing strong hygiene, and avoid any symptomatic individuals, or individuals exposed to symptomatic individuals.
12. Elective surgeries should be allowed [as has been allowed with the 7th public health order].
13. Any business not open as of the 7th public health order issued on April 21, 2020 should file a plan with county health indicating how they will meet social distancing and hygiene requirements and in which the businesses certify that they will follow the measures identified in their plan.

At-Risk Populations: Prioritizing protection of at-risk populations will reduce our risk of overwhelming the healthcare system if transmission rates increase. Tailoring national and state guidelines to Gunnison County, we recommend:

1. Strong education and communication of the dangers to at risk individuals, combined with asking them to voluntarily reduce their social interactions beyond what is required of the general population.
2. Isolate at-risk individuals from symptomatic individuals until testing clears the symptomatic individual.
3. Restrict at-risk individuals from working in high contact positions.
4. As discussed in the movement section, restrict the movement of at-risk individuals into the county, and limit the contact of individuals coming into the county with at-risk individuals for 7 days after arrival.

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Unique Characteristics of Gunnison County

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Gunnison County's opening plan was developed within the context of national and state recommendations, tailored to Gunnison's unique circumstances. Common recommendations include not beginning opening until the number of cases has steadily decreased for 14 days, hospitals have sufficient resources, testing, and contact tracking can be adequately implemented. Additionally guidelines generally suggest that until a vaccine is developed, hygiene (hand washing, face covers, cough/sneeze etiquette) and distancing (keeping a minimum distance and protection of at-risk individuals) should continue.

The state and federal guidelines are just that, with opportunities for local communities to tailor recommendations to their specific needs. As we developed Gunnison's guidelines, we identified the following as important local considerations:

1. Gunnison County is located at a relatively high elevation with lower oxygen levels. This puts additional stress on sick individuals, heightening the likelihood and severity of respiratory distress.
2. Gunnison Valley Health Hospital has limited capacity and no intensive care unit. Furthermore, regional hospitals have limited ICU capacity.
3. We have a tourism-based economy that includes lots of service businesses (e.g., restaurants, ski resort, lodging, and recreation services), large numbers of short-term visitors, as well as a significant part-time local community. Many part-time local families have been part of the community for decades and across generations.
4. Recreation and access to the outdoors is a high priority for many of the locals.
5. As a small county there are a limited number of services, including a lack of specialty retail, and non-urgent medical care (e.g., dermatology, ear, nose & throat, etc.).

Analysis of Gunnison County Epidemiology Mid-February-Mid-April
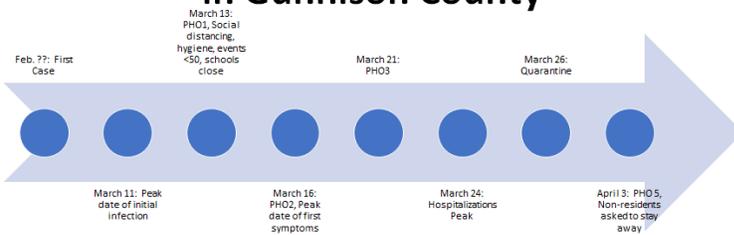**Key Findings/Analysis**

Key Findings: Disease
- Gunnison county experienced an epidemic that stressed the hospital system, generating more than 10 individuals simultaneously experiencing severe respiratory distress (See Appendix 4: Number of Gunnison Hospitalizations).
- The virus doubled every 3-5 days and a delay of a week in closing the school and/or the first public health order could have quadrupled the number of deaths and completely overwhelmed the hospital (See Appendix 5, Doubling Time, Estimates of Lags Between Infection, Symptoms, and Hospitalizations).
- Despite the rapid doubling and large number of hospitalizations, the best estimates of the number of individuals in Gunnison County who have been infected are low (see Appendix 3: Estimates of Number of People Infected in Gunnison County).
- Gunnison County will not achieve herd immunity without a vaccine. The population is very susceptible to a second infection wave of equal or greater severity, if transmission rates are not managed appropriately. See Appendix 6: Herd Immunity Is Unlikely.
- The initial interventions, which consisted of social distancing, limiting group sizes to 50, improved hygiene including thorough hand washing and not touching one's face, and closing the schools, dramatically reduced transmission or resulted in more asymptomatic or mild cases. We do not know which of these measures drove the response. Additionally, movement in/out of the county was also simultaneously changing, in part because of the ski area closure, which could also be associated with the decline.
- Protecting at-risk individuals is critical to overwhelming the health care system. The infection of one person 65 or older will lead to approximately the same number of hospitalizations as the infection of 100+ children 17 or younger, ignoring secondary infections (see Appendix 7, Comparison of Hospitalization Rates of Older Individuals Relative to Children).

