An examination of the accessibility implications of a pilot COVID-19 vaccination program in Hamilton, Ontario

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Abstract

The province of Ontario in Canada announced the pilot for a new vaccination program, with designated pharmacies across the province now able to offer COVID-19 vaccines. The accessibility of this program raises questions about the cost of travel and the distribution of the cost among the population. In our examination of the City of Hamilton we find that selected sites do not serve well the rural and urban population of Hamilton, and that the associated cost of travel is expected to be disproportionally borne by lower income populations. Modest additions to the list of pilot sites in the city can substantially alleviate this inequity.

Research Questions and Hypotheses

Along with the provision of health care facilities to treat severe cases of COVID-19 (Pereira, C. K. V. S. Braga, et al., 2021), another front in the fight against the pandemic is the rolling out of vaccination programs. The Province of Ontario, in Canada, announced on April 1st 2021 the expansion of a pilot program to offer vaccines in pharmacies in the City of Hamilton[1]. This program is in addition to dedicated vaccination centers for people aged 70+. Twenty pharmacies in Hamilton were added to an earlier list of 325 locations in other cities across the province, and the program was extended to people aged 55 years old and over.

Critics were swift to point out that the list of pharmacies approved for Hamilton by the province were mostly located in lower density parts of the city that are not well serviced by transit and are difficult to reach by foot[2]. Indeed, as seen in Figure 1, a vast majority of the pharmacies are in suburban Hamilton. The issue is somewhat less clear-cut when we consider that Hamilton's population skews suburban (see Figure 2). Given the target demographic for the program, it is possible that suburban sites could be convenient for mature adults and young old: the population aged 55 to 69 in Hamilton is approximately 58,710 suburban, 35,490 urban, and only 8,360 rural. Nevertheless, the selection of sites by the province raises some important questions[3]. As Yu et al. (2021) note, good geographical coverage is a key element for a successful vaccination campaign; at the same time, siting vaccinations sites in car-oriented locations may introduce inequities in access.

In this research, we investigate the accessibility implications of the sites selected for the pilot vaccination program. Concretely, we ask:

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[1]https://www.cbc.ca/news/canada/hamilton/astrazeneca-vaccine-hamilton-1.5972704

[2]See inter alia: https://twitter.com/RyanMcGreal/status/1378027149790224386?s=20 and https://twitter.com/NrinderWard3/status/1378679195514060801?s=20.

[3]The decision-making process to select these sites appears to have been opaque, and the typically inert Major of the city was caught flat footed by the announcement; see: https://twitter.com/FredEisenberger/status/1378350123114242053?s=20

- What is the estimated cost of travel to reach the vaccination sites, assuming that every person requires a vaccine?
- What is the distribution of this cost across the population of the city?
- How does the cost and its distribution change with the addition of candidate sites in urban Hamilton?

We concentrate on the 55 to 69 years old population segment because the older 70+ group have access to other dedicated facilities besides those in the provincial pilot.

