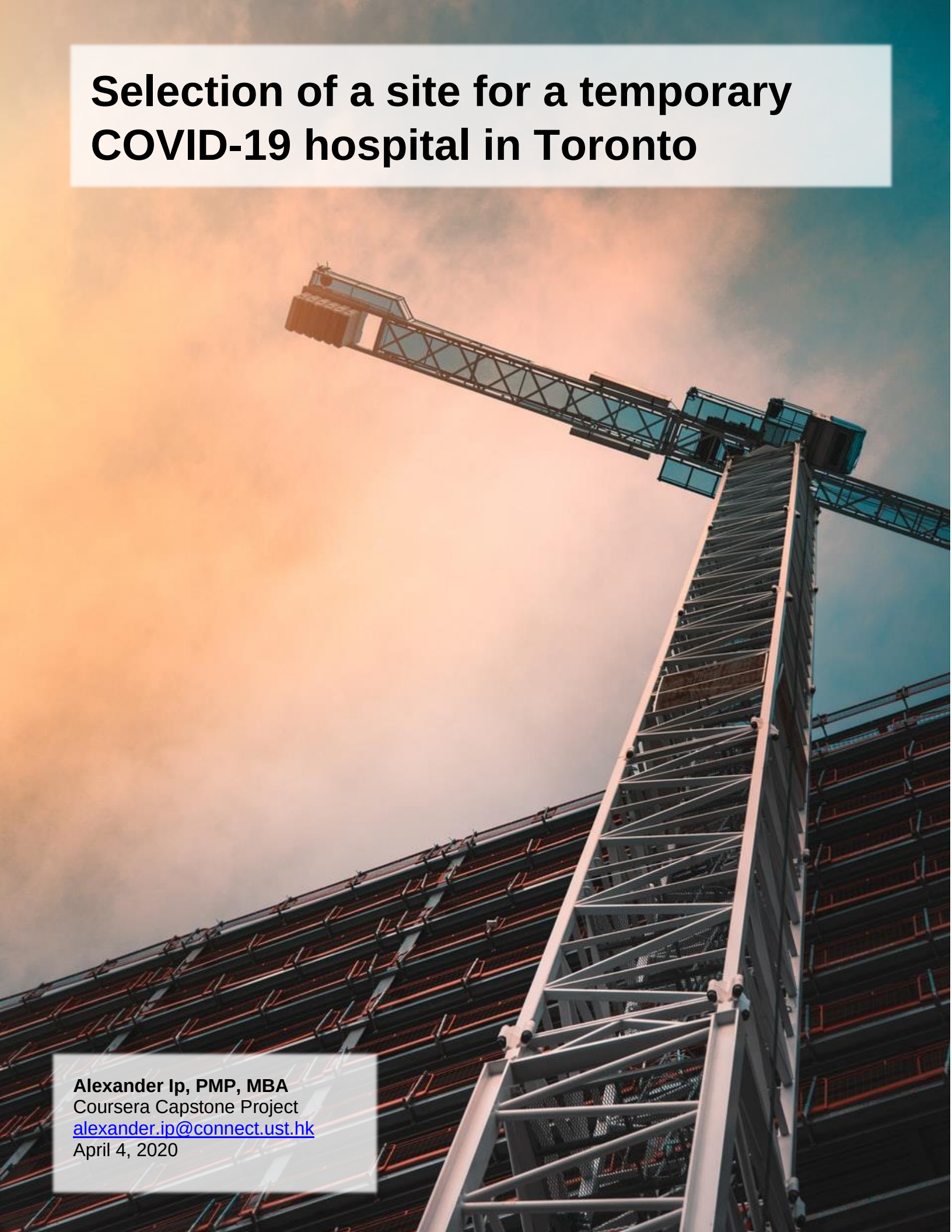
Selection of a site for a temporary COVID-19 hospital in Toronto



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Executive Summary

The impact of the COVID-19 pandemic has sent shockwaves through the world, striking at vulnerable populations that require intensive care to ensure their survival. Hospitals have been overwhelmed with exponentially growing cases, causing governments around the world to implement drastic population control measures to restrict movement and public gatherings, including quarantines and lockdowns, in a bid to slow the spread of the virus.

