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DEMOCRATIC ACCESS TO OUR CITIES: THE IMPACTS OF RECENT CHANGES TO TRANSIT SERVICES IN MAJOR CANADIAN METROPOLITAN AREAS

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ABSTRACT

In recent decades, transit ridership plateaued in Canadian cities, and the COVID-19 pandemic further altered public transit patterns. Understanding how changes in transit services affect democratic access to essential amenities is the first step in building a transportation system that enables access for all. This paper reports changes in public transit service in Canada's 12 largest census metro areas (CMAs) from 2019 to 2023. We assess transit accessibility to jobs and groceries and show spatial changes and changes by income level. The resulting changes in accessibility were not uniform across metropolitan areas. Some remained largely unchanged, while others had greater accessibility in 2023. Toronto, Montreal, and Vancouver experienced greater losses in public transit accessibility, while areas in urban peripheries tended to see gains. Lower-income households were disproportionately affected by reduced accessibility. Differences between metropolitan regions point to the importance of municipal policy.

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INTRODUCTION

Transportation accessibility can be defined as the potential offered by a transportation system to reach destinations.[1] In particular, public transportation plays an essential role in creating more inclusive and sustainable transportation systems: it is a collective form of transportation that can be for all people but is especially important for those who cannot use or afford private vehicles. In this way, public transit is valuable not only economically, but also in contributing to democratized access to the city and its essential services.[2]

The question of who benefits from public transit is a matter of equity. Recent applications of theories of justice to the domain of transportation have identified accessibility as the main benefit of transportation systems, as opposed to simply the ease of movement for vehicles.[3] An equitable and just transportation system provides accessibility to all individuals regardless of their socio-economic characteristics. And public transit that serves different groups without large inequalities of access between them makes cities more democratic.

While transit ridership has generally been strong in Canadian cities in the 21st century, there have been substantial recent changes. Some authors have suggested that ridership was already levelling off or declining in the pre-pandemic period, and the restrictions and changing work arrangements associated with COVID-19 contributed to further decline in service levels and ridership.[4] While other modes of transportation have regained their pre-pandemic levels, as of February 2024 transit revenue in Canada is 9.34% below the pre-2020 peak, and ridership is 19.39% below the peak.[5] Current trends suggest that ridership and revenue have been diverging since the pandemic (Figure 1) – a concerning development, because ridership losses paired with fare increases and service decreases may result in a vicious cycle known as the "transit death spiral."[6]

Avoiding such a death spiral is important, as an underfunded and underdeveloped transit system can deepen automobile dependency and exacerbate unequal access to opportunities. A reduction in service levels could also be detrimental to Canada's aspirations as an inclusive society, as transit is essential in enabling people to fulfill their basic needs and access other services. The changes in public transit following pandemic restrictions exemplify the gap between the infrastructure available to Canadians in basic areas such as transportation and the needs of a modern, equitable society. Crucially, our equity needs are also tied to the country's sustainability goals.

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[1] Páez, Scott, and Morency, "Measuring Accessibility."

[2] Nazari Adli and Donovan, "Right to the City."

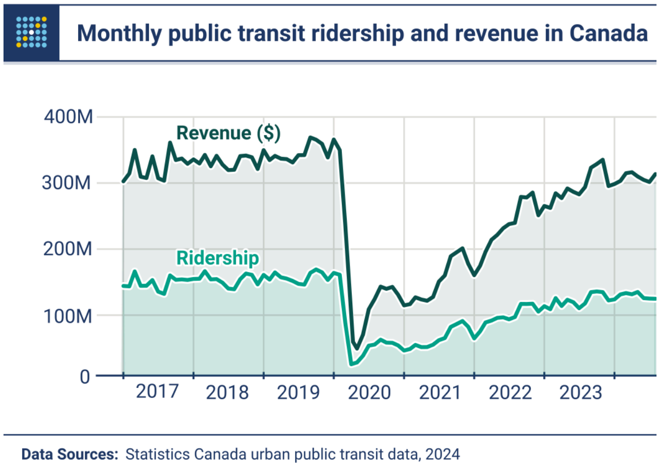
[3] Pereira, Schwanen, and Banister, "Distributive Justice and Equity in Transportation."

[4] Diab et al., "Rise and Fall of Transit Ridership Across Canada"; Harris and Branion-Calles, "Changes in Commute Mode Attributed to COVID-19 Risk."

