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

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**Abstract**

The Government 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 rural and urban residents 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.

## Questions

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 Government 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 less clear-cut when we consider that Hamilton's older 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 the 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 lead to inequities in access.

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

- What is the estimated cost of travel to reach the vaccination sites, assuming that every person requires a vaccine?

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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 Mayor of the city was caught flat footed by the announcement; see: https://twitter.com/FredEisenberger/status/1378350123114242053?s=20

- 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.

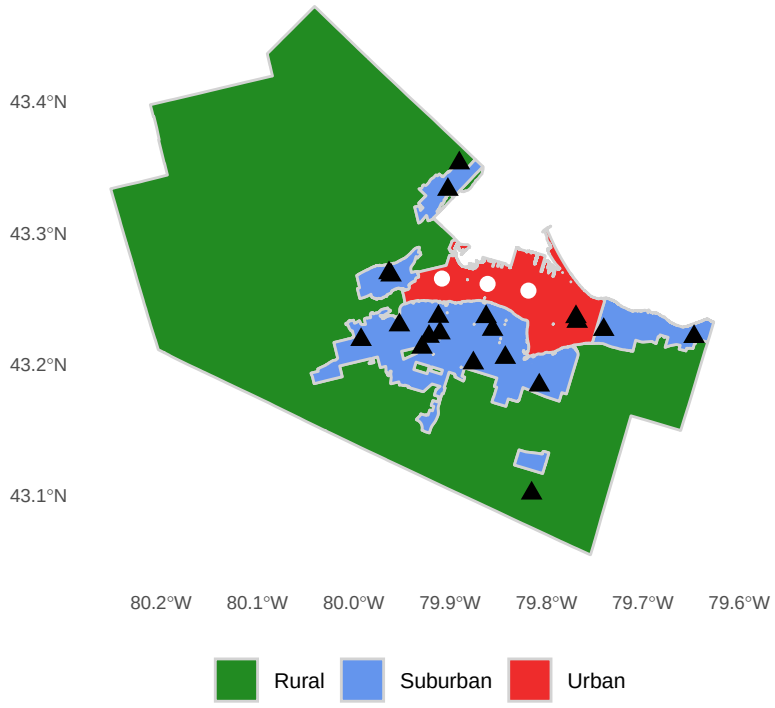


Figure 1: Regions with the City of Hamilton; the location of pharmacies in pilot is shown (black triangles) along with urban locations for scenario analysis (white circles).