Like most major metropolitan cities, Toronto has seen its count of COVID-19 cases rise, and its hospitals are at risk of being overwhelmed with cases requiring intensive care. A temporary hospital could be built in the style of Wuhan's Huoshenshan Hospital and Leishenshan Hospital, which focuses on dealing with the rising cases of COVID-19. Such a temporary hospital could be built on top of Toronto's Eglinton Park, which is both large enough to accommodate a temporary hospital at the appropriate scale to treat Toronto's potential case load of COVID-19 patients requiring intensive care, while minimizing the total distance needed to travel by those patients to get to this temporary hospital.

Once a site has been selected, additional considerations could be investigated, such as the cost and timeline of building such a hospital in Eglinton Park. There may be concerns raised from nearby residents who may be uncomfortable with a large influx of COVID-19 patients in the area, as well as the loss of a prominent green space that would be further disturbed the construction and later deconstruction of the temporary hospital after the pandemic is over.

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Introduction

2020 was a remarkable year that saw the introduction of COVID-19 as a global pandemic. COVID-19, a highly infectious respiratory disease caused by the SARS-CoV-2 coronavirus, caused flu-like and pneumonia-like symptoms, with more severe cases requiring hospitalization and in the worst case causing death. The mortality of the disease appeared to be correlated with the age and other comorbidity factors of the infected patient, such as diabetes and obesity. The virus was thought to have originated from Wuhan, China and had quickly spread across the world, with some countries such as USA, Italy, and Spain exceeding the case count within China. The high case count had quickly overwhelmed the hospitals of these countries, causing the mortality of the disease to rise sharply as vulnerable patients were unable to receive adequate treatment from the overwhelmed hospitals and died. Many nations across the world have implemented drastic population control measures to restrict movement and public gatherings, including quarantines and lockdowns, in a bid to slow the spread of the virus and alleviate the number of cases their hospitals would encounter at once.

As of April 1, 2020, COVID-19 is present within Toronto, Canada, and case counts, including severe cases, have been steadily rising. Hospitals in Toronto are at risk of being overwhelmed by the steadily increasing case counts, especially severe cases requiring hospitalization and intensive care. This project investigates what would be an ideal site for a temporary COVID-19 hospital in Toronto in anticipation of the expected surge of severe cases requiring hospitalization in intensive care. The temporary hospital would be expected to be similar to the Huoshenshan Hospital or Leishenshan Hospital used in Wuhan. The analysis will include the selection of a site within Toronto that can best accommodate the highest concentration of total potential severe cases of COVID-19 that would require hospitalization in intensive care not already served by Toronto's current hospital infrastructure. Eligible sites for temporary hospitals would include unbuilt land in Toronto that is not expected to be used for erecting other buildings. Parks are assumed to be the best fit, and for the purposes of this analysis all parks will be assumed to be flat and without any significant vegetation or structures already built on them. Other considerations, such as build timeline, cost, political response, and other feasibility-related issues, are not in scope of this report. The report would be expected to be useful for any city planner or healthcare organization that is interested in looking at locations for deploying a temporary hospital within Toronto that can maximize its impact on treating the very sick while minimizing the physical distance they will need to travel to get there.

Literature review

As the COVID-19 pandemic is currently ongoing, there are many conflicting reports and rapidly obsoleted information that can be found. Accepted best practices and government actions may change rapidly as the situation of the pandemic evolves. Where possible, official sources of information were used for this report, while being cognizant that even official data may be subject to change as better information becomes available.

Data

Sources of data were pulled from official sources where possible, or from news sources for simple data points:

- Toronto's neighbourhood demographic data[1], neighbourhood maps[2], and parks maps[3] were pulled from the City of Toronto's Open Data Portal.
- The hospitalization rate requiring intensive care by age group were scraped from United States Center for Disease Control's (CDC) Morbidity and Mortality Weekly Report[4].
- Location data for hospitals were taken from the Nominatim module of Python's geopy library, or from Foursquare's developer API.
- Hospitals' Intensive Care Unit capacities were pulled from the Canadian Institute for Health Information's COVID-19 resources database[5].
- The size and capacity of Wuhan's Huoshenshan Hospital and Leishenshan Hospital were pulled from an article from Quartz[6] covering its construction.
- The projected amount of fatalities in the US from COVID-19 were pulled from the White House Task Force report covered by an article from Washington Post[7].