[5] Negm and El-Geneidy, "Exploring the Changes"; Statistics Canada, "Urban Public Transit."

[6] Redelmeier and El-Geneidy, "If You Cut It Will They Ride?"

Figure 1. Transit revenue and ridership in Canada, pre- and post- first-wave COVID-19 pandemic



Within this context, in this chapter we examine how transit accessibility has changed since the pandemic, and who was affected. Specifically, we compare changes in transit accessibility levels for weekday morning access to employment and weekend afternoon access to grocery stores across 12 large census metropolitan areas (CMAs) in Canada. We find that accessibility levels are on average comparable to those prior to the pandemic, but that in several cases accessibility changed in uneven ways across income groups, especially with regard to employment.

DATA AND METHODS

The study areas for this work were the 12 largest urban regions across Canada based on 2021 population counts (Table 1). These include the 12 largest CMAs as well as Oshawa, Ontario, and Abbotsford-Mission, British Columbia. (The former is included as part of the larger Greater Toronto Area study region because of its proximity; the latter is included as part of the Vancouver study region as it is home to a transit station on the region's West Coast Express commuter rail line.)

Table 1. Census metropolitan areas (CMAs) by population and transit modes

Size rank	CMA name	Province	Population (2021)
1	Toronto	Ontario	6,202,225
2	Montreal	Quebec	4,291,732
3	Vancouver	British Columbia	2,642,825
4	Ottawa-Gatineau	Ontario and Quebec	1,488,307
5	Calgary	Alberta	1,481,806
6	Edmonton	Alberta	1,418,118
7	Quebec City	Quebec	839,311
8	Winnipeg	Manitoba	834,678
9	Hamilton	Ontario	785,184
10	Kitchener-Cambridge-Waterloo	Ontario	575,847
11	London	Ontario	543,551
12	Halifax	Nova Scotia	465,703
15	Oshawa	Ontario	415,311
23	Abbotsford-Mission	British Columbia	195,726

Conventionally, accessibility is calculated as a measure of the number of reachable destinations from a given origin given the cost of reaching them using the transportation network.

We estimate accessibility for two types of destinations: jobs and grocery stores. Our aim was to isolate the changes in accessibility between 2019 and 2023, so we used the same origin locations, destination locations, and opportunity weights for both years.

To calculate public transit travel times, we used the {r5r} R package.[7] We collected the General Transit Feed Specification (GTFS) transit schedule files and street networks from OpenStreetMap for the 12 analysis regions for both time periods. For each amenity type, we chose a likely travel time and day of the week: for grocery stores, we selected a departure date time on a weekend afternoon;[8] for employment, we ran the analysis on a typical weekday morning rush-hour commute.[9] In both cases, we assumed that walking was the mode of travel from origin to transit stop and from transit stop to destination.

Finally, we assigned travel weights to each destination's travel time according to the distance to each origin. This meant that opportunities located closer to an origin had greater travel weights, while those farther away had smaller travel weights.

We used different weight (travel decay) functions according to the opportunity types, following the literature.

By keeping the origins, destinations, and weighting functions constant over time, we aimed to isolate how changes in transit service and travel times, taken together, affected accessibility between 2019 and 2023 in each dissemination area (DA) from the 12 cities. We base the analysis in the next section on the relative percentage change in accessibility from 2019 to 2023.

(See the Appendix for more details on the data and methods.)

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[7] Pereira et al., "R5r."

