Identifying 15-minute neighbourhoods with complete caring potential

Anastasia Soukhov

Léa Ravensbergen

Lucía Mejía Dorantes

Antonio Páez

# Abstract

The “15-Minute Neighbourhood” concept has been adopted by leaders around the world as a way to promote human-scale cities. The concept emphasizes a transport and land-use mix that supports short-trips to daily necessities by foot or bicycle from ones’ residence. This study adopts the 15-minute neighbourhood concept through the lens of “Mobility of Care”, a framework that foregrounds travel to care destinations, travel done predominately by women, in contrast to the better-studied travel to employment and leisure. While the 15-minute neighbourhood concept is flexible enough to consider all destination types, gendered examinations are relatively lacking in the literature and no research to date has focused explicitly on care destinations. In this study, we address these gaps by identifying which areas in Hamilton, Canada have the potential to be ‘caring 15-minute neighbourhoods’. To do so, a database of care destinations was compiled and used to estimate both the number (cumulative opportunities indicator) and diversity of mix (entropy measure) of destinations reachable within a 15-minute walk from all residential parcels. Parcel-level results were classified into ‘caring’ (quantity of reachable opportunities) and ‘complete’ (diversity of care destinations) neighbourhood typologies of varying degrees using machine learning techniques (Self-Organizing Maps (SOM) and hierarchical clustering). Inequalities in the relationship between the identified caring typologies and social-economic indicators of who currently reside in the neighbourhoods were then explored. Our results suggest the majority of ‘caring and complete’ neighbourhoods are within the urban core where a higher proportion of lower-income and single-parent households reside. Further, certain neighbourhoods in suburban and rural communities are ‘caring and somewhat complete’, showing the potential to become ‘complete’ through possible urban policy intervention. Taken together, this study offers a theoretical bridge to connect Mobility of Care and the 15-minute neighbourhoods concept, a data-driven classification and clustering methodology to assess neighbourhoods on a ‘caring and complete’ continuum, and discussion of relevant gender mainstreaming policy interventions.

Keywords: Accessibility; 15-Minute Neighborhoods; Chrono-Urbanism; Cities of Proximity; Mobility of Care; Inequality; Gender Gap;

# Introduction

The “15-Minute City” has been recently adopted by leaders as a way to promote human-scaled cities (Teixeira et al. 2024, 2024). As introduced in Moreno et al. (2021), the 15-Minute City is a urban planning model based in chrono-urbanism, a theory that emphasizes the positive impact on quality of urban life when urban space becomes multi-rythmic, in opposition to the segregation of urban time and space for individual uses and mobility (Mulíček, Osman, and Seidenglanz 2015; Moreno 2016). It is in opposition to the forces that supported the formation of single-use neighbourhoods such as industrial Fordism and single-use zoning (Mulíček, Osman, and Seidenglanz 2015; Moreno 2016). The “15-Minute City” is a utopic ideal, it is a city where one that accommodates the ability for all to reach important destinations within a walkable, bikeable or transit supportive radius. This form of neighbourhood planning would allow individuals to reclaim time spent on car mobility, giving way to sustainable modes and prompting urban spaces that are responsive to human needs and environmental sensibilities (Allam et al. 2022).

Though the term 15-Minute City is relatively new, neighbourhood planning practice aiming to foster community and local travel to amenities is not. As recent examples, planned neighbourhoods dominated post-WWII built urban form: the Neighbourhood Unit Concept in the western world (Brody 2013) and a parallel concept of the “mikrorayons” neighbourhoods in the Soviet Union (Kissfazekas 2022). These planning forms have also been extensively critiqued: as summarized in Talen (2017), urban planners struggled to determine suitably universal design aspects such as neighborhood size, the type and quality of amenities, and local and regional connectivity. Social scientists also emphasized that top-down neighbourhood planning approaches overestimated the built environment’s influence on social life (Talen 2017). Neighbourhood planning approaches such as the 15-Minute City concept are being re-embraced by some, but from bottom-up perspective. How to equitably prescribe urban form that ‘enables’ contact with social opportunities (instead of ‘engendering it’ from the top-down) is still under debate. For instance, questions such as *what* are destinations that matter, by what mode and travel time threshold, and *for whom* remain under discussion among proximity-based planners who frequently use accessibility-based tools (Silva et al. 2023; Silva and Altieri 2022; Guzman, Oviedo, and Cantillo-Garcia 2024).

