TRB Annual Meeting

Toward Gender-Mainstreaming Transport Planning: Measuring Access to Care

--Manuscript Draft--

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Manuscript Classifications:	Public Transportation; Planning and Development AP025; Accessibility; Sustainability and Resilience; Transportation and Society; Women and Gender in Transportation AME20; Accessibility and Mobility; Gender and Women; Transportation and Sustainability; Economic Development and Land Use AMS50; Accessibility and Mobility; Gender-Responsive Design; Gender Equality
Manuscript Number:	
Article Type:	Presentation
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Question	**Response**
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Word Count: 5991 words + 4 figures (250 words per figure) = 6991 words

Submitted July 31st, 2023.

ABSTRACT
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Keywords: Accessibility; Mobility of Care; Gender; Equity; Travel Mode

INTRODUCTION

A gender bias exists in transport planning whereby research and policy historically has focused on one trip purpose, the on-peak commute to work, a travel pattern more frequent amongst men (*1*). To counter this bias, the concept 'mobility of care' was developed; it refers to all the travel needed to fulfil household needs (e.g., travel to grocery stores, to run errands, to pickup/ drop off children), and is a type of travel that is predominantly done by women (*1; 2*). Transport planning research to date has inadequately considered mobility of care, for instance, trips to care destinations such as grocery stores, schools, and daycares, are not explicitly considered in typical large-scale travel surveys (*1*), including major Canadian surveys such as the Transportation Tomorrow Survey (*3*) or the Montréal Origin-Destination Survey (*4*). This results in the mislabelling of these trips into 'shopping' or 'leisure' trips (*1*). When travel surveys are designed to explicitly capture mobility of care, preliminary research has found that it comprises approximately one third of adults' trips (*1; 2; 5*). The omission of mobility of care in research and planning has important equity considerations, as studies have found that mobility of care are completed predominantly by women, especially low-income women (*1; 5*). For instance, in lower income households in Montréal, women complete twice as many care trips than men (*5*).

Mobility of care research stems from previous work examining household-serving travel. Focusing on the gender inequity found within this type of mobility; this body of work examines individual household-serving trips (e.g., grocery shopping *or* escorting children), and identifies the multiples roles women play within this type of mobility. Ample research on this inequity has found that women take on more responsibility for the travel needs of their children (*6-10*) and grandchildren (*11*) than men. In addition, women also complete the bulk of elder care within households, likely resulting in more travel for these care purposes (*14*). Women's role in care mobility does not end there, with studies showing that women make more shopping trips and run more errands than men as well as shouldering the responsibility of planning mobilities of care even when a male partner undertakes them (*8; 10; 15-17).* While this literature on gender and household-serving travel has made significant contributions to the literature of mobility of care, Sánchez de Madariaga (2013) argues that focusing on separate household-serving trips results in the under-representation of mobility of care (*1*). Only by considering household-serving trips together (i.e., mobility of care), do we see that they represent approximately 30% of daily mobility.

The idea of mobility of care also warrants special sustainability considerations when planning for urban mobility. Transport planners aiming to discourage high emitting car travel and encourage low emitting travel by walking, biking, and public transit should consider mobility of care whilst informing policies. In Ravensbergen et al.'s (2022) study on mobility of care, Montréalers were two and half times less likely to use public transport for care trips than for work related trips. Similarly, residents were nearly two times less likely to use bicycles for care trips than for work trips. Yet, car use was almost 8% more likely for care trips than for work trips *(6).* Furthermore, qualitative research in Europe has identified that this type of travel is considered easier to complete by car as it tends to include carrying items (groceries, library books, etc.) or children, which is seen as a barrier to travelling by foot, bicycle, or public transport (*12*). Therefore, with this preliminary research suggesting a bias towards car travel when accessing care, transport planners should consider mobility of care when informing policies aiming to encourage sustainable urban mobility.