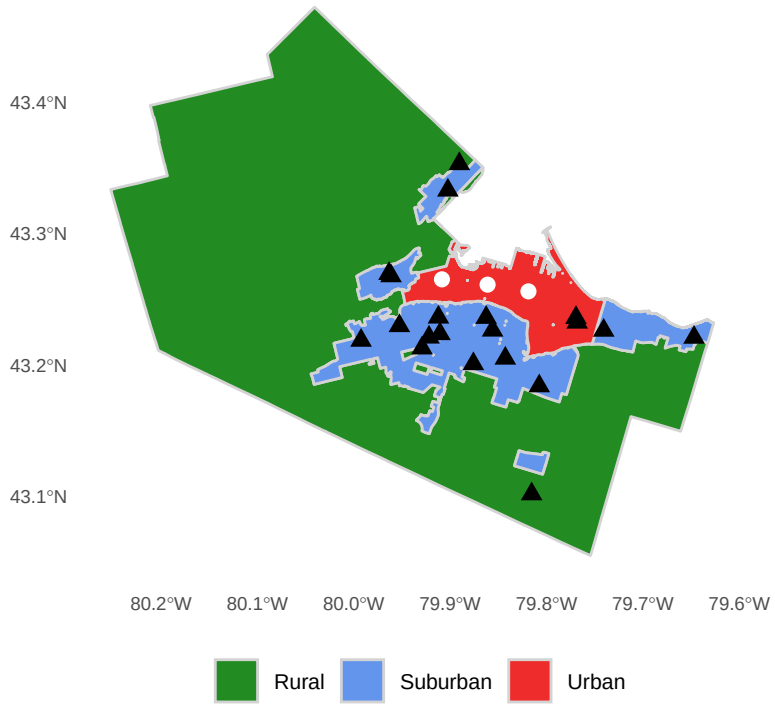

Figure 1: Regions with the City of Hamilton; the location of pharmacies in pilot is shown (black triangles) and urban locations for scenario analysis (white circles)