Key Findings: Monitoring
- We currently do not have sufficient active virus tests to detect an increase in transmission, though this may change soon.
- Self report data is a valuable tool, when used in conjunction with testing data, to detect an increase in transmission and respond before the healthcare system is overwhelmed, and should be actively followed, at least initially, even after testing capacity expands.
- There will be approximately a two to three week lag between infections and hospitalizations. We estimate that the initial doubling time of the number of people infected, in the absence of any interventions, was 3-5 days, with an approximately 4-6 day lag between when people were infected and when they reported the first onset of symptoms, and a 13 day lag between the date when the maximum number of people reported the first onset of symptoms and a maximum number of people in the hospital.

Timeline of Disease and Interventions in Gunnison County

Feb. ??: First Case

March 13: PHO1, Social distancing, hygiene, events <50, schools close

March 21: PHO3

March 26: Quarantine

March 11: Peak date of initial infection

March 16: PHO2, Peak date of first symptoms

March 24: Hospitalizations Peak

April 3: PHO 5, Non-residents asked to stay away

PHO: Public Health Order
Assumption: 5 days from infection to first symptom
Data sources: Peak date of first symptom– self report; Hospitalizations- hospital

Timeline

Based upon the self-report data we see a peak in first onset of symptoms on March 16th. If we assume 5 days from infection to self-report data, the peak of initial infection is March 11. The county data shows that the number of people in the hospital peaked at 7 people, not including transfers (which would affect both our estimate of peak hospitalizations and when that occurred), on March 24th.

Model

This epidemiological model describes the relationships between behaviors such as hygiene, social distancing, and travel into the county and the progression of the disease. This provides a simple framework to analyze the outbreak experienced by Gunnison County from mid-February to mid-April.

Additional Observations

1. Public health orders that followed the initial changes had a greatly diminished impact on transmission.
2. An overwhelming percentage of individuals (80%) displaying symptoms justifying testing are female, but men are much more likely to be hospitalized or experience severe respiratory distress.
3. Most of our severe cases are experienced by men, older people, or people having conditions putting them at risk.
4. There is an approximately 13 day lag between the peak of when people reported first experiencing symptoms and the peak of people who were in the Gunnison Valley Hospital or another hospital (see appendix 4).
5. The peak number of people in the hospital is estimated to be 18 (see Appendix 3), almost double the target of 10 individuals.
6. A survey by the school of at-risk children revealed little to no significant problems.
7. A number of activities happened during the decline of the epidemic, which indicates the practices did not increase transmission. These practices included construction, take out and delivery of food, and operation of essential businesses, including some retail businesses such as grocery stores.
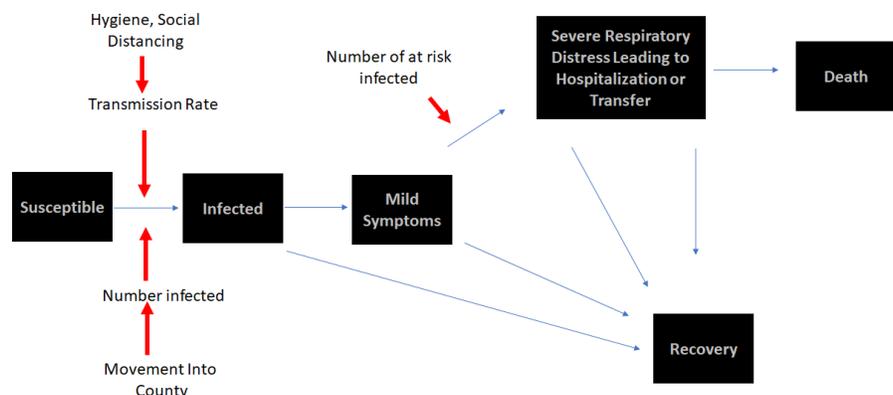
8. There were a number of events in the north end of the valley at the end of February that may have contributed to the fast community spread, including the Move the Butte (Feb. 20), a ski patrol event (approximately Feb. 22), the Red Lady Ball (March 6), a North Village Open House (March 9). These events all brought many individuals in close contact during the period of fast doubling rates.

