On COVID19 epidemiology, with application to wildland fire management practices

Karin Riley, March 24, 2020

Epidemiologists are working with emerging information in order to understand the spread of COVID-19, who is at high risk, the fatality rate, etc. The information below is the best available as of this writing, but could change rapidly, making frequent updates necessary. It is too soon for much information to be peer-reviewed and published. Much of the literature appears as fact sheets, letters to journals, and blogs. For other items, reliance on conversations with epidemiologists and media reports is necessary.

As the situation and what is known about the disease is changing rapidly, frequent update of this white paper is recommended. Because little is known with certainty about transmission, fatality rates, etc., one author recommends: "It is possible to communicate uncertainty about the underlying science, apply the precautionary approach where uncertainty exists, and implement well-reasoned decisions about how best to limit the dissemination of COVID-19" (Brosseau 2020).

- **Disease emergence, spread, fatality rate, and mutation**
  - The disease emerged in late December 2019 in Wuhan, China (Tang et al In Press). The virus is called SARS-CoV-2 and it causes the disease COVID-19 or generically "the coronavirus"; however the latter term is confusing as it encompasses a family of viruses including SARS-CoV-1 that caused the previous SARS epidemic.
  - As of Friday, March 19, more than 209,000 people globally had been infected with COVID-19, with at least 8700 dying, according to the World Health Organization (Al Jazeera 2020). Another 86,000 people had recovered, according to Johns Hopkins University (Al Jazeera 2020). The fatality rate in known cases currently hovers around 9% globally, if we calculate fatality rate as (dead)/(dead + recovered).
  - The situation is changing rapidly and the number of infected, recovered, and dead can be tracked online (e.g. https://www.worldometers.info/coronavirus/)
  - The lack of availability of testing means that the current reach of the disease is not known, and the number affected are underestimated. Therefore, the fatality rate given above is likely an overestimate, since more people are likely recovered but were not tested or reported to the World Health Organization
  - Spread rate is currently exponential globally. Three months' time was required to reach 100,000 cases; the number doubled in 12 days (WHO 2020).
  - The fatality rate varies with access to medical care, the strain of the disease contracted, whether high risk factors are present, and the patient's age (CDC 2020, personal communication with researchers working in the field).
  - Severe symptoms and death can occur in any age group. Fatality rates in the US differ by age group and fall with age. Those people aged 85 years or older had a

