Income as a Determinant of the Speed of Transmission: Study of the Fifth Wave of SARS-CoV-2 in Toronto, Ontario

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Introduction

Since the first cases in 2019, the COVID-19 outbreak has taken the world by storm. As of writing this (April 2022), there are over five hundred million cases reported worldwide (World Health Organization 2022). With its rapid spreading and continued transmissibility around the globe, the pandemic has had profound consequences in every facet of public and private life. Among these include medical, economic and social spaces respectively (Baena-Díez et al. 2020). Most importantly, these unsettling times have shone a light on pre-existing disparities within national health systems. For many researchers, this does not come as a surprise as socioeconomic factors influencing health outcomes have been noted ubiquitously throughout the world (Khalatbari-Soltani et al. 2020). According to Khalatbari-Soltani et al. (2020), there is even a link between those socio-economically disadvantaged and increased risk of infectious disease.

This research continues in a vein of spatial statistical studies which analyze COVID-19 incidence rates paired with a socioeconomic factor. Building upon Khalatabari-Soltani, et al. (2020) and the socioeconomic position (SEP) framework, this study proposes a relationship with lower income levels and COVID-19 incidence rates. More specifically, the overarching objective of this study is to analyze the relationship between low-income populations and incidence rates of COVID-19 during the fifth wave in all of Toronto's 140 neighbourhoods. The geographies of neighbourhoods were chosen for this study, as opposed to wards or dissemination blocks, not only to showcase acute changes within populations, but for this measure's longevity of statistical reporting (City of Toronto 2017).

Background

A person's income level affects how they go about their everyday lives. The associated behavioural pattern has been linked to change in health outcomes. Low income for example affects housing condition and leads to more tight housing arrangements. Such factors have been associated in the increased risk of infections for pathogens such as tuberculosis (Khalatbari-Soltani et al. 2020).

In Ontario, from January 21 to June 30, 2022, the most attributed workplace was manufacturing (Murti et al. 2021). Manufacturing accounted for 45% of outbreaks which totaled 65% of outbreak cases. Another notable sector was Transport and Warehousing (11% of outbreaks, 8% of outbreak cases). In Toronto, it has been observed the COVID-19 first infiltrate in high income communities before quickly spreading to lower income communities (Mishra et al. 2022). According to Mishra et al. (2022) lower income neighbourhoods were also defined by their higher dwelling densities and greater proportion of occupation that could not make the remote transition.

The first case of COVID-19 in Ontario (and Canada) was reported on January 25, 2020 (Nielsen 2020). As the virus began to spread, Ontario entered its first wave of covid-19 on February 26, 2020. The first wave of COVID-19 lasted 188 days, ending on August 31, 2020 (Public Health Ontario 2021). As Ontario began loosening restrictions as part of its 3-stage reopening plan, people started getting together again, and cases began to rise. Ontario's second wave began September 2020 and ended in February 2021, with cases peaking in January 2021 (Public Health Ontario 2021). The third wave in Ontario was driven by the Alpha (B.1.1.7) variant, which was more transmissible (Detsky and Bogoch 2021) The third wave lasted from March to July 2021, and was the largest wave yet, with the peak number of new cases in a day in Ontario being 5067 (Public Health Ontario 2022). The emergence of the Delta variant (B.1.617.2) caused a smaller and shorter fourth wave in Ontario that lasted from August to October 2021. The largest number of new cases reported in a day in Ontario during the fourth wave was 878.

The fifth wave of the pandemic lasted from the beginning of December 2021 till mid-February 2022. The catalyst for this was the emergence of a new, highly transmissible variant called Omicron. The variant, which was first reported globally in November 2021, has been thoroughly researched due to its scale and rate of infection. This research suggests that the variant is highly transmissible due to several factors. This includes the fact that Omicron is more likely to evade immunity from a previous infection, meaning that there is a high chance that you can get re-infected with COVID-19 (Pulliam et al. 2021). This is an alarming number which is also supported by other research suggesting that the variant is up to 3.7% more infectious among vaccinated citizens than its predecessors (Mohsin and Mahmud 2022). In the period it was active, it became the dominant strain and was responsible for 95% infections globally. In Ontario, the first Omicron cases were reported on November 28, 2021 (Government of Ontario 2021). During the Omicron wave, the highest number of cases for a single day in the province were 19,373 (Public Health Ontario 2022). This study will look at this period of Omicron specifically in the City of Toronto. The city is the densest urban core in the province and is one of the most densely populated regions in North America. This has made it a large target of COVID-19 with the city dealing with its consequences since the pandemic began. In fact, till date there have been more than 300,000 reported cases with more than 4000 deaths (City of Toronto 2021).

