

What Do We Know About a Potential Second Outbreak?

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Executive Summary

To a) Better understand the connection between local public interventions and control of the virus within the context of a second outbreak, b) Help the public understand the science behind why public health is being so diligent about a possible second outbreak, and c) To put a focus on the need for reaching a sustainable systems approach to managing the response to the virus, we analyze the current transmission dynamics of the coronavirus epidemic within Gunnison County and the potential for a second outbreak. Given a) the low number of individuals in the county who have been infected and who might have acquired immunity, b) the persistence of the disease locally and across the United States, and c) examples of multiple outbreaks elsewhere (Kirby 2020), Gunnison County remains susceptible to another outbreak. A second outbreak could be more deadly than the first, based upon patterns seen in previous pandemics (e.g., Spanish Flu, Saunders-Hastings et al. 2016), though rapidly growing knowledge about the importance of aerosols to transmission (e.g., Prather 2020), treatment (e.g., Ledford 2020), and susceptibility of at-risk populations reduces the chances of such an outcome.

There are several possible explanations for the current low level of the rate of detection of Covid19 cases within Gunnison County. The low detection rate is unlikely to be explained by a lack of testing, given the County's relatively high testing levels. While contact tracing and isolation is an important tool for controlling transmission, given the amount of transmission that happens pre-symptomatically these methods are likely insufficient to control the spread of Covid19 (Ferretti et al. 2020). The county has relaxed many of the previous public health orders, but there are still some restrictions in place, including a face covering order and restrictions on group and indoor activities. Voluntary changes in behavior are also likely to be important in controlling spread. Given that we now know the importance of superspreading (which occurs when an individual or event is responsible for a disproportionate share of new infections) and aerosol transmission (particularly indoors) *it may be* that such targeted interventions, especially when combined with contact tracing and isolation, can prevent a second outbreak.

Alternatively, there is still enough uncertainty around transmission dynamics that we cannot rule out the possibility of a second outbreak, or predict when it might happen. The importance of superspreading and evidence that the virus may be introduced into a community many times before it takes off (Pybus and Rambaut 2020), suggest it may be just a matter of chance and time before we see a second outbreak. Additionally, voluntary changes in behavior may be important to reducing disease transmission. As more time passes without an outbreak, we might see a relaxing of diligence that eventually leads to an outbreak. Alternatively, if the initial outbreak was driven by a pool of individuals highly susceptible to infection and such individuals are currently immune, we might see a second, less severe outbreak once immunity wanes in the pool of individuals susceptible to infection.

Continuing to protect at-risk groups and focusing on measures to reduce superspreading and exposure in poorly ventilated spaces, including the use of masks indoors in public places and physical distancing, will reduce the chance and impact of a second outbreak. Furthermore, if an outbreak does occur, these measures will give the county more time to detect it and respond before the hospital is overwhelmed. Furthermore, given the possibility of a second outbreak well in the future, Gunnison County needs to develop a long-term, sustainable system for managing the response to Covid19, as well as maintaining public support for a potential return to stricter public health orders.

Previous Gunnison Outbreak

Following a previous report for Gunnison County (Initial Recommendations on Reopening) Gunnison County experienced an outbreak of Covid19 that peaked in approximately mid-March, 2020. One hundred and twenty-four residents have tested positive on the viral swab tests (as of July 7, 2020), though after accounting for asymptomatic individuals, as well as symptomatic individuals who were unable to get tested, estimates as of April 22 suggested that as many 9% of the county might have been infected (with lots of uncertainty around estimates). Since April 22, there have been only a handful of positive tests per week.

Gunnison County has serological data which can help determine the number of residents who have ever had Covid19, but because it is not the result of a sampling design intended to estimate the percentage of infected individuals, interpretation is problematic. Results are biased, representing individuals who have chosen to take and pay for the test likely because they had symptoms and want to confirm having had COVID-19. With these caveats in mind, as of July 6, 267 of 948 people (28%) tested positive for antibodies.