The power of the Mobility of Care concept lies in its ability to highlight the masculinist bias in transport research – travel for care appears insignificant because travel surveys are not written to capture it (*1*). Travel surveys, however, are but one tool used by transport researchers and practitioners. Another popular tool in transport planning and research is accessibility, an indicator that quantifies "the potential of opportunities for interaction" as defined in the seminal work of Hansen (*13)*. Accessibility indicators can be interpreted to capture the ease of reaching destinations using a transport network - a representation of the land-use and transportation systems in a region (*13-15*). In reflecting the gender bias of the data collected, the points of interest in many accessibility-based assessments have been home-to-work destinations (*16; 17*). For example, in the accessibility assessment of the Ontario Line, a subway line that will be constructed in the city of Toronto (Canada), Allen and Farber (2022) highlight how this new investment will increase access to jobs for residents across the City by 1.14% overall (*17*). Jobs, however, are not the most appropriate destination for many segments of the population. Indeed, while the commute is an important trip type amongst women, on average it comprises a smaller proportion of their daily travel than men's (*18*). This focus on job-access can additionally bias accessibility-gains that children and older adults who reside in impacted areas may see as well (*19*). One way to counter this bias is to reframe the analysis and calculate accessibility to different destinations, such as mobility of care destinations.

In this spirit, this study expands the nascent body of work on mobility of care, a topic that has been thus far ignored due to systematic gender bias in transport research and planning, by focusing on mobility of care accessibility in the City of Hamilton. Given that preliminary research has found that certain travel modes are more commonly used for mobility of care (the private car and walking), this study also compared mobility of care accessibility across travel mode to test the hypothesis that certain modes provide more access to care destinations than others. Finally, because certain people have been found to be more likely to complete care travel than others (low-income women), this study also examines how accessibility varies across sociodemographic factors at the neighbourhood scale. In doing so, this research aims to contribute to gender mainstreaming in transport planning by conducting a feminist accessibility calculation, and to sustainable transport planning by examining the potential access to barriers to care destinations using low carbon modes (walking, cycling, and transit).

METHODS

Context

This paper focuses on the case of Hamilton, a mid-size city of approximately 500,000 residents and an economy historically (and still) connected to steel manufacturing and related manufacturing. Though a city in its own right, Hamilton lies within the urban and suburban Greater Toronto and Hamilton Area (GTHA) that spans a shoreline of Lake Ontario. The GTHA comprises seven million people, or approximately 20% of the Canadian population (*20*).

Hamilton is divided into six regional communities: Hamilton Central, Dundas, Ancaster, Flamborough, Stoney Creek and Glanbrook (Figure 1). Each of these regions demonstrate different characteristics of the urban and suburban landscape of the city. Hamilton Central is the densest and most urbanized of the six, and the five periphery regions of Dundas, Ancaster, Flamborough, Glanbrook and Stoney Creek are significantly more suburbanized with the furthest periphery regions being undeveloped or rural owing to their inclusion in the region's greenbelt (*21*) . Urban and suburban landscapes play a key role in accessing care as differences in infrastructure could affect one's ability to access care destinations.