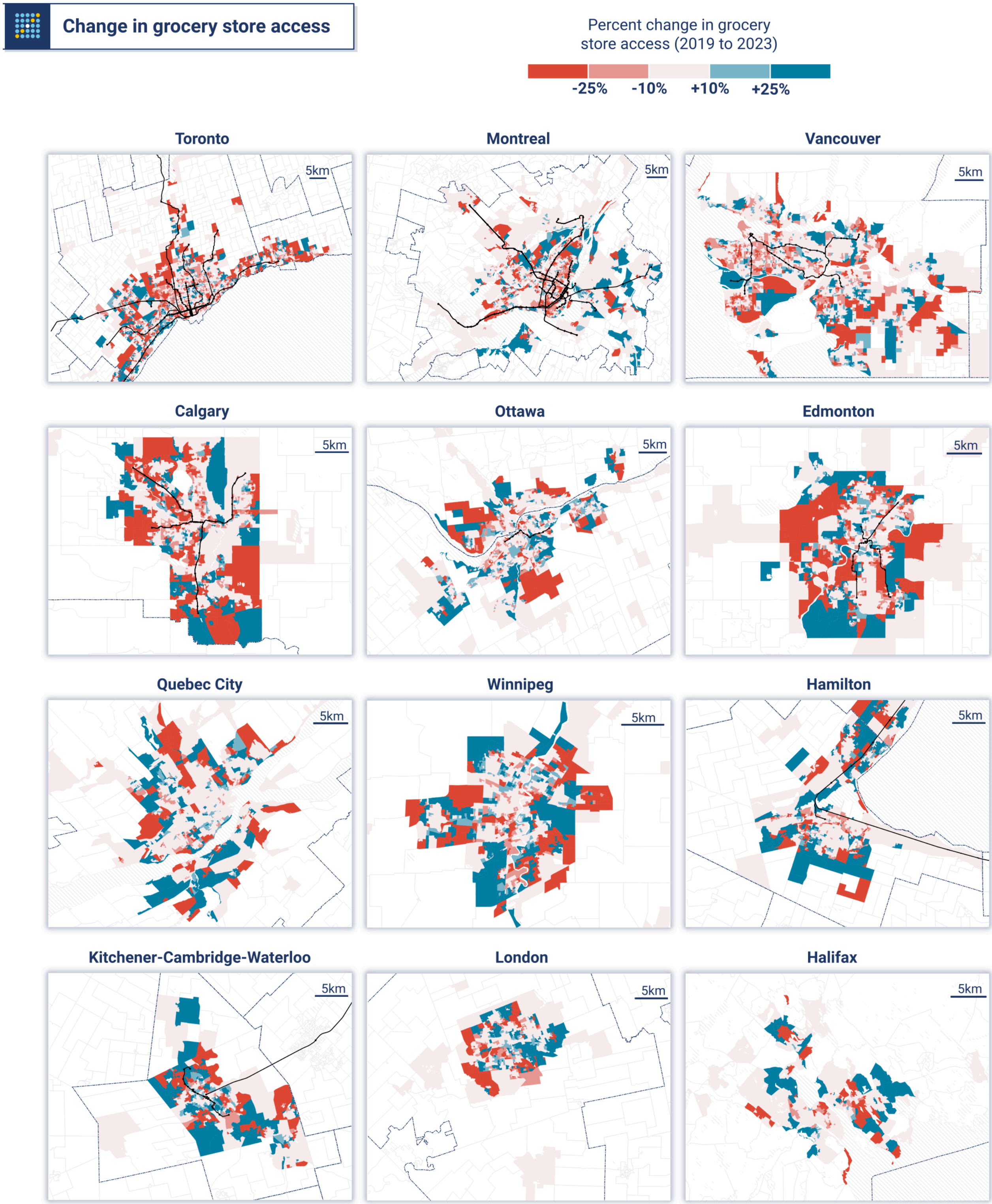
[8] More specifically, we set the routing function's time for a departure between 12:00 PM to 12:15 PM on April 20, 2019 and April 22, 2023.

[9] Specifically, 8:00 to 8:15 AM departure on Tuesday, April 16, 2019 and Tuesday, April 18, 2023. One exception to this is Quebec City, where the routing for 2019 occurs on a Saturday and Tuesday in June (instead of April) due to the GTFS data unavailability.

RESULTS

Figure 2 shows the spatial distribution of changes in accessibility to grocery stores within each region. We set values above or below 50% to ±50% in relative change in accessibility to reduce the effects of outliers on the visualizations. These exceptionally large percent changes correspond to about 5% (job) and 15% (grocery) of the DAs. Most DAs that experienced reductions in food access are in the centres of regions, while those showing gains are distributed predominantly across peripheries. The notable exception seems to be Kitchener-Cambridge-Waterloo. The concentrated nature of accessibility losses in downtowns is particularly visible in the three largest cities in the country, namely Toronto, Montreal, and Vancouver. These central areas are typically home to many middle- to low-income households.

