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About Coronavirus Disease 2019 (COVID-19)

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Abstract

SARS-CoV-2 virus continues to be a worldwide public health threat. During the early stages of a pandemic with sparse knowledge about the pathogen, limiting testing capacity, and without effective treatment options, it is a nearly impossible task for local and state governments to limit CoViD-19 associated morbidity and mortality in their jurisdictions. To predict the numbers of infected persons, hospitalizations, and deaths, infectious disease models are useful tools for Public Health officials to decide on best public health mitigation measures to prevent the rapid growth of CoViD-19 disease. The goal is to delay the rapid spread of the disease, ”flatten the curve,” to have sufficient healthcare resources such as Intensive Care Units (ICU) beds and ventilators available to treat the very sick patients but also enough personal protective equipment (PPE) such as N95 masks, gloves, and gowns to protect the healthcare workers from getting infected.

Keywords: COVID-19, epidemiology, disease transmission, mortality

Introduction

A cluster of pneumonia cases with unknown etiology was detected in Wuhan City, Hubei Province of China in late December 2019. The novel pathogen causing viral pneumonia was named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the associated coronavirus disease was named CoViD-19. Based on the rapid spread and growing numbers of countries reporting community transmission of CoViD-19, the World Health Organization (WHO) declared a pandemic on March 11, 2020 with more than 100,000 cases reported from more than 100 countries (World Health Organization, 2020). Three weeks later, there are more than 150,000 cases and nearly 3,000 deaths in the United States alone (Coronavirus Research Center, 2020; Centers for Disease Control and Prevention, 2020).

Louisiana has been particularly hard hit by COVID-19. In anticipation of this phenomenon, Louisiana's Governor declared a State of Emergency on the same day the WHO declared it a pandemic, even though the State had its first reported case from New Orleans just two days prior on March 9. Of the 34,033 tests completed and reported to the State, 4,025 cases of COVID-19 (11.8% of tests) and 185 associated deaths have been reported (4.6% of cases) (Louisiana Department of Health, 2020). Among the patients with COVID-19, 1,158 are currently hospitalized (28.8% of cases). Some patients with COVID-19 had been hospitalized and released. Among those patients still in the hospital, 385 (33.2%) require ventilation and are in intensive care units.

The very high hospitalization and death rate reflects the limiting testing capacity during the early stages of the epidemic where only people with sufficient severe symptoms were tested. Additionally the high prevalence of diabetes, obesity, cardiovascular disease, chronic kidney disease, and moderate to severe asthma in the Louisiana population, all risk factors for severe disease, contributed to the high number of hospitalizations and the high demand for intensive care unit beds and ventilators.

As more drive-through testing sites are opening throughout Louisiana for anyone who has milder signs and symptoms, we expect to observe that the hospitalization rate will decrease. However, it is evident that without any Public Health intervention such as social distancing or shelter in place that the healthcare capacity would be overwhelmed in a very short period of time.

What We Know, So Far

Since December 2019, we learned more about the virus specific characteristics. As a respiratory infection, the virus appears to be primarily transmitted directly by droplets greater than 5 micrometers. These droplets are emitted by coughing or sneezing and then inhaled by people. Droplet transmission is the rationale for the six-feet distancing of people assuming that these droplets will fall on the ground and are not able to infect others if there stand further than 6 ft. apart. Laboratory studies have also shown that the virus if aerosolized can stay in the air for up to 3 hours, which makes it plausible that the virus could be also transmitted directly through air. The potential of airborne transmission and the yet unknown role of person-to-person transmission from infected but asymptomatic persons is further the rationale for wearing protective masks and adhering to social distancing. .

Indirect transmission from contaminated surfaces is also possible. Particles that land on surfaces and are later touched and transmitted to the mouth, nose or eyes is the rationale for frequent hand washing, wearing protective gloves, and disinfecting surfaces. The virus may remain viable on cardboard surfaces for 24 hours and 2-3 days on plastic and stainless steel.

The incubation period – the time between exposure and the onset of signs and symptoms – appears to be 2-14 days with an average of 4 to 5 days (Lauer, et al., 2020). This is a relatively long incubation period for respiratory viruses and is the rationale for the 14-day quarantine recommendation for people who have been exposed to a confirmed CoViD-19 case. The duration of infectiousness people – the time period when persons are capable to infect others through coughing, sneezing, or otherwise leaving particles of the virus – is currently estimated to be about 4-7 days, which may include days prior to the appearance of any symptoms (Wei, et al., 2020)

Typically, once people have been exposed to a virus, the immune system will develop special proteins, or antibodies, to stop replication of the virus. Since this is a new (novel) virus, we assume that everyone is susceptible to infection. Once infected and recovered, people will have antibodies that may provide immunity to subsequent infections for 2-3 years, unless there is a mutation of the virus. Research is focused on both treatments of COVID-19 directly, and immunizations which enable the development of antibodies before any exposure. Treatments, if discovered to be effective, may be available in a matter of months. Immunizations may take 18-24 months to develop, test, and make available for the public.