To clarify questions surrounding the 15-Minute City concept of what destinations matter and for whom, this work builds a theoretical bridge to “Mobility of Care”. The Mobility of Care term was coined in Sánchez de Madariaga (2013); it refers to all travel required to sustain the needs of a household, such as grocery shopping, escorting children, travelling to health appointments, and running errands. While decades of research have examined types of household-serving trips (e.g., shopping trips, escorting to school), Sánchez de Madariaga (2013) was the first to consider them all as one category. In doing so, Mobility of Care is shown to be a significant proportion of daily travel, characterizing the trip purpose of approximately 30% of adults’ trips (Sánchez de Madariaga 2013; Sánchez de Madariaga and Zucchini 2019; Ravensbergen, Fournier, and El-Geneidy 2023). We argue Mobility of Care is especially relevant to the 15-Minute City, as care trips are necessary for *all* people and they most often occur at the local level. Moreover, care trips take on tremendous gendered and socio-economic importance, as women, and especially those from lower income households, complete the majority of care trips (Ravensbergen, Fournier, and El-Geneidy 2023). Despite care travel’s importance in advancing gender equality and equity broadly, the examination of mobility of care and access to care destinations have been under-examined relative to employment destinations. This is especially pertinent in accessibility research that has largely focused on employment points of interest e.g., (Farber and Allen 2019; Duarte, Mota Silveira Neto, and Silva 2023; Ryan, Pereira, and Andersson 2023).

The objectives of this research are two-fold. First, we aim to theoretically bridge Mobility of Care with the 15-Minute City concept to to re-imagine what local amenities matter and define an associated accessibility and diversity of accessibility measure. Second, taking a bottom-up data-driven approach, we apply a classification and clustering machine learning methodologies to support the bottom-up identification of *15-minute caring neighbourhoods* through an empirical examination of the mid-cited city of Hamilton, Canada. These neighbourhoods are then interpreted on the continuum of having (and not having) the region-relative land-use and transportation infrastructure to support *completely caring* access. Who currently resides in which neighbourhood is examined, and ways to further expand the care accessibility story are discussed.

# Review of neighbourhood planning literature

## From the 15-Minute City to the NUC

In the last decades, the need for more sustainable, healthier, and liveable cities have received signficant attention. Planners and decision-makers have proposed alternatives to mobility-based neighbourhood planning principles to ones that center proximity to urban functions (Pozoukidou and Chatziyiannaki 2021). In this context, the 15-Minute City is now in the public spotlight (Logan et al. 2022; Moreno et al. 2021). In Moreno et al. (2021) where the 15-Minute City concept was introduced, four universal dimensions are outlined: density (in terms of people per km), diversity (including mixed-land use and diversity of people), the temporal and spatial proximity to essential services, and digitalisation. However, the framework presented has been criticized within academic and planning circles (Guzman, Oviedo, and Cantillo-Garcia 2024). Critiques highlight the concept falls short in addressing the pre-existing structural forces and individual characteristics that drive inequalities, influencing who benefits or could benefit the most from such a paradigm (Di Marino et al. 2023; Willberg, Fink, and Toivonen 2023). A 15-Minute City for all people is an aspirational ideal, but how will existing mobility and accessibility inequalities be addressed. Without directed and context-specific solutions, this increasingly popular concept risks becoming a place-branding slogan (Pozoukidou and Chatziyiannaki 2021).