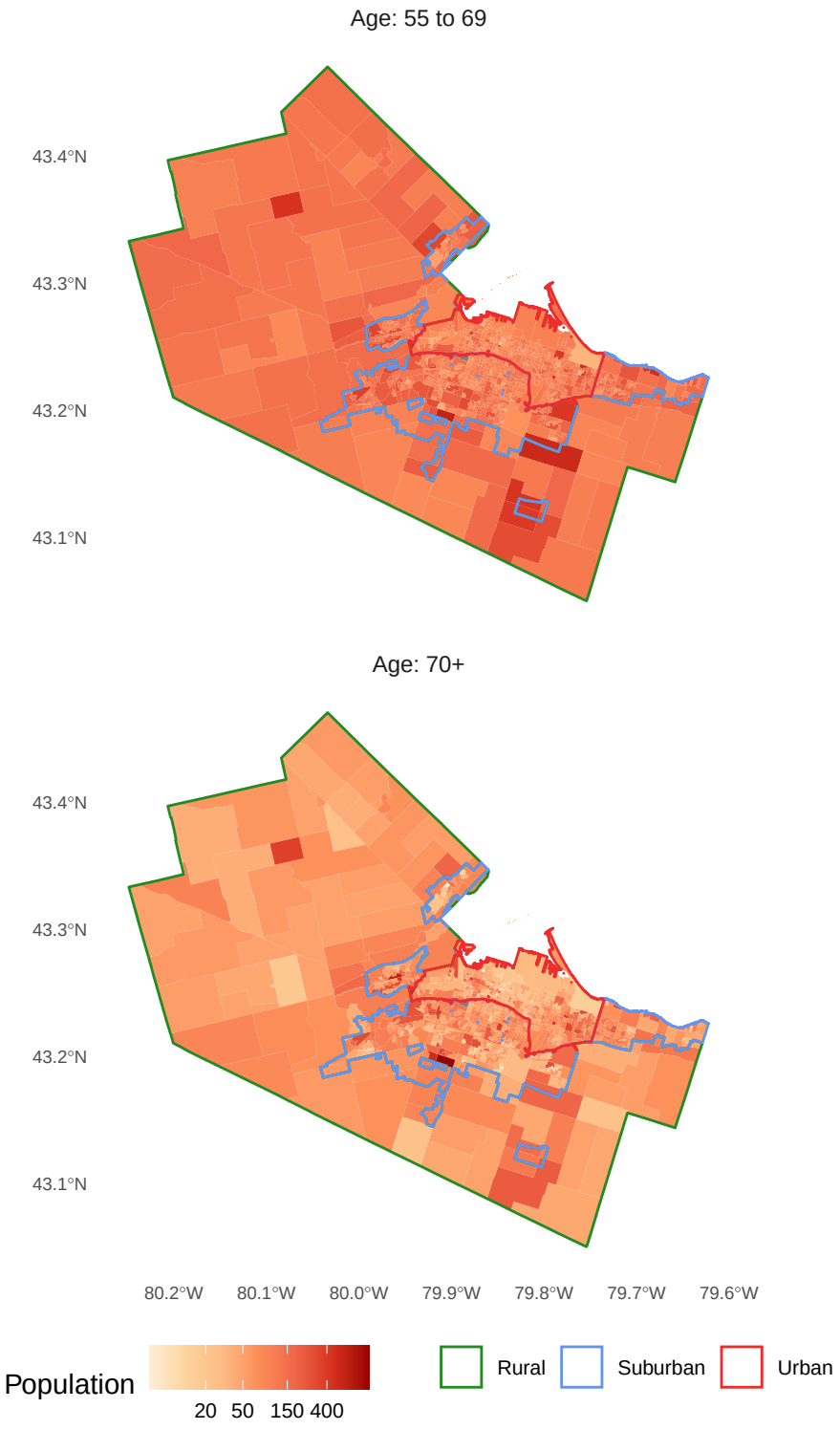

Figure 2: Distribution of population age 55+ in the City of Hamilton

Methods and Data

Data

We use data from the following sources.

Open Hamilton

From the open data portal of the City of Hamilton[4] we obtained boundaries for the city's various regions (the definition of urban, suburban, and rural regions follows the classification of development applications).

Statistics Canada

Population and income statistics at the level of Dissemination Areas (DAs) were retrieved using the package `cancensus` (von Bergmann et al., 2021). Dissemination Areas are the smallest publicly available census geography in Canada. We use data from the 2016 Population Census.

Transportation Tomorrow Survey

Data about modal split by age by place of residence were downloaded from the Data Retrieval System of the Transportation Tomorrow Survey (TTS)[5]. The data are geocoded at the level of Traffic Analysis Zones (TAZ).

Other

The locations of pharmacies in the pilot were obtained from public records and geocoded. Three urban sites not in the program were also identified and geocoded for comparison purposes. In addition, we converted all recorded residential parcels in the City of Hamilton to points on the road network. Each point includes information about the number of residential units in the parcel.

Methods

We used the population aged 55 to 59 y.o. in each Dissemination Area to calculate the average number of people per dwelling. This value was then assigned proportionally to the number of dwellings per parcel. The median total household income of the corresponding DAs was joined to the parcels. In addition, we calculated the proportion of trips by mode from the total number of trips by each of the three modes retrieved from the TTS data. These proportions were joined to the parcel data based on their corresponding TAZ. The package `r5r` (Pereira, Saraiva, et al., 2021) was used to calculate the travel time from each parcel to all pharmacies by three modes: car, transit, and walking. For routing purposes we used a cutoff value of 180 min and a maximum walking distance of 10,000 m.

Once we obtained travel time tables with population, proportion of trips by mode, and income information, we calculated the expected travel time *ett* from each parcel i to a pharmacy j as follows:

$$ett_i = p_i^c \min(tt_{ij}^c) + p_i^t \min(tt_{ij}^t) + p_i^w \min(tt_{ij}^w)$$

where p_i^k is the proportion of trips by mode k in the TAZ of parcel i, and tt_{ij}^k is the vector of travel times from parcel i to the pharmacies. In other words, the expected travel time is the weighted sum of travel times to the nearest pharmacy, with the weights given by the expected modal split in the TAZ.

[4] https://open.hamilton.ca/
[5] http://dmg.utoronto.ca/

The expected travel time i was multiplied by the population in parcel i to obtain a measure of person-hours of travel (PHT) as follows:

$$PHT_i = P_i \cdot ett_i$$

Please note that this paper is a reproducible research document (see Brunsdon and Comber, 2020) conducted using open source tools for transportation analysis (Lovelace, 2021). The code and data necessary to reproduce the analysis are available in a public repository[6].

Findings

The top panel of Figure 3 shows the average expected travel time by TAZ in Hamilton. It is apparent that travel times tend to be lower in much of suburban Hamilton, and higher in the urban core and some rural parts of the city, particularly to the west. This is unsurprising, given the higher probability of travel by car and the predominantly suburban character of the vaccination sites. However, even accounting for the distribution of population, this leads to large disparities in the number of person-hours of travel across the city, with a concentration of the burden of travel in the urban core and the rural west (see bottom panel of Figure 3).