The following key assumptions were made to help with the modelling:

- Patients that require intensive care are assumed to need it for the duration of the pandemic; patients do not die, but they do not recover either.
- Cases will appear all at once, and patients will be treated by hospitals according to their proximity to them.
- The quality of care at all hospitals are the same, and patients will not enter or leave Toronto to seek treatment.
- Hospital networks will have their capacities concentrated on the first single hospital identified.

- Hospitals' intensive care units will be used exclusively for the treatment of COVID-19 patients in Toronto.

Methodology

Analysis was performed using Python 3.6 on a Jupyter Notebook hosted on IBM Watson Studio. The amount of potential COVID-19 cases in Toronto requiring intensive care was calculated by multiplying the demographics of Toronto neighbourhoods by the CDC's hospitalization rate requiring intensive care and the hypothetical infection rate. The hypothetical infection rate was inferred from the White House Task Force based on their projected number of American deaths. These potential cases were mapped to their neighbourhoods to determine the likely incidences of intensive care cases by Toronto neighbourhood.

Hospitals in Toronto were mapped according to their locations given by Python geopy's Nominatim or by Foursquare's developer API. Each hospital's Intensive Care capacities were subtracted from the potential cases in Toronto's neighbourhoods based on the proximity to each neighbourhood. Remaining intensive care cases unserved by Toronto's current hospital intensive care capacities were plotted to Toronto's neighbourhoods.

The size and locations of parks in Toronto were calculated according to the coordinates used to plot their boundaries. Areas were converted to square meters while locations were calculated at the centroids of the park boundaries. Using the areas and bed capacities of Huoshenshan Hospital and Leishenshan Hospital, an appropriately sized temporary hospital was linearly extrapolated based on the outstanding potential intensive care cases left in Toronto. Parks were selected based on their ability to accommodate such a hospital, and the final park was selected based on the minimum total distance that would need to be travelled by potential cases to get to the site of the temporary hospital.

Results

From the results of the modelling, there are expected to be 2263 potential case of COVID-19 requiring intensive care hospitalization. Once the current intensive care capacity of Toronto's hospitals is subtracted, there will still be 1833 potential cases remaining. The distribution of the outstanding cases can be found in Figure 1 below.