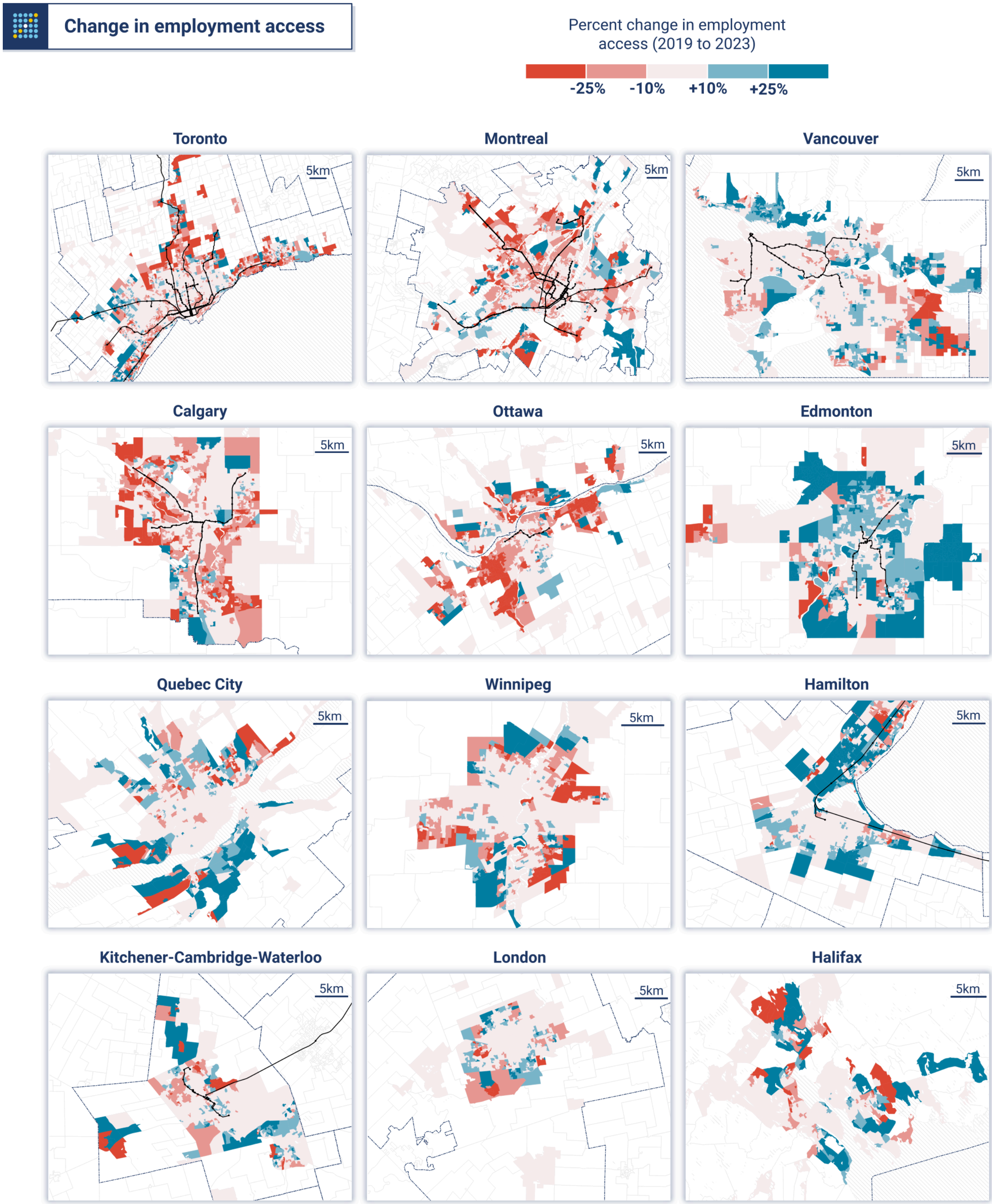
Figure 2 . Spatial distribution of changes between 2019 and 2023 in transit accessibility to grocery stores, by region



Data Sources: Authors' analysis; Statistics Canada; OpenStreetMap

Figure 3 displays the spatial distribution of changes in accessibility to job opportunities. In Toronto, Calgary, Edmonton, and Hamilton, the largest losses or gains in accessibility (darker shades of reds and blues, respectively) are concentrated in the CMA peripheries. This outcome is somewhat expected – because the outer edges of metropolitan areas usually have less dense transit networks than downtown areas, any increase or reduction in service is likely to have a greater impact in the fringes. Thus, people who live in these cities' suburbs are more susceptible to changes in service levels than those in the downtown cores. This can be particularly relevant for suburban low-income families who depend on public transit to access essential services. It is also worth noting, however, that DAs in the peripheries often cover larger geographic areas but are less densely populated core areas.