The disparities are not trivial.

As seen in Table 1, under the pilot program approximately 36.42% of people live in DAs in the bottom 40% of the median household income scale, but they account for 51.98% of the total person-hours of travel. In contrast, 44.5% of people aged 55 to 69 in DAs in the top 40% of the median household income scale accrue only 35.03% of the total person-hours of travel. Where the mean travel time of residents of DAs with high median household income is 6 minutes, residents of lower income DAs average 12 minutes in travel time. In addition to longer average travel time, residents in lower income DAs also see substantially larger variations in travel times, and some may face considerably longer travel times (see top-left panel in Figure 4).

There are also important disparities by region. As shown in Table 1, the urban and rural populations in Hamilton are approximately 42.75% of the population but they bear 69.25% of the total person-hours of travel, with also much greater variability in expected travel times (Figure 4, bottom-left panel).

For comparison purposes we consider a scenario with some modest additions to the list of pharmacies in the provincial pilot. We repeat the analysis, but include the three urban sites shown in white circles in Figure 1. The results of this scenario appear in the last two columns of Table 1 and the two right panels of Figure 4. We begin by noting that all income groups benefit from the addition of these three sites with shorter mean trip durations; the most remarkable difference is the large reduction in the disparities between residents in DAs with different levels of income. The top-right panel of Figure 4 shows that the distribution of expected travel time is now more in line for all income groups, even if the bottom two income quintiles still have somewhat wider spreads. With respect to the distribution of expected travel time and person-hours of travel by region, unsurprisingly the addition of three urban vaccination sites in the scenario makes a difference for urban residents but not for rural residents.

The results indicate that the locations chosen by the province for the pilot vaccination program do not serve well urban or rural residents of the city, and there are some important questions regarding equity of access to the program, with a disproportionate burden in the cost of travel falling on lower income urban populations and rural populations. A scenario did not consider candidate sites in a systematic way. Nonetheless, selection of three sensible urban locations does much to alleviate disparities in the burden of transportation. On the other hand, unlike the urban context where there are numerous candidate locations that could be chosen for a vaccination program, there are not many

[6] https://github.com/paezha/Accessibility-Pharmacies-Hamilton-Vaccines

candidate locations in rural regions of the city. Increasing access in rural Hamilton likely will involve an expansion of existing mobile vaccination pop-up clinics[7].