Reflecting the flexible and aspirational presentation of the 15-Minute City; cities that have adopted the concept have done so using a diverse range of definitions and tools along with indistinct universal approaches. An early adopter was Portland, US in the Portland Plan (Portland 2010) of April 2012. It aims to foster an inclusive city development based on prosperity, education, health, and equity over a 30 year horizon. It promotes neighbourhood self-sufficiency and connectivity to city centers and centres of employment. The progress report describes a high-level focus on equitable service delivery to all residents with equity concerning topics related to racial equity and people with disabilities (Government 2017), similarly taking on an “all populations” approach. Later, other cities also incorporated proximity-based goals into their plans, adopting similar neutral entity approaches. For instance, in the plan that later catapulted the 15-Minute City into public discourse: Paris mayor Anne Hidalgo proposed a 15-minute city plan in her 2020 re-election campaign that foregrounded six social functions that should be easily accessible from any location, namely: housing, work, health care, groceries, education and leisure (Paris 2022). These ideas inspired language in the agendas of other cities in the Western world such as Ottawa, in the Canadian context, who also adopted a 15-Minutes approach in their recent Official Plan (d’Ottawa 2021). From the review of worldwide practice literature in Teixeira et al. (2024), the 15-Minute City concept is in early phases of implementation around the world and the diverse range of definitions, strategies, and instruments present a significant knowledge and implementation gap: the 15-Minute City is aspirational but *how do we get there and whom will benefit*?

The past can shed light on cautionary tales. While the 15-Minute City concept is new, neighbourhood planning to improve society outcomes is not: in fact the literature has drawn parallels from the 15-Minute City to Clarence A. Perry’s Neighbourhood Unit Concept (NUC) from the 1930s (Kissfazekas 2022). The NUC is a socio-spatial normative scheme widely adopted by government agencies (and the real-estate community) in the Western world after the Second World War (Talen 2017; Solow, Ham, and Donnelly 1969). Pairing well with the objectives of planning agencies at the time, Perry’s NUC would allow for efficient mass-building of cellular units that prioritized the perceived functional needs of women and children: each unit providing proximate access to an elementary school and supporting community facilities, shopping, parks and housing (Talen 2017; Brody 2013). The NUC primarily prioritized local service provision, though Perry had confidence in good design’s contribution to ‘neighbourhood spirit’ (Hall 2014). From the NUC’s conception until the end of the 1960s, planners’ aspirational attempts to prescribe social meaning to the neighbourhood’s physical form had been criticized to near extinction (Talen 2017). By social scientists, the overestimation on the impact of built environment on social life was critiqued. By other planners, the inability to agree on the specificity of the neighbourhood (i.e., population size and the type, quality, and quantity of amenity) as well as how neighbourhood units are connected to other neighbourhoods and the rest of the region. In response to these criticisms, neighbourhood planning proponents redefined deterministic terminology; their prescriptive physical form will ‘enable’ social contact with opportunities rather than ‘engendering’ it.

The re-defined bottom-up approach to community and neighbourhood planning has been adopted by New Urbanists, from which the 15-Minute City stems (Kissfazekas 2022); however, the effectiveness of these bottom-up processes remain to be seen due to the contemporary nature of the concept. Though, related research can be examined. In recent years, the question of *how can physical form be planned to enable an improved quality of life, and for whom with what outcomes* has occupied the urban planning research agenda. For instance, the examination of low-income households access to transportation and their likelihood of gaining employment (Blumenberg and Pierce 2017; Bastiaanssen, Johnson, and Lucas 2022) or the relationship between children’s access to public transit and participation in after-school activities (Palm and Farber 2020). A new wave of researchers and practitioners focused on local and context-specific relationships with the proximity to destinations have also emerged (Silva et al. 2023; Silva and Altieri 2022). As reviewed in the city plans that have adopted 15-Minute City approaches, the NUC’s criticisms, and recent urban planning research, the question of *how to enable improved quality of life through urban built environment* has shown to be highly context-sensitive, with the need for further investigation.

