Coursera Capstone Project

SELECTION OF A SITE FOR A TEMPORARY COVID-19 HOSPITAL IN LAGOS, NIGERIA

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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 18, 2020, COVID-19 is present within Lagos, Nigeria, and case counts, including severe cases, have been steadily rising. Hospitals in Lagos 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 Lagos 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 Lagos 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 Lagos' current hospital infrastructure. 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 Lagos 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

The following sources of data were used to perform analysis:

Demographic data of lagos various neighbourhoods was taken from Nigeria Open Data Portal https://nigeria.opendataforafrica.org/.

The COVID-19 Data for Nigeria was gotten from the Nigerian Centre for Disease Control Website (NCDC) Website.

The COVID-19 Data for Italy was gotten from City Population Online database. https://www.citypopulation.de/en/italy/covid/

Capacity of Lagos hospitals' intensive care units were sourced from Nigerian Health Data. Eligible sites for temporary hospitals would include unbuilt land in Lagos that is not expected to be used for erecting other buildings. Parks and Stadiums 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 structures already built on them. Location and size data for parks were taken from Lagos Open Data Portal - Parks.

To calculate the number and location of hypothetical severe cases of COVID-19 requiring hospitalization in Lagos:

Determine the demographics of Lagos's neighbourhoods. Multiply the demographics by the hypothetical rate of infection and rate of hospitalization requiring intensive care by age cohort. Map the hypothetical intensive care cases to their Lagos neighbourhoods. To determine current hospital capacity and locations:

Determine hospitals in Lagos with intensive case units. Search their coordinates using Foursquare. Map their location and capacity to neighbourhoods in Lagos. To evaluate potential sites for temporary COVID-19 hospital:

Map the parks of Lagos and determine their size. Determine the capacity of a hypothetical temporary hospital by interpolating or extrapolating from Huoshenshan Hospital and Leishenshan Hospital's footprints and bed capacities. Map the hypothetical hospitals to the neighbourhoods of Lagos To decide which site is most suitable:

Determine if there are any underserved neighbourhoods in Lagos based on distance from existing hospitals and capacities of those hospitals. Determine which hypothetical hospital can best alleviate the most underserved clusters. If there are sites large enough to accommodate all potential intensive care cases, determine the site that minimizes travel distance for these patients

Key Assumptions

For the purposes of modelling, the following assumptions about patients will be made:

1. 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.

2. Patients will appear all at once, and they will be served by hospitals according to their proximity to them.

3. The quality of care at all hospitals are the same, and patients will not enter or leave Lagos to seek treament.

4. Hospital networks will have their capacities concentrated on the first single hospital identified.

Data 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 Lagos 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 Lagos neighbourhood.

Hospitals in Lagos 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 Lagos' current hospital intensive care capacities were plotted to Lagos' neighbourhoods.

The size and locations of parks in Lagos 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, 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, Lagos is best situated to minimize the amount of travelling needed to be done by the remaining potential cases to get to the temporary hospital.

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 and Recommendation

A temporary hospital for treating COVID-19 patients requiring intensive care can be built in Lagos in the style of Wuhan's Huoshenshan Hospital and Leishenshan Hospital large enough to treat all of the projected COVID-19 patients in Lagos 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.