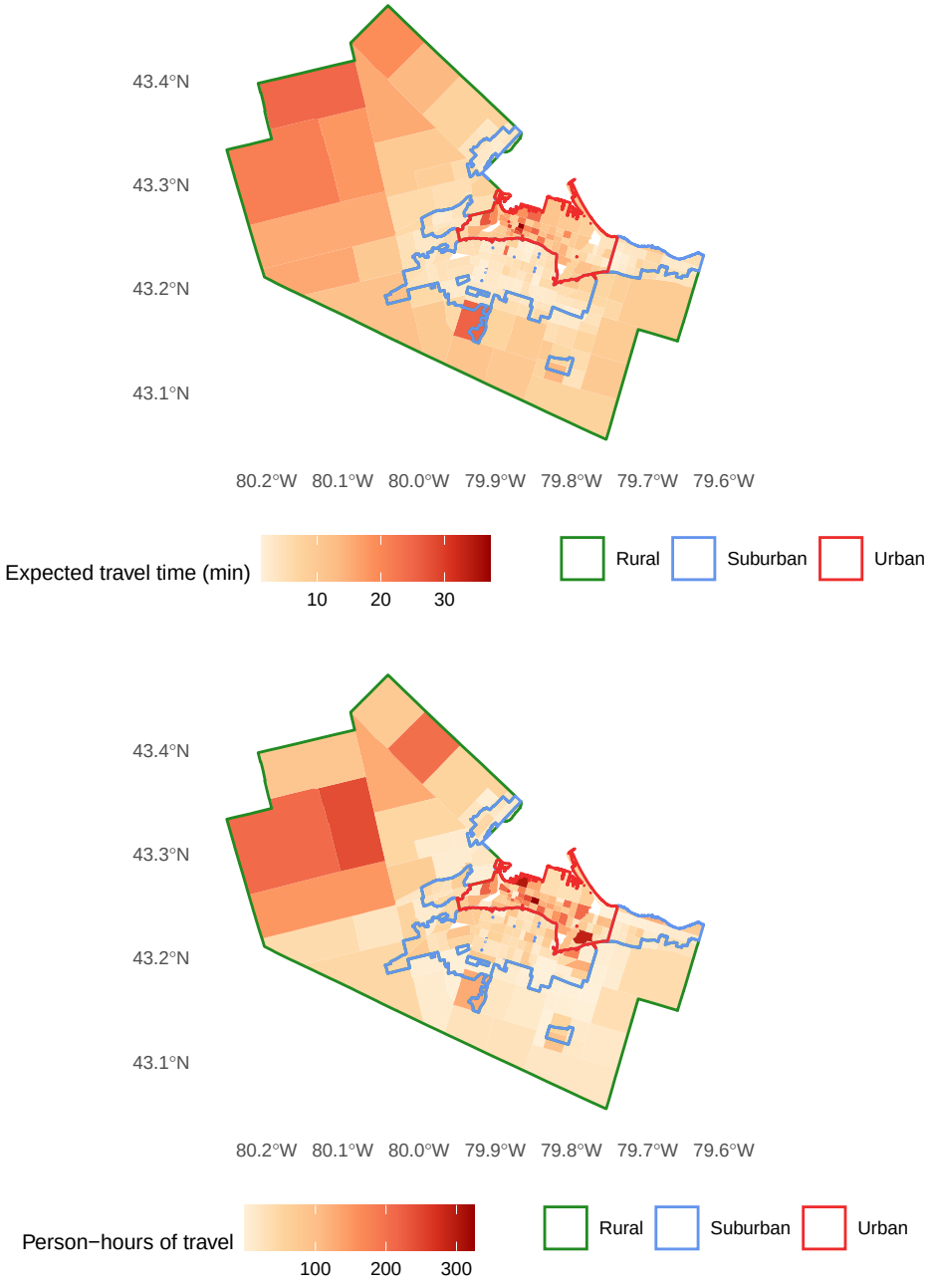

Figure 3: Average expected travel time by TAZ (in minutes) and total person-hours of travel by TAZ.

[7]https://www.hamilton.ca/government-information/news-centre/news-releases/hamiltons-covid-19-vaccination-program-expansion-1

Table 1: Distribution of person-hours of travel (PHT) by median total household income and region: pilot locations only, and scenario with three urban locations added

		Pilot Program		Scenario	
Group	Population	Total PHT	Hours per person	Total PHT	Hours per person
Income Quintile					
Top 20%	23297.315	2243.857	0.096	2146.558	0.092
Second 20%	22356.413	2471.952	0.111	2351.858	0.105
Third 20%	19570.061	1749.497	0.089	1563.978	0.080
Fourth 20%	17729.139	2928.959	0.165	1950.312	0.110
Bottom 20%	19629.952	4068.548	0.207	2388.422	0.122
Region					
Rural	8356.963	1730.268	0.207	1730.242	0.207
Suburban	58711.629	4138.482	0.070	4138.392	0.070
Urban	35491.942	7588.590	0.214	4527.021	0.128

Note:

The population totals differ due to small differences in the classification of the regions