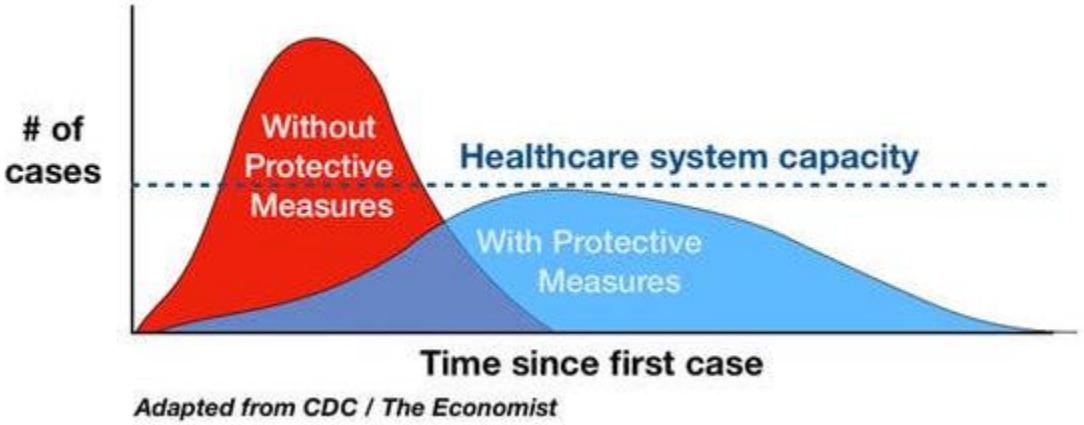
fatality rate of 10-27%, 3-11% among those 65-84 years of age, 1-3% in ages 55-64 years, <1% in those aged 20-54 years, and no fatalities recorded as of a March 18, 2020 report in those less than 19 years of age (CDC 2020).
    - Over half of children in one Chinese study who contracted SARS-CoV-2 had radiologic findings consistent with pneumonia but no clinical presentation; one died in the study died (Lu et al 2020).
    - COVID-19 likely poses the greatest threat to public health from a respiratory virus since the 1918 H1N1 influenza pandemic (Ferguson et al 2020).
    - After the SARS-CoV-2 virus that causes COVID-19 made the zoonotic jump from its animal host (likely a bat by way of a pangolin), the virus experienced rapid mutation (Tang et al In Press). There are currently two distinct strains of the virus, known as the L and S strains, with L being prevalent (70%) and S accounting for 30% (Tang et al In Press). In some patients, mutations in the virus from both strains have been identified, meaning that co-infection or two subsequent infections are likely possible (Tang et al In Press). It is possible that a person infected with one strain would not be immune to the other. Therefore it may not be possible to consider a person who has had COVID19 now immune to the disease.
    - Risk factors include age, gender (men are more likely to die of the disease), and co-morbidities, with the most common being hypertension, diabetes, and coronary heart disease (May 2020, Weiss and Murdoch 2020).
    - The leading cause of death from COVID-19 is acute respiratory distress syndrome. An underrecognized second cause may be cytokine storm and hyperinflammation (Mehta et al 2020).
- **Disease transmission**
    - The SARS-CoV-2 virus is stable in aerosols for three hours, on carboard up to 24 hours, and up to three days on stainless steel and plastic (van Doremalen et al 2020). The virus is present in smaller quantities even longer (for example, it is still detectable on cardboard up to 72 hours).
    - Some health care professionals are voicing frustration with conflicting and sometimes shifting guidance from the Center for Disease Control (CDC) and World Health Organization (WHO) regarding how the disease transmits and how to protect oneself from contracting it (Brosseau 2020).
    - According to the Chinese Center for Disease Control and Prevention, which likely has the greatest experience in dealing with cases of COVID-19 at this time, transmission of the disease is primarily through close contact and airborne droplets from coughing or sneezing, with transmission via aerosols possible in relatively closed environments when exposure to high concentrations is over some period of time (Chinese CDC 2020).
    - The above suggests that the disease does not require droplets from coughing or sneezing in order to be transmitted, but may be transmitted through the air from breathing or talking or from touching contaminated objects (ScienceDaily 2020, Brosseau 2020).

- Transmission has been documented as far as 4.5 meters away and as long as 30 minutes after an infected person was present in a closed environment (Chen 2020).
- Prevention efforts should focus on droplet transmission rather than fomites (objects which may carry the disease), according to some researchers (Wölfel et al 2020).
- The more infectious particles one inhales, the greater the likelihood of contracting a disease (Brosseau 2020).
- Viability of the virus may be linked more strongly to the amount of time it has been in the air rather than the distance away from an infected person for viruses where aerosol transmission occurs (Brosseau 2020).
- Increased hand washing has been shown to be effective in reducing flu transmission in health care settings, but it may not be effectual in "community settings" based on a review of the available peer-reviewed literature (Moncion et al 2019).
- SARS-CoV-2 is present in urine and feces, so transmission may be possible from direct contact or aerosolized particles (Chinese CDC 2020).
- Virus shedding may be at its highest level in the first five days as the disease and symptoms are developing, but it continues to be present in sputum through at least the first week during which symptoms are experienced (Wölfel et al 2020).
- Incubation period of the disease is variable, with the median being 5.1 days (Lauer et al 2020). A small number of cases (2.5%) took longer than 11.5 days for symptoms to appear. Out of 1000 cases, 101 would take longer than 14 days to manifest.
- SARS-CoV-2 continues to shed for a prolonged period after the symptoms subsist including in feces, with the virus appearing to replicate in the digestive tract, though it is not known whether the virus is contagious after travelling through the digestive tract (Wölfel et al 2020). Transmission through plumbing has not been ruled out and is suspected in a set of cases in Hong Kong (Regan 2020).
- Close contact is likely the primary risk factor for transmission, with close contact defined as being within 1 meter (Chinese CDC 2020).
- Travelling in a vehicle with others may increase likelihood of transmission
- It is too soon to know how factors like heat, humidity, and pollution affect SARS-CoV-2, though research is currently underway. However, research with previous SARS strains (CoV-P9) indicates that the virus remained infectious at temperatures between 39-100 degrees F for 2 hours or more, but became non-infectious when exposed to a temperature of 133 degrees C for 90 minutes (Duan 2003). UV radiation for 60 minutes also destroyed the infective capability of the virus. Cases of SARS rose with pollution (the number of inhalable particles) (Xie et al 2004), which may be an analog for disease propagation in smoky conditions.
- A dog has tested positive for SARS-CoV-2; its owner had the disease (Lanese 2020). The dog subsequently died but it is not known whether COVID-19 was the