Figure 3. Spatial distribution of changes between 2019 and 2023 in transit accessibility to employment, by region



Data Sources: Authors' analysis; Statistics Canada; OpenStreetMap

Figure 4 explores the distribution of these changes at the population level, plotting the distribution of accessibility changes to both grocery shops (yellow) and jobs (blue) by the population (per million) across the 12 regions. This plot provides an overview of how accessibility has changed for the two representative travel periods and purposes (access to jobs on a weekday morning and access to grocery stores on a weekend afternoon) between 2019 and 2023.

While the majority of people in each region did not see any difference in transit access to either type of amenities, a sizable number did. In Toronto, Montreal, and Calgary, a significant proportion of the population experienced a decline in transit accessibility for both amenities. Variations in accessibility changes by amenity type are also evident. For example, Vancouver saw gains in job accessibility but losses in access to groceries. In general, the losses in access to grocery stores that we found, particularly in Toronto, Montreal, Calgary, and Vancouver, are in line with the findings of earlier studies showing reductions in food access within large Canadian cities.

In Edmonton and Hamilton, Figure 4 shows a right-skewed distribution for accessibility changes to jobs (indicating gains), with access to grocery stores more evenly distributed between gains and losses. In contrast, Ottawa and Winnipeg display left-skewed changes in job accessibility (indicating losses), – but again, accessibility changes to grocery stores were more balanced. The remaining regions (Quebec City, Kitchener-Cambridge-Waterloo, London, and Halifax) have a similar distribution of access changes in terms of losses and gains.

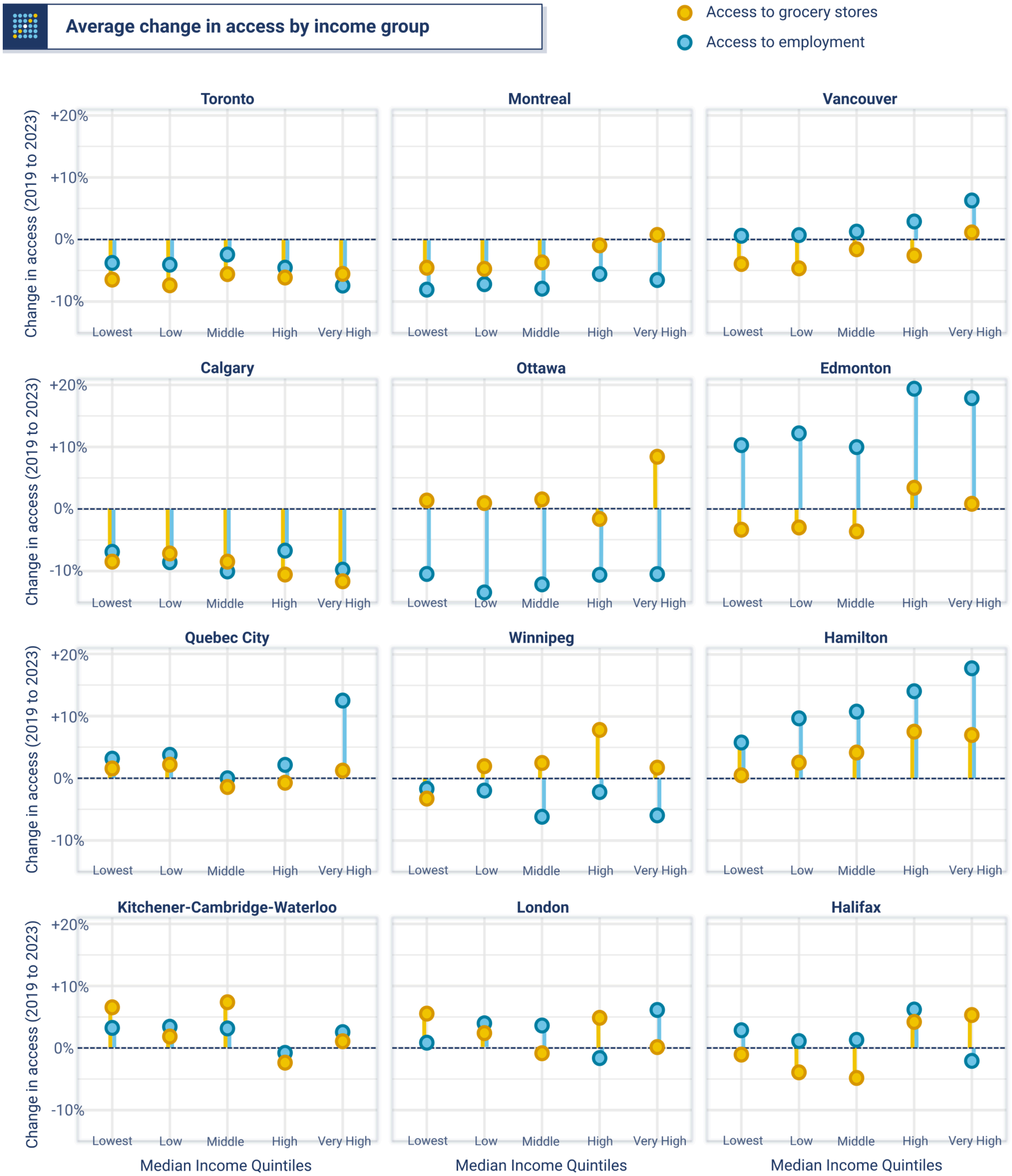
Figure 4. Density plots of accessibility changes between 2019 and 2023 to employment and grocery stores, by region