Monitoring

It will be critical to have an early monitoring system to allow us to make proper adjustments before the healthcare system is overwhelmed. We can see a change in infections for a range of reasons, including relaxing of measures in the public health order, a change in people's behavior separate from requirements in public health orders, or a change in other factors, such as changes in transmission associated with summer.

<u>What to Monitor</u>
We recommend that until other options emerge, the community use self-report data to determine whether transmissions, and ultimately hospitalizations, are increasing. Given that our goal is to manage hospitalizations and severe respiratory distress, we recommend explicitly tracking at risk individuals in addition to tracking the entire population.

Cell phone data: If we can acquire appropriate cell phone data we will be able to track changes in social contacts on a rapid basis, anticipating potential changes in transmission rates, including the impacts of updated health orders.

Self-report data: This data allows us to have a relatively comprehensive sense of what the entire Gunnison population is experiencing, without limitation by the number of available tests. While there is an error rate, the PCR test also has a high error rate. Furthermore, most previous epidemics in human history have been managed successfully relying upon symptom data since the ability to use PCR to detect viruses and bacteria at scale is relatively new. Our best estimate of the average lag between infection time and symptoms is 5-6 days, which is likely to be 1.5-2 or less doubling cycles. ***By analyzing self-report data of individuals who test positive and/or randomly sampling self-report individuals who by current protocols are not tested, we may be able to link self-report data to testing.***

Analysis of self-report data: There may be ways that we can expand and improve (e.g., collecting temperature and adding a likert scale to severity of symptoms) self-report data to improve estimates, such as by tracking data on people being forwarded to screening centers.

Number of people tested: This is a function of the availability of tests and health care decisions, not a function of how many people are infected. It is also worth noting that while 80% of the people tested are female, most hospitalizations and severe respiratory distress are experienced by men.

% of people testing positive: This is a function of how many tests are being administered and to whom they are being administered, not how many are infected.

Random sampling to detect community transmission: With current testing capacity we do not have the statistical power to detect community spread. This is based upon an estimate of a relatively low number of people infected (and an intent to maintain those low levels to keep hospitalizations low), a high false negative rate associated with the tests, and a short window of time to detect an infection.

Hospitalizations: There is an estimated lag of 14 days between infection and hospitalization, or 2.5-4.5 or less doubling cycles. By using self-report data instead of hospitalizations, we can cut the lag in detection of a change in transmission by over half.

Appendix 1: Estimates of Number of People Infected in Gunnison County (As of April 21, 2020)

It is very difficult to estimate the number of people infected, though we can estimate numbers in various ways. We do these calculations simply to generate a very rough estimate of how many people are infected. We make our calculations transparent so that they can be updated as new information emerges, or so that people can change the assumptions and see how that changes the calculation.

We can calculate infections from mortality. Gunnison has had 4 deaths. We will use a low mortality estimate because this will lead to a large estimate of the number of people infected. Assuming a mortality rate of 0.5% of people who are infected suggests 200 infections for every death or 800 infections (allowing for a potential additional). Allowing for deaths to double from individuals still suffering severe respiratory distress from the initial spread of the virus suggests 1600 infections on the high end. Assuming a population of 18,000 individuals, that means 9% of the population is currently or has been infected.

We can also attempt to estimate the number of infections from testing data, self report data, and estimates of asymptomatic individuals. As of April 21 103 individuals had tested positive and 233 individuals had tested negative. Assuming that 30% of individuals testing negative are positive, we expect 173 of tested individuals to be infected, or 51% of individuals tested are infected. Additionally, 1260 individuals have self-reported systems. We have self report data and testing data for 198 individuals (11 indeterminate, 53 positive, and 134 negative). If we assume indeterminate tests are positive, and 30% of negatives are positive, the percent that were likely to be positive in the self-reporting group is 53%. If we take out the individuals in the self report data that have been tested, there are another 563 infected individuals from the self report. Adding the tested individuals to the self report individuals generates an estimate of 763 individuals were or are infected and were captured among the test and self report data.