Modeling the Growth and Decline of COVID-19

An important task for epidemiologists and biostatisticians is the modelling of the number of predicted infections, hospitalizations and deaths early in the epidemic. It is very helpful for health care organizations, governments, business, and the population at large to understand the severity of a pandemic (how many people are infected, how many require hospitalization, how many require ventilation, and how many will die) and the timeline of a pandemic. The problem with modeling infected persons and health outcomes is that there are literally dozens of parameters involved with any model. Until we have a good understanding of the virus and the disease, model parameters start as assumptions (Koerth, Bronner & Mithani, 2020). As time progresses and we learn more about the epidemiologic characteristic of the virus, we can then validate these assumptions or adjust them based on real data.

The usual pattern for infectious diseases is a normal distribution with a steep rise and slower fall of the number of cases, called the epidemiological curve. Modeling the number of cases of CoViD-19 in a geographic area requires the usual set of parameters (contact rate between a susceptible and infectious person, the transmissibility of the pathogen, duration of infectiousness, if infected persons develop immunity after infection, etc.) plus parameters regarding any interventions can also be incorporated into the model. For CoViD-19 modeling, one key set of parameters involve public policy interventions on individual and group behavior to reduce the spread of disease. Among the policy options for isolation are Social Distancing and Shelter in Place. Social Distancing calls for voluntary efforts of people to stay more than 6 feet away from others, closing schools, places of worship, and canceling sports events and any other gatherings of many people. Shelter in Place calls for requirements not to leave home except for essential business such as food shopping, picking up medications at the pharmacy, etc.

The predicted number of infections based on a Susceptible–Exposed- Infectious-Recovered (SEIR) model developed in early March for the New Orleans Metropolitan Statistical Area (MSA) is presented in Figure 1. With no intervention, the number of infections increases rapidly and achieves a very high level of infected persons before decreasing (blue line). Social Distancing may decrease the peak number of infections by half and spread them over a longer period. Shelter in Place may decrease the number of infections to one third of no intervention and further spread them over time. These data may enable decision-making on policy selections, and inform planning for resources required to diagnose and treat infections

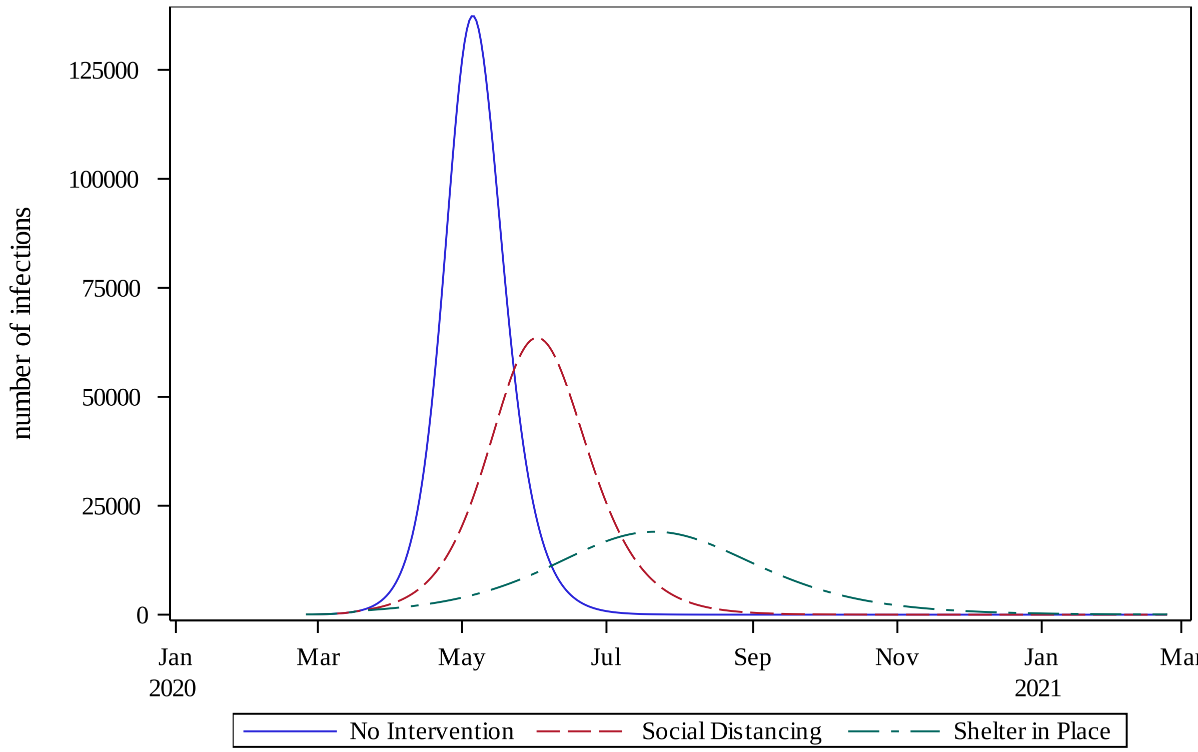

Figure 1. Number of Predicted New Infections per Day in New Orleans MSA under Three Non-Pharmaceutical Intervention Scenarios.