Data Sources: Authors' analysis

Figure 5 highlights differences across income levels by using population-weighted changes to show which income groups benefited or were disadvantaged by accessibility changes. Income brackets are based on a quintile distribution of median household incomes at the DA level, calculated separately for each metropolitan area. In Hamilton, for instance, there is a direct relationship between the income brackets and changes in transit access, with lower-income-residing groups being disadvantaged while higher-income-residing groups benefit from changes in accessibility.

For grocery access, Figure 5 shows that in most regions, groups in the lowest two income brackets tend to reside in areas that saw a decline in transit accessibility; the exceptions were Ottawa, Quebec City, Kitchener-Cambridge-Waterloo, and London. These declines were more pronounced in regions like Montreal, Vancouver, Edmonton, and Halifax: lower-income groups were disproportionately impacted while higher-income groups experienced either stable or improved accessibility. A different trend was seen for job access: lower-income groups tended to reside in areas that saw gains in access in 7 out of 12 regions (Vancouver, Edmonton, Quebec City, Hamilton, Kitchener-Cambridge-Waterloo, London, and Halifax). Accessibility gains were generally lower in areas where higher-income groups reside, except in Kitchener-Cambridge-Waterloo, where lower-income residing groups saw comparable gains.

Figure 5. Average population-weighted accessibility changes between 2019 and 2023, by dissemination area (DA) median household income quintile



Data Sources: Authors' analysis; Statistics Canda 2021 Census of Population. Averages are weighted by DA population

CONCLUSIONS

In North America, where automobiles are the primary means of transportation, people who depend on transit to access opportunities are especially susceptible to disruptions in local public transit networks such a those triggered by the COVID-19 pandemic. This dependence is particularly pronounced with access to grocery stores. Only 5% of Canadians use public transit for grocery shopping, compared to 83% who travel by car and 10% who travel on foot. They tend to be lower-income households, non- or low-vehicle owning households, and people who cannot drive. These populations are more vulnerable to additional travel time and monetary costs caused by public transit service reductions.[10] Reduced accessibility to grocery stores can impose additional barriers on these vulnerable households and result in negative social outcomes. For individuals who commute daily to their jobs, reductions in service levels mean greater travel times and less flexibility in their routines. Thus, if transit agencies now operate at lower ridership levels because of the long-term effects of the pandemic shock, this new normal is potentially pernicious for people's well-being. A new ridership plateau may also entail a transit "death spiral" – a reduction of the financial viability of transit agencies in the longer term.

At first glance, our results show that many people now experience accessibility levels similar to those of pre-pandemic times. The distributions of relative percentage changes in accessibility shown in Figure 5 concentrate around the middle, meaning that multiple residents faced little accessibility gains or losses at the end of the period. On an aggregate scale, service levels – and, thus, accessibility levels – did not suffer drastic alterations from the period before the pandemic to now. That, however, is not the full picture.