Study area

Income and change in COVID-19 incident was examined at the neighbourhood level for the City of Toronto (See Figure 1). Toronto was specifically selected because of the availability of both COVID-19 and income at such a fine spatial scale. In total there are 140 unique areas. The large number neighbourhoods enable this study to capture a diverse levels of wealth accross the city. There were created by City of Toronto to help government and other planning oganizations with obtaining socio-economic data. The boundaries are based around the Canadian Census Tracks. Each niehgbourhood may contain between two to five census tracts. (City of Toronto 2017)

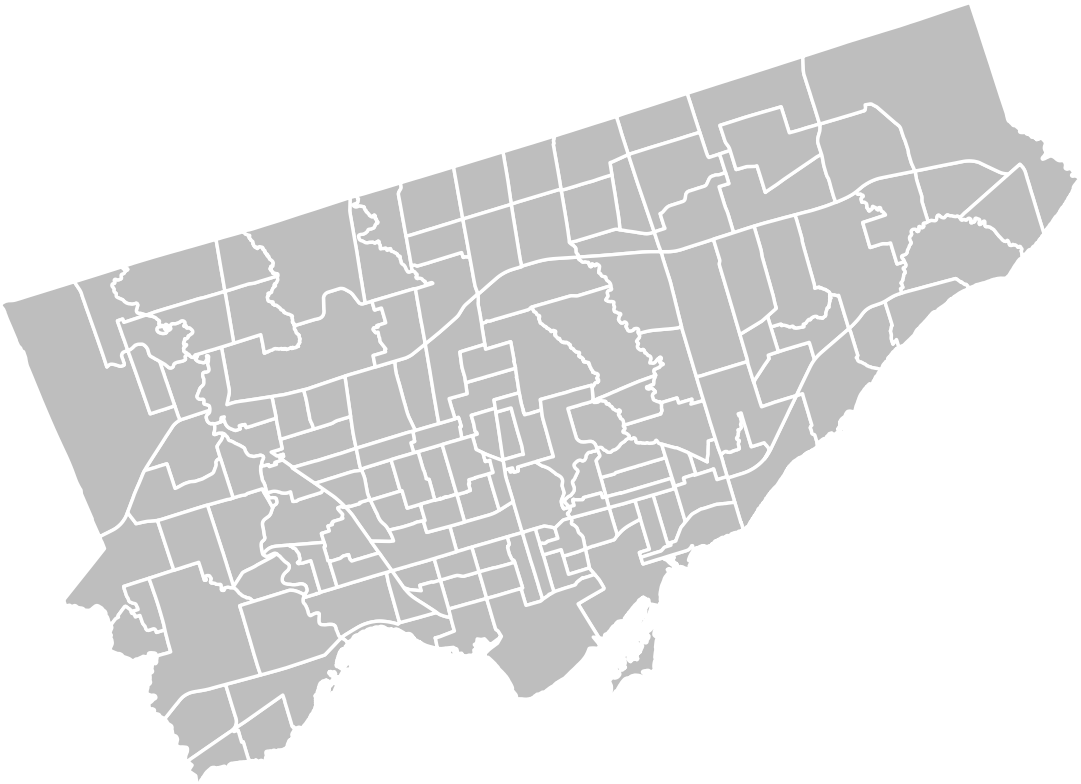

Figure 1: Neighbourhoods in Toronto, Ontario, Canada

Data

The COVID-19 data was retreived from the City of Torontro Open Data portal (Toronto Public Health 2022). The data was downloaded as a comma-seperated values (CSV) file. This data is updated weekly by the city and reports each individual case as a record. For this study the time period of interest is through December 2021, corresponding to the fifth wave of the pandemic in Ontario. The cases from the first week of December 2021 (Dec. 1 - Dec. 7) and the last week (Dec. 25 - Dec. 31) were filtered out and aggregated by neighbourhood. The income data used in this study were also retrieved from Toronto Open Data and come from a neihgbourhood profile which contains an assortment of other socio-economic variables (Toronto Social Development, Finance & Administration 2011).

Methods

This study used RStudio to conduct both the data pre-processing, that is cleaning of the original datasets as well as the analysis. The data pre-processing file can be found here: https://github.com/lamj54/4GA3-Project/blob/main/Data%20Pre-Processing.Rmd

The analysis was done using several packages, including spatstat, tidyverse, ggplot2, dplyr, webshot, gridExtra, patchwork, and spdep.

This document was also written and exported through R-Markdown file with the minimally adapted Steven V. Miller template for academic manuscripts. See: http://svmiller.com/blog/2016/02/svm-r-markdown-manuscript/https://github.com/svmiller/svm-r-markdown-templates/blob/master/svm-latex-ms.tex

Results

Analysis

Conclusion

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