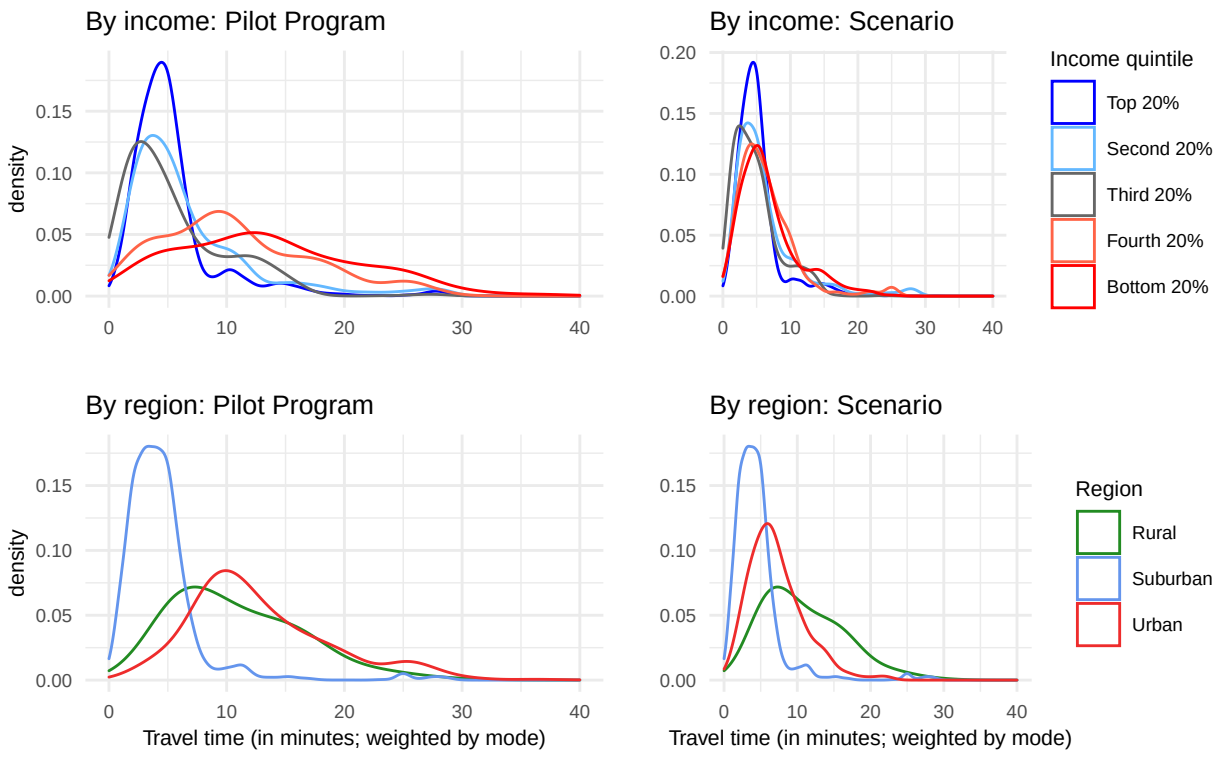

Figure 4: Distribution of expected travel time for different population groups

References

Brunsdon, C., Comber, A., 2020. Opening practice: Supporting reproducibility and critical spatial data science. Journal of Geographical Systems 1–20. doi:10.1007/s10109-020-00334-2

Lovelace, R., 2021. Open source tools for geographic analysis in transport planning. Journal of Geographical Systems. doi:10.1007/s10109-020-00342-2

Pereira, R.H.M., Braga, C.K.V.S., Mendes and Serra, L., Amaral, P.B., Gouveia, N., Paez, A., 2021. Geographic access to covid-19 healthcare in brazil using a balanced float catchment area approach. Social Science & Medicine 273, 113773. doi:https://doi.org/10.1016/j.socscimed.2021.113773

Pereira, R.H.M., Saraiva, M., Herszenhut, D., Braga, C.K.V., Conway, M.W., 2021. R5r: Rapid realistic routing on multimodal transport networks with r^5 in r. Findings. doi:10.32866/001c.21262

von Bergmann, J., Shkolnik, D., Jacobs, A., 2021. Cancensus: R package to access, retrieve, and work with canadian census data and geography.

Yu, J.H., Jeong, H.J., Kim, S.J., Lee, J.Y., Choe, Y.J., Choi, E.H., Cho, E.H., 2021. Sustained vaccination coverage during the coronavirus disease 2019 epidemic in the republic of korea. Vaccines 9, 8. doi:10.3390/vaccines9010002