A closer inspection shows that accessibility did, in fact, change for many people. In terms of accessibility to jobs, losses were especially common in the largest cities – Toronto, Montreal, Vancouver, Calgary, and Ottawa. In contrast, Edmonton, Quebec City, Hamilton, Kitchener-Cambridge-Waterloo, and London saw gains in aggregate. Variations in accessibility to grocery shops were less pronounced, but changes generally trended toward losses rather than gains. Toronto, Montreal, and Vancouver in particular experienced aggregate reductions in transit access to grocery stores over the period under examination.

Examining how these changes were distributed across income levels reveals potential equity issues. Our results show that in most regions, people from the middle to the lowest income quantiles suffered the greatest proportion of losses in accessibility. Meanwhile, the highest-income quantiles experienced little reduction in accessibility – or even saw accessibility gains. In other words, it seems that where service and accessibility levels did decline, it was in lower-income areas, and where accessibility improved, those who benefited were at the top of the income distribution.

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[10] Competition Bureau Canada, "Canada Needs More Grocery Competition."

Our findings suggest that the pandemic may have widened the transportation infrastructure gap for some Canadians, but not all. In the 12 largest Canadian cities, reductions in public transit supply disproportionately affected regions mostly inhabited by low-income households, who have historically made up a larger share of transit users. This means that those who more heavily depend on transit to access essential services are the ones who now face worse conditions. These declines in accessibility may create transportation barriers for these groups, which can be particularly challenging given the economic environment following the pandemic.

Spatially, accessibility changes were distributed unevenly across cities, without following a distinct pattern but showing potential ties to city size. Our results suggest that post-pandemic transportation responses and the resulting changes to service levels were shaped at the local level, as patterns of job and grocery establishment locations are specific to each city (for example, as we noted above, larger shifts in accessibility occurred in the outskirts of Toronto, Calgary, Edmonton, and Hamilton). A more integrated approach to transportation policies and to the financing of public transit agencies – one that involves municipal, provincial, and federal levels of government – could potentially address these accessibility disparities more evenly.

Future research could evaluate whether there is a significant statistical association between these accessibility changes and spatial characteristics, to determine whether the locations of these losses or gains are randomly distributed or tied to the spatial distribution of the opportunities and the transit network of each city. For example, the differences in the behaviour of accessibility to jobs and grocery shops might be related to these opportunities' spatial distribution within each studied area. Considering that recent research has linked the recovery rates of centres with their economic character, we suggest that further investigation regarding the relationship to accessibility changes is needed.[11]

We should note some limitations of our study. First, the accessibility changes investigated here say little about the current levels of accessibility in Canadian public transit systems. Our results do not allow us to assess the degree of inequality with which these levels are distributed either across different population groups or throughout space. Future studies derived from this investigation can use equity metrics more appropriate to the domain of transportation, such as the Palma ratio or the concentration index, to quantitatively evaluate these changes in accessibility.[12] We can say, however, that changes derived from the pandemic seem to have been unequally distributed among income levels. Further investigation is needed to assess how the new accessibility levels relate to sufficiency measures and metrics of justice in transportation.[13] Moreover, as mentioned earlier, we were not able to account for land use and demographic shifts derived from the pandemic due to data unavailability. Furthermore, this chapter does not provide an explanation as to *why* passenger ridership and transit agencies' revenue are diverging after the pandemic.

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[11] Forouhar et al., "Assessing Downtown Recovery Rates and Determinants."

[12] Karner, Pereira, and Farber, "Advances and Pitfalls in Measuring Transportation Equity."

[13] Pot, Heinen, and Tillema, "Sufficient Access?"; Humberto, "How to Translate Justice Theory into Urban Transport Metrics?"

We conclude with some policy remarks. First, we propose that further investigations should evaluate the consequences of the widening of the transportation infrastructure gap and investigate who is most affected by it. These might use qualitative studies to draw insights about different groups' subjective perspectives of (in)sufficient transit accessibility levels and the reduction of public transit service. Additionally, more rigorous quantitative studies using causal inference methodologies can assess the policy impact of these reductions on social outcomes, such as changes in the labour market and food insecurity. Future analysis could even broaden the scope and evaluate the consequences of accessibility changes for other outcomes, such as activity participation and social exclusion, and how these impacts are distributed among the population, across spatial locations, and over longer periods of time.