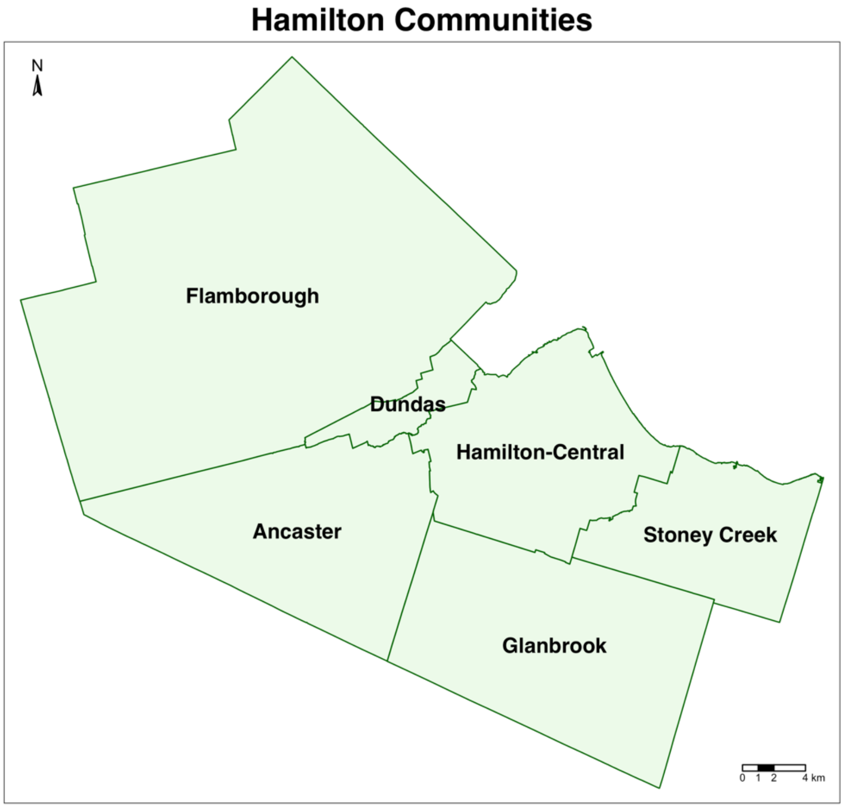

Figure 1 The City of Hamilton: Study Context

Destination data collection

To complete the accessibility analysis, a geospatial database of care destinations for Hamilton (e.g., full addresses of longitude and latitude) was compiled. The geospatial data was sourced from governmental open data portals (specifically that of the City of Hamilton and the Province of Ontario), Data Axle, a consumer database compiled of businesses and companies within Canada (*22*) or manually through Google Maps. Each destination was categorized based on the specific type of care being accessed. Categories include child centric, elder centric, errand centric, grocery stores, and healthcare destinations. These final categories, and their sources of data, are described below.

Child Centric: This category includes the geospatial location of all child-oriented destinations such as schools, daycares, community centers, and parks. Many of the locations were identified through Open Data Hamilton (*23*) and Open Data Ontario (*24*).

Educational Institution data for Hamilton (*25*) was used for the care category specific "Schools". The data was then filtered, and the following categories found from the dataset were removed: Post-Secondary, Adult-Learning Centres, Group Homes, and Foster Care Centres. The reason for eliminating these categories was due to these locations not centering on the age demographics of children. Through close examination, within the Educational Institution data, some Section 23 institutions (*26*), which are defined as "centres for children who cannot attend school to meet the needs of care or treatment, and rehabilitation" (*26*), were kept due to their innate connection to care.

Care category specific "Daycare" data was identified from the Ontario Open Data Portal (*24*) for Registered Child Care Facilities in Ontario and filtered to Hamilton. EarlyON, childcare locations, which are defined as "…locations for child rearing and development where parents accompany their children" (*27*), were added manually from the Hamilton Child Care Registry (*27*), and were given the category "Daycare EarlyON".

Recreation and community centre data was identified from Open Data Hamilton (*28*), and filtered into their own respective specific care categories. Parks were also gathered from Open Data Hamilton (*29*).

Elder Centric Destinations: The Elder Centric destinations include senior centres, long-term care homes, and retirement homes. Long-term care home and retirement home data was derived from the Ontario Ministry of Health GEOHub for Health Service Locations (*30*). Senior centres were derived from the Recreation and Community Centre database from Open Data Hamilton (*28*).

Errand Centric: Errand centric travel is a route many families embark on, which is often remised in previous studies and supplemented with a broader category of trip being grocery shopping (*31*). For this research errand centric destinations include libraries, post offices, and banks. Library data was derived from Hamilton Open Data Portal (*32*). Post Offices were collected from two sources; Axle Database and then supplemented from the Canada Post Postal Office Tracker Website (*22; 33*). The supplemented locations from Canada Post Postal Office Tracker Website were manually entered into the database to ensure data was accurately being represented from its source. Banks were also derived from Axle Data and then cross referenced to ensure data quality with the ABM Bank Locator websites for the following banking firms: Bank of Montreal, CIBC, HSBC, National Bank of Canada, Royal Bank of Canada, Scotiabank and TD Financial (*34-39*).

Grocery Stores: This category includes all grocery stores, regardless of size, from convenience stores to large retail stores. Data was gathered from Data Axle through the McMaster University Library and filtered by Company Name, Suite Number, Address, City, Province, Phone Number and Postal Code (*22*). From there it was separated by type of grocery store, (grocers specialty foods, grocers retail, grocer health food, grocer wholesale, grocer curbside, grocer delicatessen wholesale, grocer convenience). After data was compiled, it was cross referenced to ensure that all stores were operational, and legitimate grocery stores. Some locations were removed for being closed permanently, for being food distribution warehouses, or because they would have been double counted in two different categories.

Health Destinations: Health destinations include hospitals, clinics, pharmacies, and dentist offices. As was the case for the Elder Centric locations, Hospitals and Pharmacies were derived from the Ontario Ministry of Health GEOHub for Health Service Locations (*30*). Clinic location data was manually entered with data being gathered from Hamilton Niagara Haldimand Brant Health Line – Health Service Locations (*40*). Clinic data was then double checked to ensure locations were in operation. Dentistry locations were also manually entered through Google Map search filtering as well as reassessed for operational use.