## Tools: accessibility methods, diversity measures and typology-classification

In examining how to enable improved quality of life through urban built environment, an increasingly popular tool have been accessibility measures. These measures are a way to quantify the ease of reaching destinations from a given point in space and have been used to examine urban areas through just and sustainable city planning agendas (Vale and Lopes 2023; S. Handy 2020). As the 15-Minute City is an amenity-provision neighbourhood planning concept which aims to enable urban environment that improves life quality, its analysis lends well to the use of accessibility tools (Guzman, Oviedo, and Cantillo-Garcia 2024). Foreseeably, recent works have applied accessibility measures to investigate the 15-Minute City across various geographic scopes. For instance, in Naples, Italy (Gaglione et al. 2022), Barcelona, Spain (Graells-Garrido et al. 2021), Vancouver, Canada (Hosford, Beairsto, and Winters 2022), and in urban areas across Europe (Vale and Lopes 2023). The “cumulative opportunity” measure has been applied to many 15-Minute City accessibility examinations. This form of accessibility quantifies how many destinations can be reached from a point in space within a given travel time threshold, pairing well with examinations that have a normative travel time threshold, like the 15-Minute City. Furthermore, the cumulative opportunity measure is widely appreciated for its intuitive computation and popularity among practitioners (S. Handy 2020; S. L. Handy and Niemeier 1997; L. Cheng et al. 2019). However, accessibility measures other than the cumulative opportunity have also been applied, reflecting the diversity of measures in the literature (Guzman, Oviedo, and Cantillo-Garcia 2024).

Another method which compliments the assessment of the 15-Minute City as it relates to the diversity of opportunity types, is entropy. The entropy measure has been widely used to characterise the diversity of land-use mix in early work by Frank et al. (2005) based on the species diversity Shannon-Wiener index that expresses relative evenness throughout a sequence (see review in Whittaker 1972). It has also been used in social sciences to comprehend the occurrence of social events in a structured manner specially with regard to life trajectories (Ritschard and Studer 2018). In the realm of urban studies and planning literature, the malleable concept of entropy has been used to characterise the diversity in land-use mix (Ewing and Cervero 2010), especially in the context of active modes (Lu, Xiao, and Ye 2017; Mavoa et al. 2018) and suburban sprawl (Randall and Baetz 2015). As well, it has been used to understand mobility behaviour (McBride, Davis, and Goulias 2020; Montero, Mejı́a-Dorantes, and Barceló 2023a, 2023b). Work that has used diversity indices alongside accessibility analysis are scarce, though examples of its use as parameters within accessibility scores in the case of employment opportunities (J. Cheng and Bertolini 2013; Dai et al. 2018) and more recently to describe the diversity in transit facilities (Yin, Zheng, and Li 2024) are present. To the authors knowledge, the use of an entropy measure to reflect the diversity in care destination amenity types and in context within a 15-minute neighbourhood, has yet to be done. However, entropy measures theoretically compliment the 15-Minute City concept.

In addition, classification algorithms have been useful tools in the identification of mobility and spatial typologies in relation to transportation planning. Machine learning approaches have often been deployed. For instance, Burke et al. (2022) uses spatially constrained multivariate clustering, a regionalisation technique, to develop urban form typologies related to the 15-Minute City. The k-means algorithm is another popular method; Gan et al. (2020) applies it to analyse travel behaviour and classify metro stations based on mobility patterns. Combing classification techniques is also common; for instance, Delmelle (2017) uses self-organizing maps (SOM) algorithm to group US neighbourhoods by minimising dissimilarity in attributes before applying k-means for further classification. Similarly, Victoriano, Paez, and Carrasco (2020) uses SOM to classify individuals’ travel patterns according to the dissimilarity in mobility attributes and uses the decision tree algorithm to partition the data into interpretable classifications.