An infection rate of 9% is not out of line with estimates of how many people have been infected in other hard-hit communities based upon serological surveys. Estimates (see also Table 1 in Flaxman et al. 2020) include:

1. 3% for Santa Clara, CA (Bendavid 2020).
2. 3.5% for Wuhan, China (Xu et al. 2020)
3. 4.4% for France (Salje et al. 2020)
4. 5% for Spain (Yasinski 2020)
5. 11% for Geneva, Switzerland (Stringhini 2020)
6. 14% for Gangel, Germany (Streeck et al. 2020)
7. 14% for the State of New York (Rummler 2020)

There have been 6 deaths in Gunnison County, representing 0.03% of the population. In general, Covid 19 has been quite lethal. In comparison to Gunnison County, 0.15% of all of the individuals in the state of New York have died because of the virus (<https://www.worldometers.info/coronavirus/country/us/>). As of July 6th (also from worldometer) the United States has experienced 134,000 deaths. To get a sense of magnitude, Covid19 deaths are often compared to the flu, which according to the CDC has caused 12,000-61,000 deaths per year since 2010. However, these flu deaths are modeled deaths, and not directly reported deaths, which have a peak estimate of around 10,000. Consequently, despite extraordinary measures to reduce Covid19, we have already experienced ten times as many Covid19 deaths as seen in the worst flu season, with deaths continuing to accumulate. For an analysis of comparing mortality of Covid19 to that of the flu, see Faust (2020).

There has been additional confusion comparing the flu and Covid19 based upon the use of infection fatality rates, which estimate the proportion of individuals who die after contracting the disease. However, these analyses fail to account for differences between the flu and Covid19 in terms of how many people are infected (Ferretti 2020).

Mortality and infection in Gunnison County are consistent with general findings that the virus is more likely to infect some individuals, and that some individuals are more likely to have worse outcomes. There is compelling evidence that men are hit harder (Williamson et al. 2020). Younger people are less likely to suffer from the virus (Williamson et al. 2020). There is also evidence that their blood vessels are less susceptible to Covid19 induced clotting (Cyranoski, Nature, 2020b).

Individuals at-risk due to underlying conditions, such as individuals with diabetes, obesity, recent haematological malignancy, and chronic respiratory disease are more likely to have a severe form of the disease (Williamson et al. 2020).

Impacts of Gunnison Public Health Orders Restricting Activities

There was a dramatic decline in the number of positive cases following the initial public health order (March 13), 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 and ski resort. The second public health order (March 16), including limiting group sizes to 10, closing retail establishments, eliminating short term lodging, requiring visitors to leave/stay away, and limiting public transportation, happened shortly thereafter. We do not know which of these measures contributed to the decline in transmission.

Later public health orders, including the stay at home order (March 26) and requiring non-resident homeowners to stay away (April 3), were implemented after the drop in new cases and as such did not have a noticeable impact on transmission rates.

The impact of the initial Gunnison public health orders is largely consistent with findings elsewhere that interventions have been important to stop the spread, eliminating half a billion infections in China, South Korea, Italy, Iran, France, and the United States (Hsiang et al 2020). While we have not attempted to conduct a thorough review of the impact of interventions on the virus, we note that Flaxman et al (2020) found that stay-at-home orders were very effective in reducing transmission, a finding supported by Hsiang et al (2020), along with beneficial impacts of canceling gatherings, limiting travel, and social distancing. Dehning et al. (2020) analyzed the impact of interventions in Germany and found evidence that canceling large events and increased awareness reduced transmission by a factor of 2, and that closing schools and stores, and limiting contact further reduced transmission.

In considering future interventions, we highlight three recent scientific findings.

1. There is strong evidence that presymptomatic individuals are responsible for much of the transmission, accounting for over half of transmission in one study (Casey et al, 2020).
2. There is growing evidence that a small number of individuals, and superspreading events, are responsible for much of the transmission, with one study suggesting that 80% of the transmission is caused by as little as 10% of the individuals (Kupferschmidt 2020).

3. There is growing evidence that transmission is driven by aerosol and droplet transmission, and not as much by manual contamination/fomites (Prather et al. 2020). Given the substantial amount of transmission driven by asymptomatic/presymptomatic individuals who are not yet coughing or sneezing (Ferretti 2020), this has led to an emerging consensus about the importance of masks, good ventilation, and social distancing, especially indoors.