Once the care destinations were compiled and arranged in separate spreadsheets according to their care category, the data was validated to ensure that duplicate locations were removed. Then, quality controls were conducted on all non-open source data to ensure that each location was in operation. This was done by examining each location manually through Google Maps. As a result, all locations that were permanently closed were manually removed. Within the Recreation and Community Centre data, locations were not given an innate category, therefore any location that was not previously categorized as a "Senior Centre" and involved physical activity was categorized as "Recreation Centre", the rest being categorized as "Community Centre". The complete care destination database was imported into RStudio for further processing.

Census data and travel time estimations

To supplement the care destination database and complete the accessibility calculation, population data for the City of Hamilton was sourced from the most recent 2021 Canadian census (*41*). The number of residents and the percent of after-tax low-income-cut-off (LICO) residents was sourced for the highest level of spatial resolution, the dissemination area (DA). LICO is a composite indicator included in the census that reflects the proportion of households spending 20% more than the area average on food, shelter and clothing (*42*). The 'cancensus' open-sourced R package was used to access the 2021 Canadian Census data in a programmatic way (*43*). Overall, there are 891 DAs in Hamilton, with populations ranging between 0 and 7,631 (one DA had a population of0, the average population size was 639) in each DA, and a LICO ranging between 0.5% and 52% (on average 6.8%) in each DA.

Travel time estimations were conducted using R5R, an open-source R package for rapid realistic routing on multimodal transport networks (*44*). The inputs were the geometric centroids of the DA, the centroids of all care destinations, the Open Street Map (OSM) road network retrieved from Geofabrik, (*45*) and the static GTFS (transit network in which only urban buses operate) for Hamilton (*46*). Travel times for walking, cycling, transit (with walking to stations), and car were calculated for each origin to all care destinations using the travel_time_matrix() function in (*44*) that relies on the java-based R5 routing engine developed by Conveyal (*47*).

Travel times were calculated for origin/destination trips under 60 minutes in length for all modes. Additional parameters were included for transit and cycling modes. For transit travel times, a departure time set at 8 am on a non-holiday Wednesday with a +/- 30 minute departure time window and 25^{th} and 50^{th} percentile travel time were selected, A weekday 8am departure was selected as it is representative of relative accessibility over the course of the day (*48*), the travel window parameter allows for the selection of the shortest travel time from between 7:30am-8:30am departure allowing for flexibility in the transit schedule. Ultimately, the 25^{th} percentile travel time was selected – it indicates that 25% of trips from that origin to destination have a travel time that is that length or shorter; this assumption provides an optimistic assumption of transit travel times. For cycling travel times, the default parameter for cycling routes of level 1 or 2 traffic level of stress (dedicated or separated cycling lanes), was selected. The level of traffic stress is associated with the OSM road network.

Cumulative opportunity accessibility

The cumulative opportunity accessibility measure was used to calculate a DA-level value of how many care destinations can be reached, within a given travel time, from each DA. This approach was selected as it is highly interpretable (e.g., the value assigned to each DA is simply the number of destinations that can be reached within a given travel threshold) and has been shown to yield similar results to a gravity-based measure assuming an accurate selection of the travel time threshold (*49*). The cumulative opportunity measure takes the following general form: (*15; 50*)

$$A_i = \sum_{j=1}^{J} O_j \cdot f(c_{ij})$$

Where:

- i is a set of origin locations ($i = 1, \ldots, N$).
- j is a set of destination locations ($j = 1, \ldots, J$).
- c_{ij} is the travel time moving between i and j.
- $f(\cdot)$ is an impedance function of c_{ij}; within the cumulative opportunity approach it is a binary function that takes the value of 1 if c_{ij} is less than a selected value.
- O_j is the number of opportunities at j.