cause. Dogs contracted mild cases of SARS during the 2003 epidemic. Transmission from dogs to humans is not thought to occur.

- **Protocols for dealing with infected persons, or those suspected of infection**
  - If you have traveled in a vehicle with or been within 1 meter of someone known to be infected, evaluation in a medical setting is recommended or if that is not available, then self-quarantine and monitoring symptoms for 14 days is recommended (Chinese CDC 2020).
  - When dealing with an infected person (or one who is suspected to be infected), wearing a gown, head-covering, N95 filtering facepiece respirator, eye protection, and gloves is the protocol for viruses such as Ebola; workers who did not deploy this protection initially in China were infected (Brosseau 2020).
  - High levels of COVID-19 can be found in rooms where workers remove protective clothing and in bathrooms, perhaps due to toilet flushing aerosolizing the virus (Brosseau 2020, Johnson et al 2013).
- **Strategies to reduce disease propagation at the community level**
  - Two strategies to reduce the disease propagation include mitigation (defined as slowing the spread) and suppression (in which the number of cases is slowed to low levels, with that situation being maintained for some period of time, potentially up to 18 months) (Ferguson et al 2020).
    - If a mitigation strategy is pursued, it might include a set of non-pharmaceutical interventions including placing suspected cases on home isolation and quarantining other family members, and using social distancing of all high-risk cases including the elderly (Ferguson et al 2020). Such a strategy would be likely to reduce peak healthcare demand by 2/3, based on simulation studies, but health systems including ICUs and resources such as ventilators would be overwhelmed and thousands of deaths would likely result (Ferguson et al 2020)
    - A suppression strategy in the US would require at a minimum social distancing of the whole population, accompanied by home isolation of those with COVID-19 and quarantine of family members (Ferguson et al 2020).
  - As a vaccine may not be available for 18 months or more, suppression may be necessary for a long time period, with standards being relaxed at times as the disease becomes less frequent. However, simulations indicate that the disease levels would quickly rebound, making a return to a suppression strategy necessary to avoid widespread deaths. Unfortunately, a suppression strategy would carry serious economic impacts (Ferguson et al 2020).
  - The effect of public health interventions such as social distancing and shelter in place on "flattening the curve", or reducing the rate at which COVID-19 is spreading can be viewed in interactive graphs here: https://www.nytimes.com/interactive/2020/03/13/opinion/coronavirus-trump-response.html (Kristof and Thompson 2020). Such strategies mean that hospitals

may be able to handle all cases, and buy time for a vaccine to be developed and deployed. (Chart below appeared in Roberts 2020)



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  - In summary, COVID-19 cases are likely to come in waves, with vaccine development and deployment possibly being 18 months away. The severity of the waves (number of cases) can be reduced by aggressive public health measures.

Disclaimer: It should be noted that the author of this document, Dr. Karin Riley, is a Research Ecologist and not an epidemiologist. As such, Dr. Riley has expertise in research and reviewing literature in general, but no expertise in epidemiology. Dr. Riley has submitted this white paper for informal review by those working in with COVID-19 research, but as of this writing the paper has not received review. Because of the evolving nature of this pandemic, information that is the best available today may soon be outdated by newer studies.

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