The number of predicted hospitalizations during a pandemic are presented in Figure 2. The pattern of hospitalizations is identical to the pattern of infections, at a lower level, assuming that 7.3% of all infected persons require hospitalization. A key addition to the presentation of hospitalizations is recognition of the resource constraints of the healthcare system. With no intervention, the number of hospitalizations is predicted to exceed hospital capacity well before the peak level. Social Distancing may decrease the peak number of hospitalizations to a level that could be managed by hospitals if they are able to sufficiently shift resources and optimally manage care. Shelter in Place may decrease the number of hospitalization to a level where the pandemic does not exceed available resources and permits hospitals to treat non-COVID-19 patients.

Conclusions

Infectious Disease Models are extremely useful during the early epidemic stages when only very limited scientific knowledge of the emerging novel disease characteristics are available. These models can help local and state health officials to better understand the potential spread of the pathogen in their jurisdictions so that they can decide on best Public Health interventions such as Social Distancing and Shelter in Place. The goal is in the absence of an effective treatment and vaccine to "flatten the curve" to ensure that enough healthcare capacity is available to treat the most seriously ill CoViD-19 patients. As the pandemic progresses, more CoViD-19 data will become available. Models then can also help us to understand the impact of the timing and best ways to slowly reverse necessary Public Health measures.

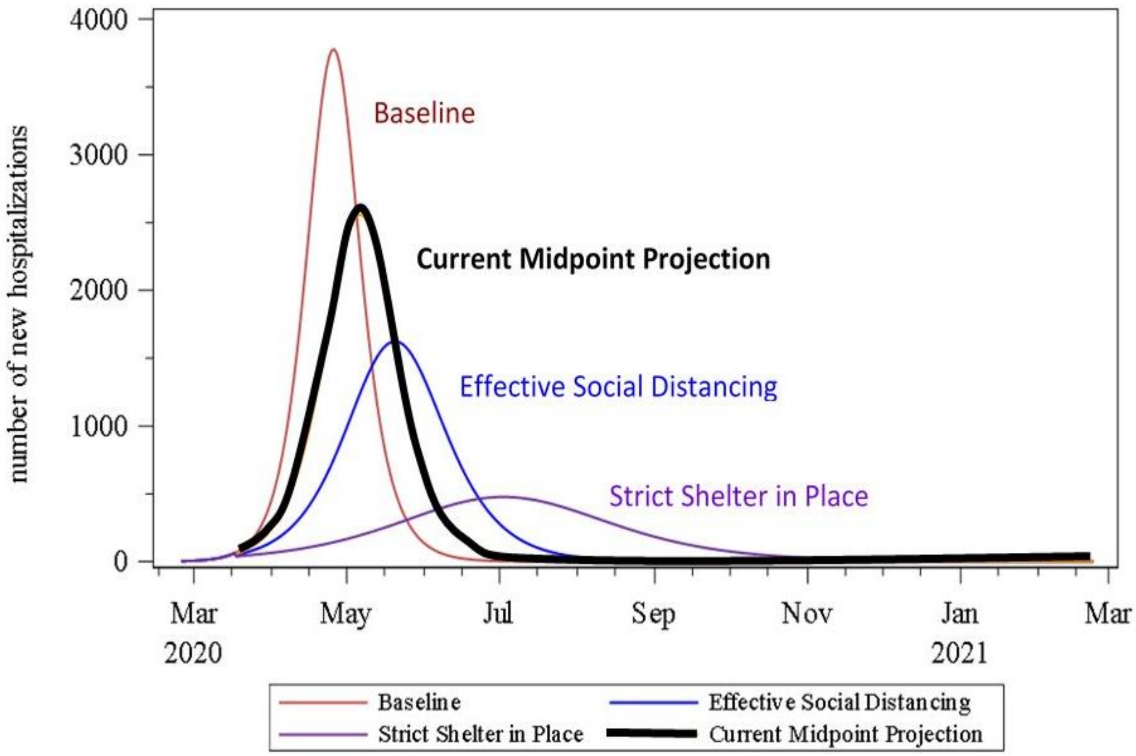

Figure 2. Number of Predicted New Hospitalizations per Day in New Orleans MSA under Three Non-pharmaceutical Intervention Scenarios.

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