For simplicity in presentation, the cumulative opportunity measure was calculated for all care destination categories twice. The first calculate was with a travel time threshold of 15 minutes, and the second for a travel time threshold of 30 minutes. Put formulaically, j are all destination types, and $f(c_{ij})$ is equal to 1 only for trips under 30 minutes in travel time for the first calculation and under 15 minutes for the second calculation. The travel time threshold selection was informed by the literature. Only one study to date has calculated the average travel time to all different categories of care destinations (16 minutes by car and 36 by public transport) (*18*). Other literature on travel to care trends to consider trips to one type of care category (e.g., health, or school, or grocery stores). Here, travel times vary by care category (e.g., 15 minutes to grocery shopping (*51*) or 20.45 for cancer treatments (*52*)). In other care-related accessibility analyses, time-cut offs include 10 mins (for daycares) (*53*) and 30 mins to 1hr (for hospitals) (*54*).

RESULTS

The cumulative opportunity accessibility plots for each mode are shown in Figure 2 (30-minute travel time threshold) and Figure 3 (15-minute travel time threshold), and the results are described across three sections: Across the City, Travel Modes, and Equity Considerations (with reference to Figure 3).

At large when accessing care within the city of Hamilton, longer trips (30 minutes) are significantly favoured with a maximum destination opportunity of 2,115 (Figure 2) compared to 15-minute trips yielding a maximum of 1,818 cumulative destinations (Figure 3).