We know that many infected individuals do not have symptoms, or have such low levels of symptoms that they have not reported symptoms. It is very difficult to estimate the numbers of these individuals, but a 1:1 ratio is reasonable, generating an estimate of 1194 individuals who are infected (763 symptomatic individuals plus 763 asymptomatic individuals). Assuming a population of 18,000 individuals, that means 8.5% of the population is currently or has been infected. If there were fewer individuals in the county because of the closure order and the end of the ski season, we would expect the percentage of infected individuals to climb accordingly.

Notes:
1. In a presentation on April 20, Governor Polis provided an estimate that 1.1-1.3% of Coloradans are infected. Given that Gunnison County had a high rate of infection for the state, we would expect Gunnison to be higher.
2. From a study of pregnant women using the virus detection method, **the ratio is 7:1**. Additionally, pregnancy causes substantial changes in immune systems which could affect interpretation. //www.nejm.org/doi/full/10.1056/NEJMc2009316: 88% of pregnant women (215 women screen, 29 positive/asymptomatic, 4 positive/symptomatic)

3. From a study of one of the military carriers using the virus detection method the ratio is **1.5:1.** https://www.reuters.com/article/us-health-coronavirus-usa-military-sympt-idUSKCN21Y2GB?utm_source=Nature+Briefing&utm_campaign=ff928b9a9f-briefing-dy-20200417&utm_medium=email&utm_term=0_c9dfd39373-ff928b9a9f-44296129, 60% (4500 tested)
4. From Iceland using the virus detection method**, the ratio is 1:1**. https://www.usatoday.com/story/news/world/2020/04/10/coronavirus-covid-19-small-nations-iceland-big-data/2959797001/.
5. The virus detection method tends to overestimate the ratio because some individuals initially classified as asymptomatic progress to being symptomatic.
6. Updated testing, particularly serology testing, may substantially change these estimates, potentially identifying a much higher number of individuals who have been infected without symptoms.
7. The CDC cites several studies, one that found that 13% of infected children were asymptomatic (**0.13:1**) and another study of a nursing facility that found half of individuals were asymptomatic **1:1**. https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-guidance-management-patients.html

Appendix 2: Definition of At-Risk Individuals

According to the National, Opening Up America Again plan, vulnerable individuals are defined as: elderly individuals and individuals with underlying health conditions, including high blood pressure, chronic lung disease, obesity, asthma, and individuals with a compromised immune system (e.g., chemotherapy).

Appendix 3: Details of State and National Recommendations for Opening

National Guidelines
The federal government ("Reopening America Again") recommends a strategy that is based upon up-to-date data, emphasizes the capacity of the health care system, mitigates the risk of resurgence, protects the most vulnerable and which can be implemented statewide or on a county-by-count basis.

They recommend that for all phases of opening, the following practices continue.
Good Hygiene: washing hands, avoiding touching face, sneezing or coughing into tissues/elbow, disinfect frequently used items/surfaces, face coverings in public (especially mass transit).
Sick People: Do not go to work/school, contact and follow advice of the medical provider.
Employers: Develop and implement policies in accordance with federal, state, and local regulations/guidance involving social distancing and protective equipment, temperature checks, testing, isolating, and contact tracking, sanitation, use and disinfection of common and high-traffic areas, business travel. Symptomatic individuals should not return to a physical workplace unless cleared by a medical provider.

The government proposes that the following gating criteria be met before proceeding phased opening.
Symptoms: Downward trajectory of influenza-like illnesses reported within a 14-day period **AND** downward trajectory of covid-like syndromic cases reported within a 14-day period.

Cases: Downward trajectory of documented cases within a 14-day period **OR** downward trajectory of positive tests as a percent of total tests within a 14-day period (assuming flat or increasing number of tests).

Hospitals: Treat all patients without crisis care AND a robust testing program, including antibody testing, for at-risk healthcare workers.

For phase 1 they have the following recommendations.

Individuals: Vulnerable individuals should shelter in place and be isolated, when in public all individuals should maximize physical distance from others, events of more than 10 individuals should be avoided unless precautionary measures are observed.