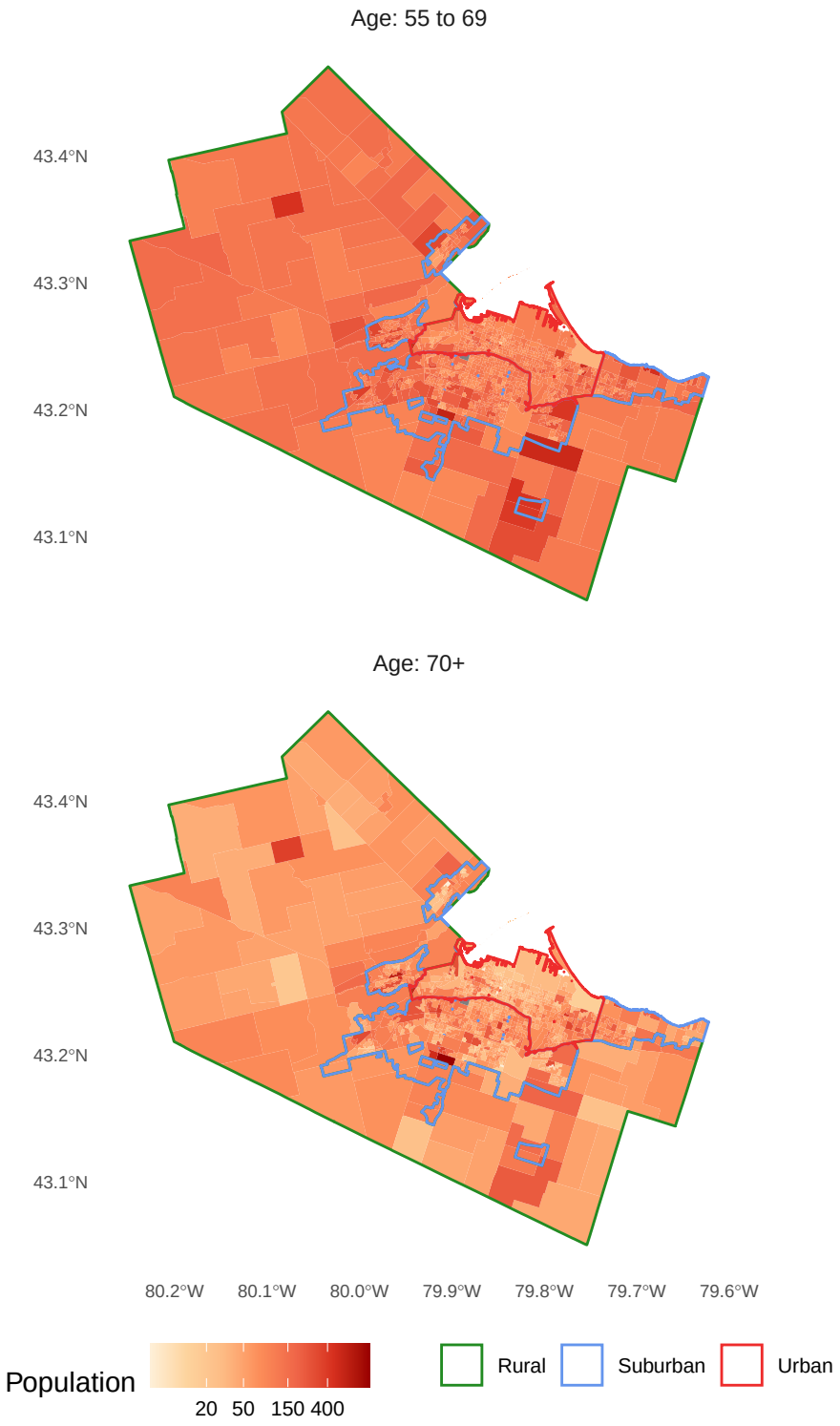


Figure 2: Distribution of population aged 55+ in the City of Hamilton.

## Methods

We use data from the following sources.

- Urban, suburban, and rural boundary definitions from the City of Hamilton[4]
- Population and median total household income for 2016 by Dissemination Area (DA) boundary using the `cancensus` package (von Bergmann et al., 2021)
- Modal split by age for traffic analysis zones (TAZ) from the 2016 Transportation Tomorrow Survey (TTS)[5]
- Locations of pilot pharmacies from public records
- Locations of three additional major chain pharmacies for scenario testing
- Residential units by land parcel

Using the population aged 55 to 59 y.o. we first calculate the average number of people per dwelling and assign them proportionally to the dwellings by parcel. Second, median incomes and modal splits across walking, transit, and car are joined to the parcels. Although our data are from 2016 (the most recent available), we assume they are largely representative of current spatial and demographic trends in the city. Third, we use the `r5r` (Pereira, Saraiva, et al., 2021) package to calculate the travel time from each parcel to all pharmacies by three modes using 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. The expected travel time is thus the weighted sum of travel times to the nearest pharmacy, with the weights given by the expected modal split in the TAZ.

The expected travel time $i$ was multiplied by the assigned 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 use-weighted multi-modal travel times 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.

[4] https://open.hamilton.ca/
[5] http://dmg.utoronto.ca/
[6] https://github.com/paezha/Accessibility-Pharmacies-Hamilton-Vaccines

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. While 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 lower 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. Unsurprisingly, the addition of three urban vaccination sites does not have a large impact 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. Selection of three sensible urban locations does much to alleviate disparities in the burden of transportation. On the other hand, because there are not many candidate locations in rural parts of the city, increasing access for residents there likely necessitates an expansion of the existing mobile vaccination pop-up clinic program[7].