Sequence of Relaxation of Gunnison County Public Health Orders

April 11: Non-resident homeowners present more than 14 days allowed to stay

April 21: elective medical services allowed

April 27: non-resident second homeowners allowed to return

May 1: Day care and childcare allowed with restrictions, some retail activity allowed, public transportation with 10 or fewer passengers allowed

May 12: Events of 10 or fewer people allowed, restaurants allowed to operate with customers eating inside, churches can have 25 or fewer people,

May 15: Short-term lodging allowed to operate at 25% of capacity

May 27: Short-term lodging allowed to operate at full capacity, visitors allowed

June 8: Face coverings required, events of 25 or less allowed, restaurants allowed to operate at 50% occupancy

Types and Causes of Multiple Outbreaks

Moore et al (2020) with the Center for Infectious Disease Research and Policy suggest that the current pandemic will probably stretch 18-24 months. They suggest three potential scenarios for transmission dynamics. The first involves a series of regular and diminishing waves of infections. The second involves a larger wave in fall or winter. The third involves regular transmission and case occurrence, but no obvious waves.

While Moore et al. (2020) did not propose the mechanisms generating the potential patterns, Mummert et al. (2016) lay out five non-exclusive hypotheses for multiple outbreaks of influenza: seasonal patterns of schools stopping and starting, more abstract temporal changes in disease transmission dynamics, first waves in two different populations that create the appearance of a second wave from a regional perspective, genetic changes that allow the disease to escape from acquired immunity, and the waning of acquired immunity.

Seasonal patterns of schools: Unlike influenza, which often hits children hard, this virus has limited health impacts on children. While it is not yet clear how much asymptomatic spread is caused by children, there is some evidence that it is limited (Davies et al. 2020, NCIRS 2020, Stringhini et al. 2020, Zhang et al. 2020). Consequently it seems less likely compared to the flu that a second outbreak will be driven by the start of the K-12 schools in the fall.

Changing disease transmission dynamics: This hypothesis involves changes in human behavior that affect transmission, as well as changes to the virus that affect its transmissibility. Human behavior,

including voluntary or legally required behaviors like social distancing, the use of masks, and avoiding groups, can change transmission patterns. If a second outbreak is driven by these behaviors, it could happen at any time unrelated to season.

Genetic changes to escape immune systems: Unlike most RNA viruses, coronaviruses have a genetic repair mechanism. Mutations happen, but at a much lower rate (Cyranoski 2020b). Influenza does not have repair mechanisms so it mutates more rapidly, which leads to antigenic drift (or the loss of the ability of an immune system to identify a flu strain even though the host may have developed acquired immunity to an earlier version of the strain) (Saunders-Hastings and Krewski 2016). This doesn't mean that the covid19 coronavirus won't escape from acquired immunity by genetic drift, but rather, it might happen more slowly than for influenza.

Waning Immunity: If people acquire immunity upon exposure to the virus, with waning immunity people's immune systems may start stepping down their defenses, eventually making them more susceptible to re-infection, even to a genetically identical virus. In this scenario, the following outbreaks of the epidemic are lower than the first outbreak. This scenario is consistent with Moore's first scenario of a series of repeated outbreaks, each one smaller than the previous outbreak. It is possible, however, that a combination of waning immunity and a change in human behavior could drive a larger second outbreak, particularly given the importance of superspreading to the spread of this virus.

Why Has Gunnison Not Experienced a Second Outbreak

Gunnison County has only had more than a single positive PCR test on one day twice since April 7, 2020 (not including indeterminate cases). This is down from a peak of 14 positive cases on March 20, at a point when testing was struggling to keep up. In terms of symptoms, 150 individuals reported symptoms on March 16, with a maximum of 3 individuals reporting symptoms on any single day since June 1. Clearly infection rates have dropped dramatically from the peak and the county has not experienced a second round of prolonged, exponential growth of infections. As we think about future policies, as well as prepare for a second outbreak, it is worth asking, why haven't we already experienced a second outbreak?

There are two sources of transmissions within the community, 1) introductions by people traveling from elsewhere, and 2) spread within Gunnison County when a resident obtains the virus from another resident. A second outbreak would involve an exponential rate of growth in infections, or an effective rate of transmission such that each infected individual transmits the infection to more than 1 new individual ($R_t > 1$). The effective rate of transmission is the result of the entire range of behaviors across the community. Below, we examine alternative and non-exclusive hypotheses for why R_t has not apparently been consistently above 1 in Gunnison County.

1. **The virus is gone from the county: We are very certain this is not true.** There are consistently positive test results in Gunnison County every several days. Furthermore, there is quite a bit of tourist traffic which is likely to be reintroducing the virus, if only at low levels.
2. **A second outbreak is happening, but is undetected: We are moderately certain this is not true.** It takes on average 5 days from infection to symptoms, with several more days to get test results. While there are currently significant delays in public reporting of test results, assuming that the symptom tracking system is robust, any recent growth would have to have started less than 5 days ago.