Employers: Should encourage telework whenever possible/feasible, have employees return to work in phases, close common areas, minimize non-essential travel, and provide special accommodations for at-risk populations. Schools and organized youth activities that are closed should remain closed. Visits to senior living facilities and hospitals should be prohibited. Large venues and gyms should only operate under strict distancing and sanitation protocols. Elective surgeries can resume. Bars should remain closed.

For states that accomplish phase 1 with no evidence of a rebound and that satisfy the gating criteria a second time, they recommend the following for phase 2.

Individuals: Vulnerable individuals should continue to shelter in place and be isolated, when in public all individuals should maximize physical distance from others, events of more than 50 individuals should be avoided unless precautionary measures are observed. Non-essential travel can resume.

Employers: Encourage telework whenever possible/feasible, close common areas, non-essential travel can resume, special accommodations for at-risk individuals. Schools and organized activities can reopen. Visitors to senior care facilities and hospitals should still be prohibited. Large venues operate under moderate physical distancing protocols. Elective surgeries continue. Gyms can open with physical distancing and sanitation protocols. Bars can operate with diminished standing-room occupancy where appropriate.

For states that accomplish phase 2 with no evidence of a rebound and that satisfy the gating criteria a second time, they recommend the following for phase 3.

Individuals: At-risk individuals can resume public interactions but with social distancing and low-risk individuals should minimize time in crowded environments.

Employers: Unrestricted staffing of worksites, visits to senior care facilities and hospitals can resume (with diligent hygiene), large venues can operate under limited physical distancing protocols, gyms can operate subject to sanitation protocols, bars can increase standing room occupancy as applicable.

Colorado Governor's Office

This is an analysis for opening issued by the Colorado Governor's office.

Phase 1/Urgent: Suppress virus transmission, understand true cases, expand testing and tracking capacity, expand healthcare capacity, determine cost-benefit of individual social distancing policies.

Phase 2/Stabilization: Keep rate of transmission so that number of cases is not increasing, increase testing, contact tracing, quaranting, and isolating, ongoing public education on hygiene and social

distancing, no large gatherings, dynamic changes based on data, achieve maximum benefit at lowest cost

Phase 3/Recovery: Building population level immunity or treatment approach, lift all restrictions, monitor for outbreaks.

Colorado Association of Local Public Health Officials (CALPHO)
CALPHO issued a letter to the Colorado Governor recommending a framework for opening, following a format similar to national recommendations.

They recommend that until a vaccine is effectively deployed they emphasize that face-coverings will need to be deployed, especially for sick individuals and when a minimum distance of 6' cannot be maintained . Additionally, until the vaccine is developed the following measures will be important: hand hygiene, cough/sneeze etiquette, maintaining 6 feet of distance between individuals, protect at-risk individuals, regular screening for symptoms, reporting and testing, and contract tracing.

They suggest that we can move from the current urgent phase to the stabilization phase when there has been (the following is an abbreviated list) a sustained decrease in new cases for at least 14 days, hospitals are able to safety treat patients without resorting to crisis standards of care, regional health care plans are in place, symptomatic individuals can be quickly tested, it is possible to implement active monitoring and contract tracing, and clear protocols are in place for social distancing, with an emphasis on isolating at-risk individuals.

Within the stabilization phase, they identify three steps (Green Circle, Blue Square, and Black Diamond). They recommend we move to the green phase when the 5 criteria are met (sustained decrease in cases for at least 14 days, hospitals operating without crisis, adequate testing, contact tracing, and ability to manage social distancing and case identification).   The blue square phase can start 4-8 weeks after the Green Circle has started if there is not a significant increase in cases. The black diamond phase can then start 8-16 weeks after the start of the green phase if there has continued to be no new cases.

In the green circle phase, group sizes should be limited to 10, businesses and child care will open with guidance around hygiene and social distancing, K-12 schools will be closed, bars should remain close,special events will not be allowed, restaurants will only be open for delivery and take-out, overnight children's camps will be closed, recreation and sports will open with restrictions, and incoming travel will be strictly limited.

In the blue phase, maximum group sizes will increase to between 25-50, K-12 schools, special events, bars, and restaurants will be allowed with social distancing, recreation and sports can increase gathering size, and limited travel will be allowed.