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

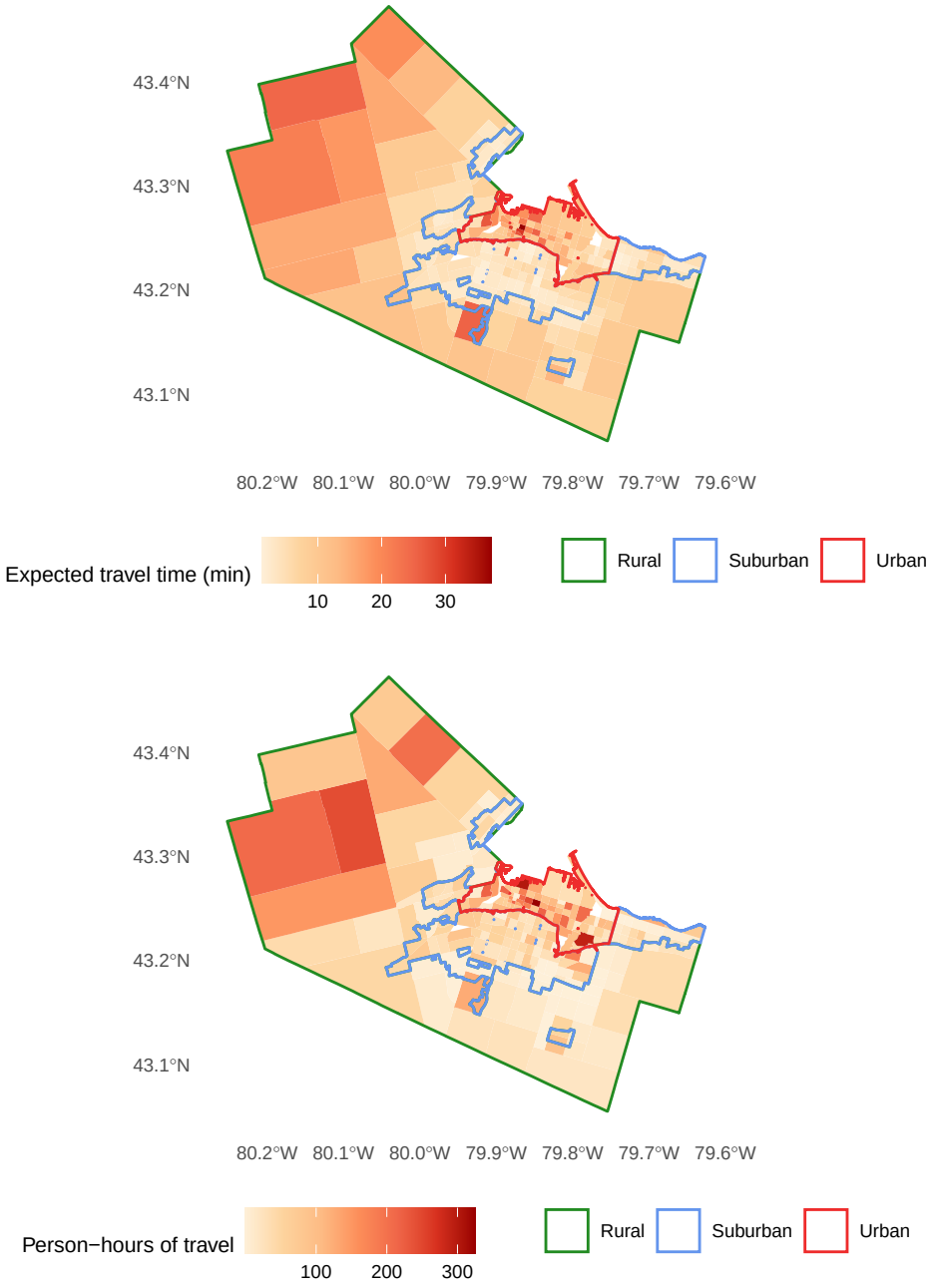


Figure 3: Average expected travel time by TAZ (in minutes) and total person-hours of travel by TAZ.

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

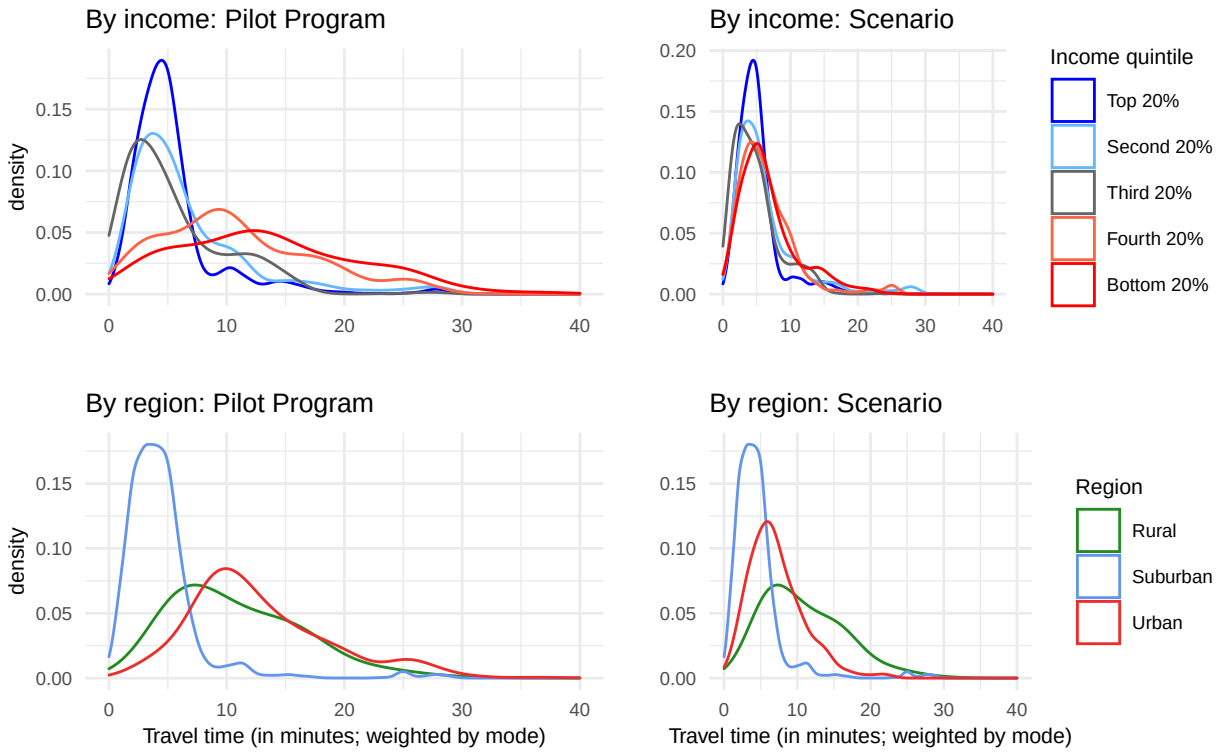


Figure 4: Distribution of expected travel time for different population groups.

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