3. **Contact tracing: We are very certain contact tracking is important to minimizing a second outbreak.** While contact tracing is an important tool for slowing the spread of the disease, the occurrence of asymptomatic and presymptomatic transmission means that as the virus becomes more widespread in the community, manual contact tracking is not capable of tracking the disease quickly enough to keep it from growing (Ferretti et al. 2020).
4. **Voluntary public action/awareness: We are very certain this is having an important impact.** Regardless of the legal requirements, many individuals are changing their behavior (e.g., less socializing, more distancing, the use of masks, etc.). These actions are likely to significantly reduce transmission, though it is unclear whether there are enough individuals voluntarily changing their behavior to prevent a second outbreak. Given human nature, we can expect that the longer we go without a second outbreak, the more likely people are to relax their guard.
5. **Arrival of spring/summer (setting aside summer tourism): We are very certain that this is having at least a minor impact in reducing disease transmission.** There is evidence that transmission rates drop at warmer temperatures, but temperature is thought to be only a minor contributor (Baker et al. 2020a) to changing transmission rates. The number of susceptible individuals, which remains high in Gunnison, is thought to be much more important than climate in determining the rate of transmission (Baker et al. 2020b). Beyond the direct impact of temperature and humidity on the virus, with the arrival of summer (and public health orders which limit some indoor activity), people are spending more time outdoors, where transmission is limited, and open windows may improve ventilation and reduce transmission.
6. **Current public health order interventions: We are very certain that this is having a major impact in reducing disease transmission.** There is growing evidence that masks are important in reducing the rate of spread (Chu et al. 2020, Liang et al. 2020). Furthermore, avoiding events, *especially indoor events*, considerably reduces opportunities for superspreading. Given that it takes approximately five days to go from infection to symptoms, and that the doubling time during the initial outbreak was approximately 3-5 days, there has been plenty of time since the public health orders have been relaxed to see an uptick. The main remaining restrictions are the limit on indoor group gatherings, and large groups in general.
7. **Chance and superspreading: We are very certain that superspreading is important to disease transmission, though we are uncertain how that impacts the current situation in Gunnison.** We know that only a few of the infected individuals are responsible for a major amount of the spread (Kupferschmidt 2020). There is evidence that communities are exposed to many introductions of the virus before community spread takes off. For example, Pybus and Rambaut (2020) found that England experienced 1000+ introductions of the virus from abroad, even when England had a small case rate. Consequently disease transmission dynamics may be such that a tourist community like Gunnison may be constantly exposed to new introductions of a virus, but an outbreak only happens when a superspreader is infected and that individual exhibits behaviors that lead to spreading (e.g., which will be influenced by voluntary and public health order restrictions on behavior). This hypothesis suggests that there is a strong element of chance to when a second outbreak happens, and that it could happen at any time. Furthermore, the arbitrariness of a superspreading event suggests it may be difficult to detect the impact of public health orders on transmission dynamics in a small community like Gunnison.
8. **Individual variability in susceptibility of infection: While this could potentially have a major impact on disease transmission, we have little certainty about whether it is actually**

happening. While there is strong variability among individuals in how they respond to infections, little is known about variability in the likelihood of being infected and, consequently, being a source of transmission. Models suggest variability in susceptibility will lead to quick declines in effective transmission rates as infections increase, and lower the threshold for herd immunity (Britton et al. 2020). In some instances, herd immunity could be reached when as few as 10-20% of the population has been infected (Gomes et al. 2020).

Summary

Gunnison County, and Colorado, have seen a marked decline in the number of positive cases, which has now been sustained for over two months. Our understanding of the disease continues to progress rapidly, including a better understanding of how the disease is transmitted as well as how to reduce mortality (Ledford 2020). Considerable uncertainty remains, however, over whether, when, or how an outbreak will occur. In addition to maintaining a robust testing, contact tracing, and isolation program, **our best strategy is reducing aerosol transmission and superspreading.** Not only will these reduce the chances of a second outbreak but they will slow the doubling time of the disease if another outbreak happens. When combined with a robust system for detecting an outbreak, this will give us more time to respond and avoid overwhelming the health care system. Given that a second outbreak could happen well in the future, it is important for Gunnison County to develop a long-term and sustainable system for managing the response, as well as maintaining long-term public support.

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