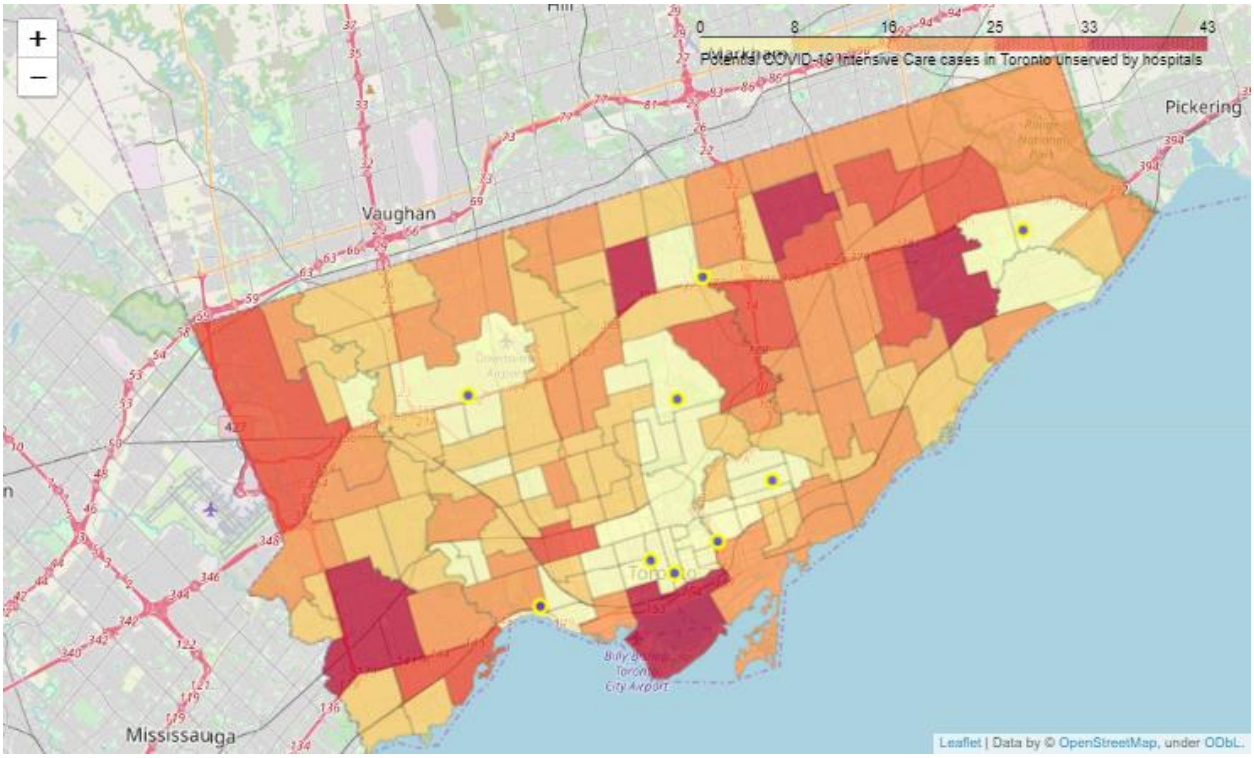

Figure 1: Distribution of potential COVID-19 intensive care cases in Toronto unserved by hospitals.

Using Wuhan's Huoshenshan Hospital and Leishenshan Hospital as references, the size of a temporary hospital large enough to treat 1833 potential intensive care cases of COVID-19 would need to be at least 38886 square metres in size. Of the parks large enough to accommodate such a temporary hospital, Eglinton Park is best situated to minimize the amount of travelling needed to be done by the remaining potential cases to get to the temporary hospital. The location of Eglinton Park relative to the remaining cases in Toronto can be found in Figure 2 below.