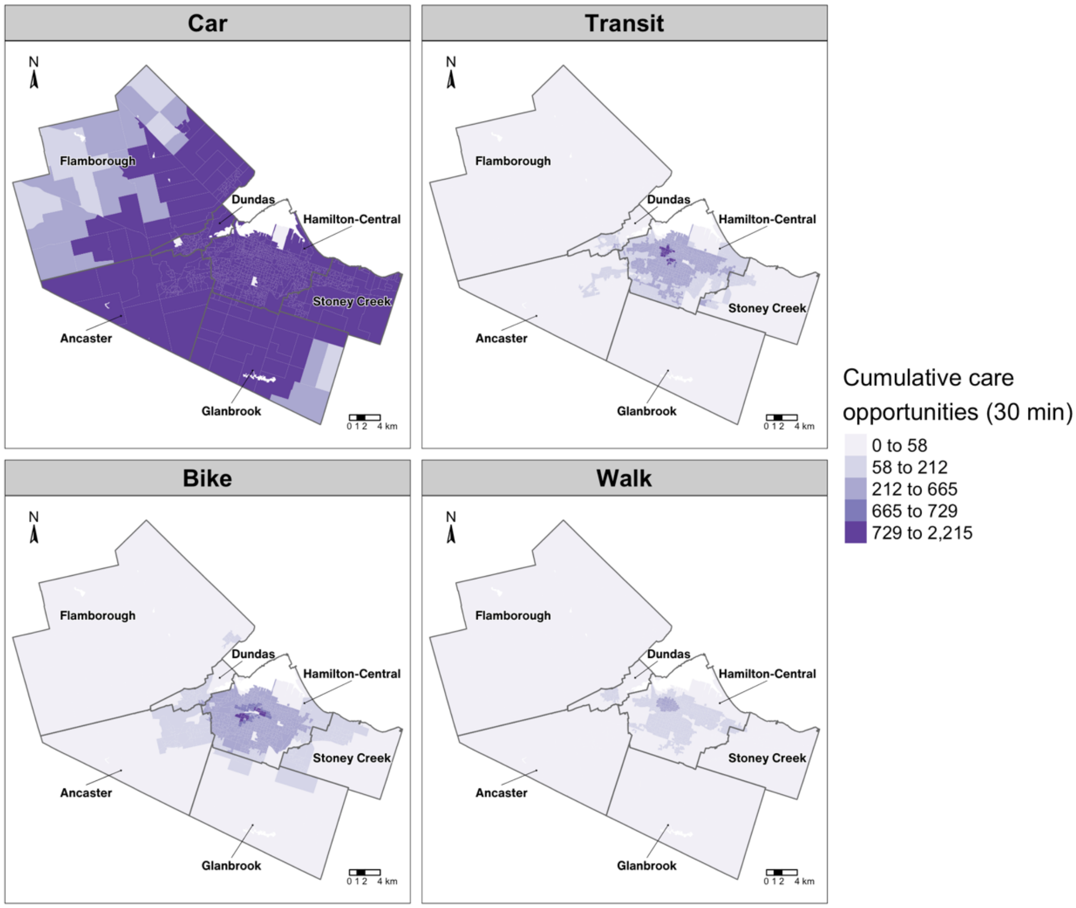

Figure 2. Access to care within 30 Minutes

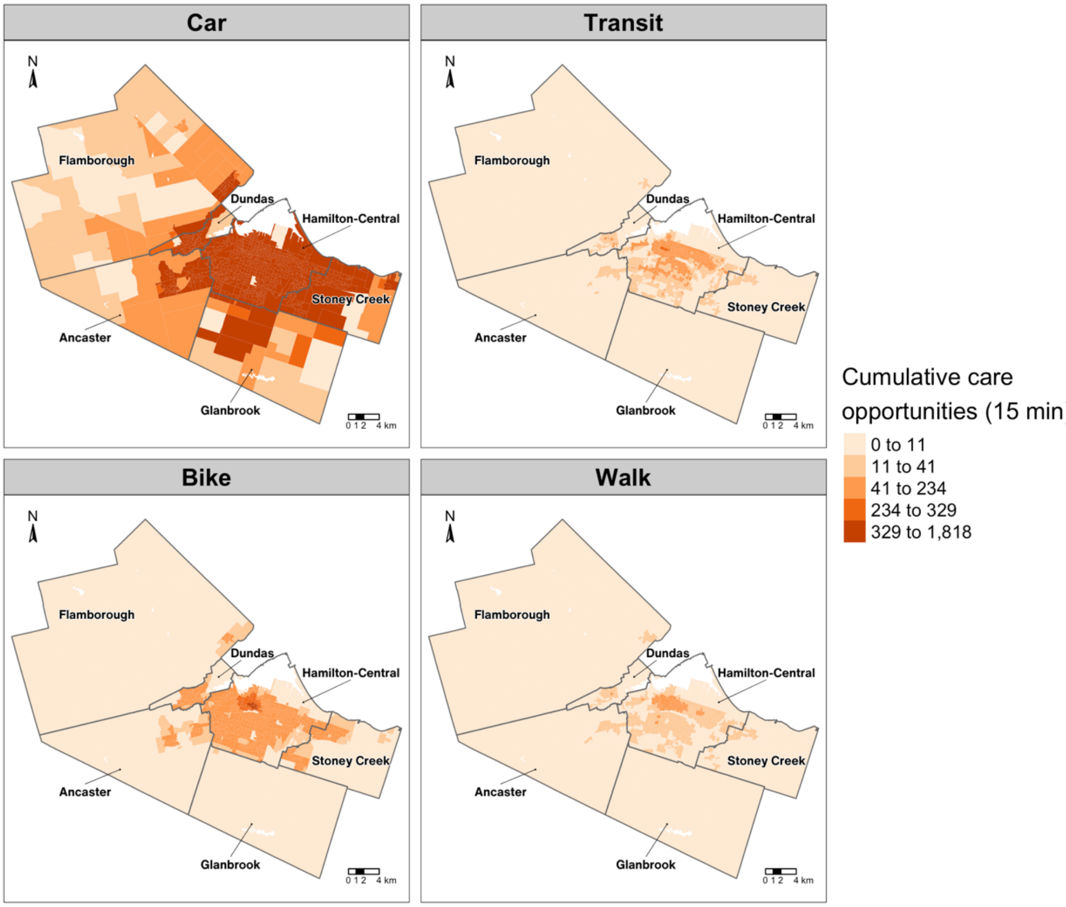

Figure 3. Access to Care within 15 Minutes

Accessing Care Across the City

When describing the access of care (to all care destination types) across the six regional communities of Hamilton, the inner city of Hamilton Central exhibits the highest accessibility – regardless of travel mode or travel time threshold (Figures 2 and 3). Across the periphery regions, the number of care destinations that can be accessed becomes significantly sparser – unless one has access to a car. It is important to note that a few exceptions exist. While the periphery regions of the city have limited access to care by all modes of transportation except the car - small pockets of Ancaster, Stoney Creek and Glanbrook do exhibit high access values by bicycle, both at 15 and 30 minutes (Figures 2 and 3). Further, nearly half of the region of Dundas can access care destinations by bicycle. The region of Flamborough which is predominantly rural, shows the lowest accessibility of all six regions especially by non-car travel. This is aside from one small region towards the south border which can be identified as the township of Waterdown which shows the greatest accessibility in the region.