In the black phase, maximum group size will increase to 250, there will be no limit on recreation and sports, and all travel will be allowed.

They indicate we will not be in the recovery phase until a vaccine is ready.

Appendix 4: Number of Gunnison Hospitalizations

Date	3/24	3/25	3/26	3/28	3/29	4/1
GVH	7	3	5	5	3	1
Elsewhere	6	10	11	12	15	11
total	13	13	16	17	18	12

Notes:
1. Generated April 18, 2020 using data provided by the hospital.
2. An individual who was identified has a high probability of not being CoVID was not included.
3. We do not have good data on individuals who transferred from Gunnison Hospital. We assumed two individuals who transferred in early March were discharged by the end of March. We assumed individuals after that remained in hospitals unless we had information otherwise, consistent with long hospitalization times for people experiencing severe respiratory distress.
4. As the epidemic progressed, the hospital began transferring individuals faster to reduce the impact of lower oxygen levels on the onset and severity of severe respiratory distress.
5. Hospitalizations from other sources (e.g., heart attacks, accidents) have dropped considerably at the Gunnison Hospital, tracking what has been seen elsewhere in the US. However, overall hospitalizations still pushed the health system to its limit, in part because of the extended length of stay experienced by many people with severe respiratory distress due to the virus.
6. The CDC cites a study that the medium length of hospitalizations among survivors is 10-13 days. https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-guidance-management-patients.html

Appendix 5: Doubling Time, Estimates of Lags Between Infection, Symptoms, and Hospitalizations

Doubling Time
1. Three individuals self-reported initial symptoms on Feb. 26 and that peaked at 128 on March 16, which translates into 5-6 doublings over 18 days, or a doubling time of 3-4 days. Doubling times reported in other communities experiencing rapid infection range from once every two days to every five days.
2. Doubling times for Gunnison County were calculated by Dr. Hannah Heinrich. Her estimate of peak rate of transmission on March 13 was sufficient to go from 1 case to 40 cases in 14 days (or approximately 5 doublings or a doubling every 2.8 days.

Lag Between Infection and Onset of Symptoms
1. There is generally thought to be a 5-6 day lag with a range between 2-14 days. https://www.health.harvard.edu/diseases-and-conditions/covid-19-basics.
2. The CDC indicates a 4-5 lag from infection to symptoms, and that 97.5% of individuals who will show symptoms will do so within 11.5 days of infection. https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-guidance-management-patients.html
3. Gunnison experienced a 3 day lag between public health order and closing of school (March 16) and peak self reported data for onset of symptoms (March 16). It is hard to imagine that infections started dropping before that intervention. There may be bias in the self report data,

with people systematically estimating an earlier or later date of onset. The observed data are roughly consistent with 3-5 day lag.

4. We reviewed the self report data to determine how robust the estimate of March 16 is to using a subset of symptoms. Within the 1350 self-report data we examined those experiencing fever and Cough or just shortness of breath (795), just cough (894), just cough and fever (427), and just shortness of breath (587).   We also examined the data using severity of symptoms. In all of those scenarios the peak is March 16.

5. A report by Dr. Hannah Heinrich based upon swabs indicated that the transition from exponential growth happened in the north end of the valley on March 13, consistent with the self report data.

Lag Between Infection and Hospitalizations

1. One source indicates a 6 day lag between the onset of symptoms.   If combined with a 5 day incubation period it suggests approximately 11 days from infection to the hospital. https://patient.info/news-and-features/coronavirus-how-quickly-do-covid-19-symptoms-develop-and-how-long-do-they-last.

2. We saw the peak number of hospitalizations occurring around March 30. If peak onset of symptoms occurred March 16, that is two weeks between when the number of people reporting first symptoms peak and the maximum number of people in the hospital. Because hospital stays are longer, the number of people in a hospital at one time will lag the mean of when people appear at the hospital. In other words, a two week lag between peak infections and peak hospitalizations is consistent with an 11 day average time between first symptoms and hospitalization.