Second, while our results are preliminary, they highlight the risk of a possible "transit death spiral" in some regions. If transit agencies are increasing fare prices and reducing service to compensate for ridership losses, this could bring about a permanent decline in transit ridership, fundamentally compromising transit agencies' financial health. This vicious cycle would disproportionately affect those most economically vulnerable and dependent on transit services. There are no easy or short-term responses to this issue. Providing better services to users is a strategy to increase ridership. An additional approach is to reduce the cost of using transit by, for example, increasing subsidies for some users or based on ride characteristics.

A more disruptive policy that has gained traction worldwide to eliminate financial barriers to transit access is the full abolition of public transit fares. This is a politically-charged topic and would require a reorganization of public transit financing. However, it fundamentally recognizes transit mobility and accessibility as a universal right. If the transportation infrastructure gap has indeed widened for some Canadians, a universal approach to removing barriers to accessibility could be the solution to providing equitable access to services across the country. This could help shift the country's transportation system to a more democratic model, one that supports mobility and opportunities for all Canadians regardless of social, economic, and spatial disparities.

OPEN SCIENCE AND REPRODUCIBILITY

This chapter is a reproducible technical manuscript. The code and data needed to reproduce it are available in a publicly available repository:

https://github.com/paezha/transit-accessibility-can-19-23

The paper uses an Open Data Product package {canaccessR}, available here:[14]

https://paezha.github.io/canaccessR/

[14] See Arribas-Bel et al., "Open Data Products."

APPENDIX

Accessibility equation

Accessibility takes the following mathematical form:

$$A_i^{tk} = \sum_j O_j^k \cdot f^k\left(c_{ij}^t\right)$$

where:

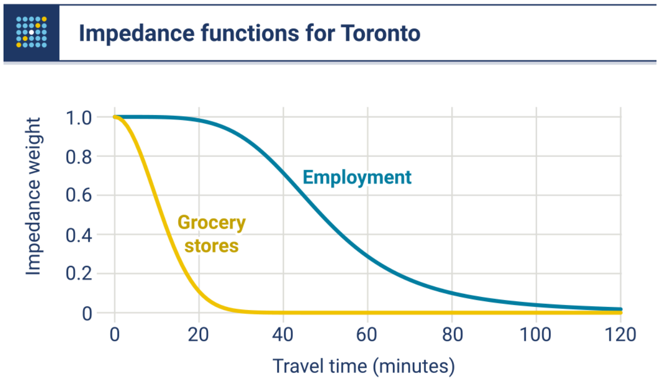
A_i : accessibility at origin i
O_j : weight of the opportunity at destination j
C_{ij}: travel cost between origin and destination
k: opportunity types, either *job* or *grocery* in this study
t: time period, either 2019 or 2023 in this study

Within this framework, the public transit accessibility A for an origin location i in time period t is the weighted sum of the opportunities O of type k at the destination locations j. The opportunities are weighted by an opportunity-specific function f^k (*) of cost c_{ij}^t for year t. For this work, the origins consist of the geographic centroids of the dissemination areas (DAs) from the 2021 Canadian Census of Population for all 12 study regions.

Weights

For jobs, we used DA centroids weighted by the number of workplace locations from the 2021 Census. In other words, each job destination is a DA with value O_j^{job} representing number of workplace locations. For grocery stores, we used locations from the DMTI 's Enhanced Points of Interest database filtered by their grocery store associated code (North American Industry Classification System [NAICS] and the Standard Industrial Classification [SIC] code). Each grocery store is assumed to have a weight of 1 to represent each $O_j^{grocery}$. The years t represent travel scenarios in 2019 and 2023 to capture transit travel times before and after the pandemic.

Figure A-1. Impedance functions used for employment and grocery store access in Toronto



Data Sources: Authors' analysis

Impedance functions

For employment, we used the weights functions calibrated for most of the regions. However, because impedance functions for Ottawa-Gatineau, Calgary, Hamilton, and Kitchener-Cambridge-Waterloo were not included in this work, we used mean commute times by transit and parameters from similarly-sized cities to calculate access in these regions.[15] For grocery stores, we adopted the function from Kwan with a decay parameter of 180.[16] Both travel decay functions are visualized in Figure A-1: note how the travel weight to jobs declines less dramatically at the same travel time than to grocery stores. This trend reflects how populations typically travel to these different amenity types.

[15] Kapatsila et al., "Resolving the Accessibility Dilemma."

[16] Kwan, "Space-Time and Integral Measures of Individual Accessibility."

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