Travel Mode Comparisons

Accessing care within the city differs significantly by transport mode. In Figure 2, almost the entirety of the city can access all destinations included in the dataset by car, an expected outcome given the tendency of North American cities to be designed around the private car (*55*). The car-oriented design of the City of Hamilton is further evidenced when one considers access to care using the other three modes of transport (Figures 2 and 3). Walking to access care in Hamilton is almost entirely limited - apart from those living within the inner parts of Hamilton Central. Only a slight increase of accessibility can be seen when increasing trip time from 15 to 30 minutes.

Though public transit is often seen as a tool to increase accessibility within the urban landscape, Hamiltonians have limited access to care within even 30 minutes by public transit - apart from those living in Hamilton Central or areas directly alongside the City's bus network. Biking shows a surprising promise to access care compared to both transit and walking. In Figure 2, bike centric travel to care destinations shows greater accessibility than transit, especially in areas where transit is limited. Periphery suburban areas in Ancaster and Stoney Creek exhibit greater accessibility by bicycle when compared to by transit. For instance, areas of Glanbrook can only access up to 58 care destinations by transit but can access between 58 and 212 care destinations by bike. Even when comparing the inner most areas of Hamilton Central, biking allows a greater area of access to care when compared to transit – this is the same for both time frames used (Figures 2 & 3).

Equity Considerations

One can begin to understand the deeper spatial and socio-economic structure of care accessibility in Hamilton by analyzing the density and prevalence of individuals who may be in difficult circumstances based on how much of their income is utilized for necessities (Figure 4). Figure 4 aids in identifying areas within the city that would benefit from infrastructure to access care destinations. When comparing Figures 2 and 3, gaps can be identified of areas that have both low accessibility as well as high population density and/or high LICO percentages.

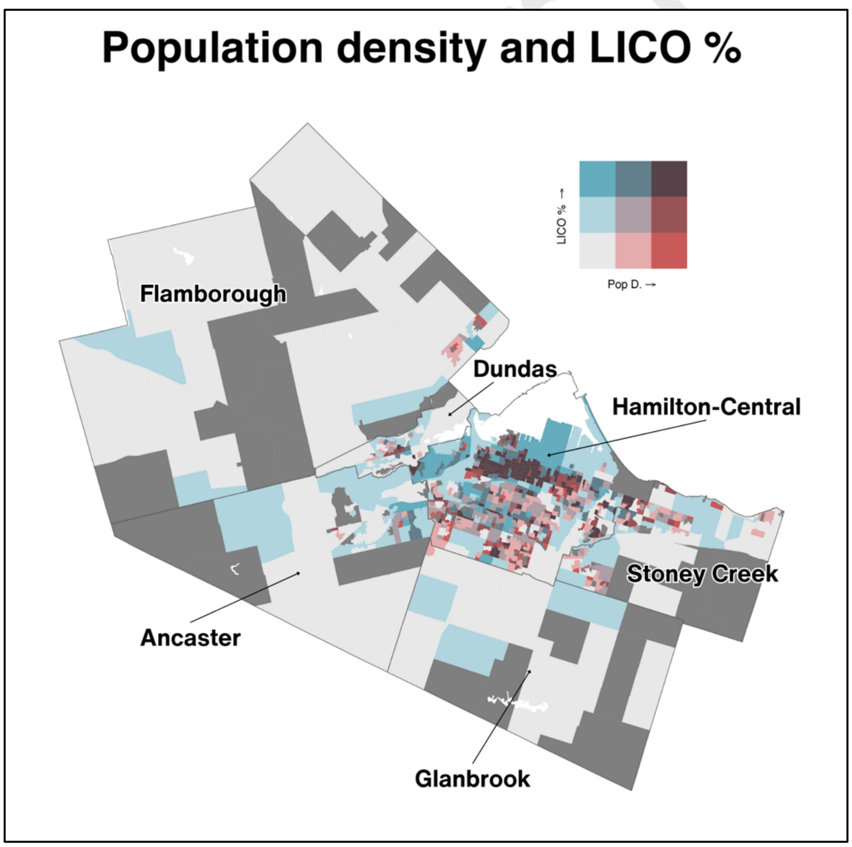

Figure 4. Population Density and Low-Income Cut off in Hamilton, Ontario

One area of the city is strongly characterised by both a high density and high LICO rating: the inner city, or within Hamilton Central. This area may be characterised by a high density and many low-income residents (Figure 4), but it also exhibits high accessibility. For this area, care accessibility by car at both 30 minutes (Figure 2) and 15 minutes (Figure 3) is significantly more favourable than any other mode. However, looking at other modes of transport, only a small, concentrated area within the inner city has the highest potential for accessibility, with biking being the most favoured transport mode across both time thresholds.