Appendix 6: Herd Immunity is Unlikely

A population can become resistant to a disease if a sufficient number of individuals are resistant such that the virus is unable to find enough new individuals to infect (herd immunity). This can be achieved with or without a disease, or in combination. To analyze what it would take to achieve herd immunity without a vaccine, we have to estimate R_0 , or the rate of spread of the disease in a population in which only one person is infected. The transmission rate of an infectious disease is generally estimated to start declining, which is when herd immunity is achieved, at 1- (1/R_0).

By fitting an SEIR model to data observed for Gunnison County we estimated R_0. This suggests that 80% of the population would need to be resistant for us to see a decline in transmissions due to herd immunity. If we assume a population of 18,000, 14,400 individuals would have to be resistant. Our estimates of the number of people are infected are well below that (See Appendix 3). Furthermore, it is unclear whether an infected person becomes resistant, how long it takes to become resistant, and how long resistance is maintained. So we cannot assume that individuals who have tested positive or had symptoms, are necessarily immune.

If we assume an R_0 of 3, which is consistent with estimates from elsewhere, and is towards the low end of what seems reasonable given the fast rate of spread observed in the county in March, we would still need to have 12,000 resistant individuals to achieve herd immunity.

For Gunnison County to currently be close to herd immunity would require a combination of:

1. The rate of spread must be much lower than apparent. This is inconsistent with the sharp peak in self-report data and rapid number of hospitalizations.
2. The number of asymptomatic individuals must be very high. This is possible, but our current assessment is that it is not likely.
3. Most individuals who have been infected must be resistant.

This finding is consistent with the CALPHO recommendation that Colorado will not enter the recovery phase until a vaccine is available.

Appendix 7: Comparison of Hospitalization Rates of Older Individuals Relative to Children

As of April 14th, New York City Health estimated that mortality associated with the virus by age is (total cases): 0-17 years old: 3 deaths; 18-64 years old: 1890 deaths, and 65+ years old: 4946 deaths.

To estimate the likelihood of an infection of a child leading to a hospitalization relative to an infection of a senior, we have to correct for the number of people in the different age categories. According to the US Census Bureau NY City has a population of 8,398,748, with 27.4% individuals being 0-17, 58.5% 18-64, and 14.1% 65+.

This suggests that every 3215 children infected will lead to the same number of hospitalizations as the infection of one person 65 or older. The ratio is 11:1 for individuals 18-64 years in age.

Notes:

1. The mortality data were acquired on April 20th, 2020 from the following URL: **Daily Data Summary**
2. The census data was acquired on April 20, 2020 from the following URL: **New York city, New York**
3. Using mortality avoids problems with differences in testing rates.
4. Because mortality rates of children are so low, we needed a large population with a high infection rate to make a reasonable calculation. For this reason we used data from New York City.
5. The ratios in Gunnison County are undoubtedly different. However, it is a general finding that the disease causes substantially more problems with at-risk populations. We use this calculation to emphasize how important isolating at-risk populations is likely to be to reduce overwhelming the hospital system.
6. The paucity of deaths for children means that this estimate is not robust.

Using CDC data yields a much lower estimate that the infection of 103 children is equivalent to the infection of one person 65 or older in terms of hospitalizations. A paper posted by the CDC estimated that hospitalizations per 100,000 broken down by age group from 99 counties in 14 states were: 0-4 years old, 0.2; 5-17 years old: 0.1; 18-49 years old: 2.5; 50-64 years old: 12.2; 75-84 years old: 15.8; and 85+ years old: 17.2. We used the number of individuals in each age class to weight hospitalizations within broader categories, generating: 0-17 years old, 0.133; 65+ years old, 13.72. While this number is much lower than the NY City estimate, it is worth noting that hospitalizations were 0.13 per 100,000. In other words, for every million children represented in the study during the month of March, only 1.3 were hospitalized.

1. The CDC data was downloaded April 21, 2020 from
   https://www.cdc.gov/mmwr/volumes/69/wr/mm6915e3.htm
2. The census data was for the elderly was downloaded April 21, 2020 from
   https://www.census.gov/content/dam/Census/library/publications/2018/acs/ACS-38.pdf
3. We obtained data on age classes within 0-17 years old from a link April 21, 2020
   https://www.childstats.gov/americaschildren/tables/pop1.asp

4.   The numbers of children hospitalized in the CDC study was also small (n=12), meaning that this estimate is also not robust.