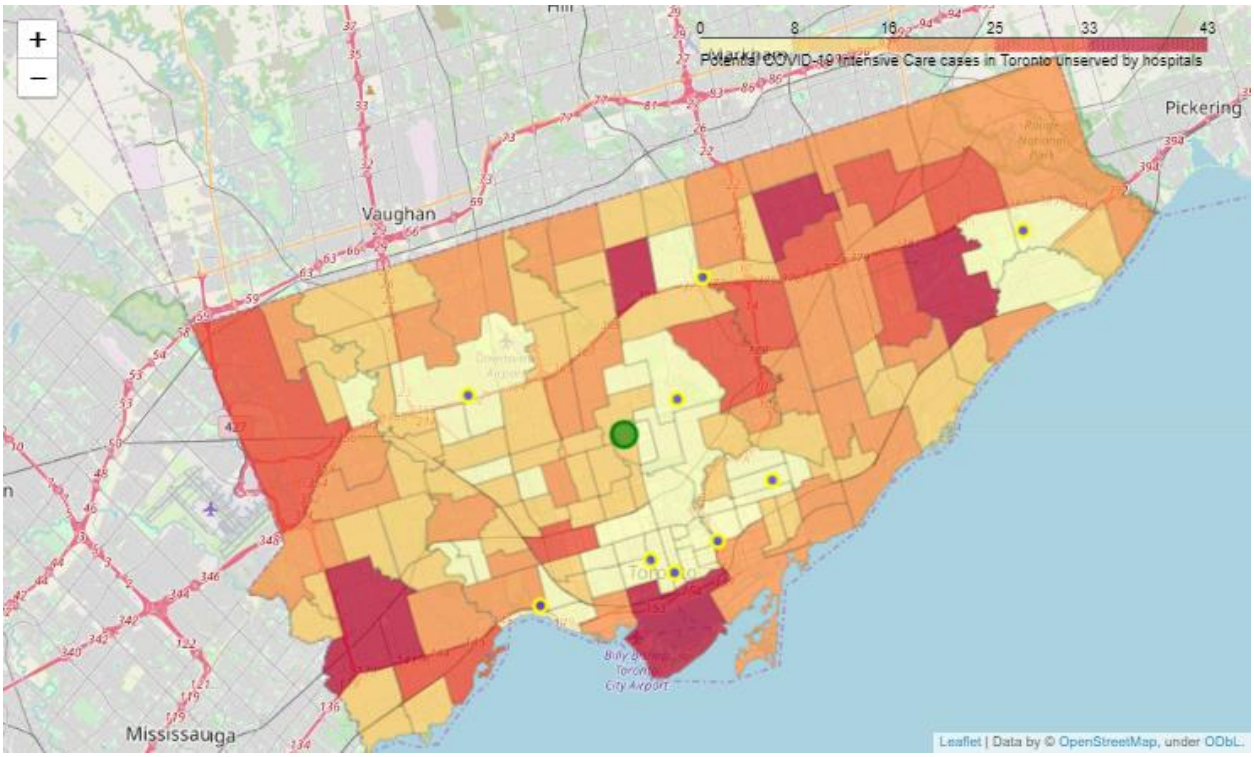

Figure 2: Location of Eglinton Park relative to distribution of potential COVID-19 intensive care cases in Toronto unserved by hospitals.

Discussion

The modeling has made significant simplifications made in the key assumptions that would warrant further investigation prior to implementation. Further exploring of these simplifications may affect the final recommendation that is given by this report.

The model assumes that the limiting factor to a patient finding treatment would be beds in the hospitals' respective intensive care units; this assumes that there would be adequate staffing of doctors, nurses, and other support staff such as cleaning staff with sufficient equipment available. As the pandemic wears on, the amount of staff available would decrease, whether from fatigue, infection, or lack of consumable protective equipment available. In the case of a long-drawn pandemic, the limiting factor may shift from the number of beds available in an intensive care unit to the number of staff able to treat the patients. This would make the beds in intensive care units the wrong metric to measure capacity for treating patients.

The model assumes that the need for capacity is static throughout the pandemic; in reality, the need at any instant would likely fluctuate based on patient outcomes; a space would be freed up at the resolution of a case either through death or recovery. This would lower the absolute number

of spaces needed. Similarly, there could be conditions other than COVID-19 that require intensive care, such as myocardial infarctions, asphyxiation, hemorrhaging, stroke, and many others. This would increase the capacity that is needed as not all can be used for treating COVID-19 patients.

The model concentrates the capacity of an entire hospital network into a single hospital; in reality, hospitals in a network may be more geographically dispersed, helping spread the geographical concentration of unmet cases. More data can help explore this relationship.

COVID-19 can spread rapidly through a population, and are not limited by the boundaries of neighbourhoods. Therefore, hospitals are likely to treat cases as they appear rather than by geographical proximity. The model could be improved by having cases pop up randomly by the population distribution; the resulting case distribution will likely be slightly more evenly spread out across neighbourhoods. The result is unlikely to change much; however it may be harder to identify pockets of untreated cases since the neighbourhoods with populations at higher risk will likely have cases pop up earlier, and thus be more likely to find treatment within the current hospitals' capacities.

It may be worth considering the construction of multiple smaller temporary hospitals that are closer to the clusters of untreated cases. This may be costlier to build but vastly reduces the amount of travel needed for patients to get to the temporary hospitals. From a public health perspective this idea would further reduce the chances of the disease transmission during the journey to the hospital when a patient may be most infectious.

Conclusion

A temporary hospital for treating COVID-19 patients requiring intensive care can be built in Eglinton Park. The park is large enough to accommodate a temporary hospital built in the style of Wuhan's Huoshenshan Hospital and Leishenshan Hospital large enough to treat all the projected COVID-19 patients in Toronto requiring intensive care. The location was chosen such that it minimizes the travel necessary for all the patients not served by Toronto's current hospital infrastructure to get to the site.

For next steps, the cost and timeline of building such a hospital could be investigated. There could be certain political ramifications, such as the loss of a major green space in the middle of the city, as well as the dissatisfaction of nearby residents who may not feel comfortable with a large influx of COVID-19 patients in the area. This would require extra effort in convincing them to overcome their NIMBYism.

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