Outside of the inner-city, areas of high density that are characterized with high LICO percentages show to have a much smaller number of opportunities. Three regions, Dundas, and small suburban areas on the edges of Stoney Creek and Ancaster, exhibit both a high LICO percentage and a high density rating. Within these areas, walking and public transport are least favourable to access high volumes of destinations. Instead, biking is the most promising sustainable transport method. This result is consistent at both travel times (Figures 2 and 3). The increased accessibility of care by biking is quite promising, however it is important to note the barriers accessing care by bicycle has within the city (*37-39*).

When looking at high LICO percentage solely, car centric travel allows the best access to care. This is apart from small areas in Glanbrook, the north edge of Hamilton Central, and south border of Flamborough having limited accessibility to care opportunities whilst being characterized with higher LICO percentages. The inaccessibility found in Glanbrook, North Hamilton Central, and South Flamborough is prevalent across all transport modes and both time frames. With these areas being identified with a high volume of individuals who spend a high proportion of their income on necessities, care accessibility by sustainable and cost-effective transport modes should be considered more widely.

DISCUSSION AND CONCLUSION

This paper is first to conduct an exploratory feminist accessibility analysis of care destinations – one that counters the current literature's emphasis on employment-related travel, a travel more significant for men, and especially wealthy and educated men (*56; 57*). Its aim is to challenge assumptions often made in transport planning tools (i.e., that work is the most important place to access), and to provide a tangible example of how one could gender-mainstream accessibility analyses.

This study also contributes to the literature on sustainable travel behaviour. Results indicate that care is most easily accessed in Hamilton by car, an unsurprising result given its car-oriented design. Previous research has found that mobility of care are more frequently completed by car or by foot than by transit or by bicycle (*5*). It is possible that the car's ability to provide higher access to care destinations, as observed in this study, shapes this tendency to complete care trips by car. Then again, car use may be more frequent for care trips because these trips tend to involve carrying things (e.g., groceries) or people (e.g., children). Indeed, past qualitative work has found that many prefer travelling by car for this type of trip due to convenience and increased safety (*12; 58*). Then again, care trips tend to be shorter than other trips (*5*), making them ideal for more sustainable travel modes, such as active modes (walking, cycling) and public transport. The low access to care by foot identified in this study is discouraging, given both people's tendency to use this mode for care trips (*5*), and the benefits of walking as a travel mode, both for individuals, cities, and the environment. Somewhat unexpectedly, access to care was found to be low by transit and by foot and relatively high by bicycle. Given that low income women, in particular, seem to be transit reliant for care trips (*5*), this result highlights both a potential bias against care trips by transit and the equity implications of that bias. Though past work has found that many barriers exist for cycling for care (*59-61*), the results of this study highlight the great potential of the bicycle for easily accessing care.

The preliminary nature of this research also comes with its limitations as a result of data availability. Firstly, the travel time estimations assume free-flow network conditions: this may not drastically impact walking travel time accuracy, but could impact car, transit and cycling estimations. Secondly, the geometric centroids of DAs (origins) and destinations (all care destinations) were used as inputs for travel time calculations. DAs are created for the purpose of the census: they vary in area and centroids may not necessarily align with where that population may be beginning their journey to care destinations. Thirdly, the cumulative opportunity accessibility measure is unconstrained and does not consider competition. It is the sum of every care destination that can be possibly reached, not taking into consideration the density of neighbouring population that may also be reaching those destinations. Fourthly, quality of the care destinations was not considered (e.g., access to a park is equal to access to a school). These limitations all contribute to how accurately results reflect the quantitative access to care landscape within Hamilton.

Future work on the accessibility of care will consider competition factors through different accessibility measures, a higher spatial level of travel time estimation, and the incorporation of different weightings of care destination categories. In addition, future work will compare care accessibility to work accessibility in Hamilton to highlight the bias in planning towards jobs as well as substantive equity critiques.

ACKNOWLEDGEMENTS

This research was funded by the McMaster Undergraduate Student Research Assistantship program of the Faculty of Social Sciences.

AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: NM, LR, AS.; data collection: NM, AS; analysis and interpretation of results: NM, AS, LR; draft manuscript preparation: NM, LR, AS. All authors reviewed the results and approved the final version of the manuscript.

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