All-in-all, within the context of examining the 15-Minute City, a variety of tools have been applied in the literature. However, the question of *15-minute cities for whom* sill demands further examination. This work aims to bridge the concept of the 15-Minute City with another normative framework: Mobility of Care.

## Mobility of Care and feminist 15-minute neighbourhoods

Rather than focusing on *all* destinations, it may valuable to examine those related to caring activities. This re-framing offers a feminist perspective on *what* urban functions matter, connecting well with the 15-Minute City concept. Caring activities, which meet the physical, psychological, and emotional needs of others, are among the most essential and fundamental activities in society (ILO 2018). Yet, they are the most unequal, undervalued, and even devalued activities worldwide. Conventionally, caring activities have been borne on women’s shoulders (Hayden 1982; Hochschild and Machung 2012). According to ILO (2018), women and girls perform more than three-quarters of the total amount of unpaid care, a gender gap that varies geographically (Ferrant, Pesando, and Nowacka 2014). This unequal share of caring responsibilities leads to multifaceted gendered differences: in career development, profession selection, contract type, pay gap, and time poverty, as recognized by various international organisations (EIGE 2016; ILO 2018). In terms of spatial and transportation planning, almost one third of daily trips are for care purposes (Sánchez de Madariaga 2013; Sánchez de Madariaga and Zucchini 2019; Ravensbergen, Fournier, and El-Geneidy 2023). From this research motivation, Sánchez de Madariaga coined the term Mobility of Care in 2013 to refer to all travel required to sustain the needs of a household, such as grocery shopping, escorting children, travelling to health appointments, and running errands (Sánchez de Madariaga 2013). While an undercurrent of research had examined these unique household-serving trips over the decades, her seminal work was the first to consider all these trips as one category and demonstrate how mobility of care is a significant proportion of daily travel.

The Mobility of Care concept also explicitly integrates inter-sectional equity considerations. In considering Mobility of Care within the 15-Minute City one could address a common criticism leveled at the 15-Minute City (Guzman, Oviedo, and Cantillo-Garcia 2024). Perhaps unsurprisingly given the gendered division of care work discussed, women have consistently been found to complete more mobility of care trips than men. In one study, mobility of care comprised 32% of women’s daily trips compared to 28% of men’s. While this gap is significant, it was found to be far greater in lower income households where women complete 20% more care trips than men (Ravensbergen, Fournier, and El-Geneidy 2023). Sánchez de Madariaga not only shows how important these mobility of care trips are, but also highlights the ways in which “mobility of care is systematically under-represented in any analysis of urban transport” (p. 37). As a product of the masculinst bias in planning, transport surveys and tools do not directly capture mobility of care, which re-enforces the idea that these trips are not a significant part of daily mobility. In this respect, the feminist perspective of the cities of proximity is still underestimated with only few examples on the topic (Gil Solá and Vilhelmson 2022; MacIntyre 2022).

Pairing well with the focus on shorter trips and the potential use of sustainable modes within the 15-Minute City, Mobility of Care trips are more local, shorter-distance and trip-chained. Compared to the trip to work, mobility of care trips are more frequently completed by foot, and less frequently by transit or bicycle (Ravensbergen, Fournier, and El-Geneidy 2023). However, little work to date examines walking to care destinations through the Mobility of Care framework. Though there is ample literature that examines walking to care destinations, such as schools (e.g., (Omura et al. 2019; Yu and Zhu 2016; Napier et al. 2011)) and grocery stores (e.g., (Morioka et al. 2023; Negron-Poblete, Séguin, and Apparicio 2016)), they tend to consider singular care destinations in research focusing on walkability.

The objectives of this research are two-fold. First, we aim to theoretically bridge Mobility of Care with the 15-Minute City concept to to re-imagine what local amenities matter and define an associated accessibility and diversity of accessibility measure. Second, taking a bottom-up data-driven approach, we apply a classification and clustering machine learning methodologies to support the bottom-up identification of *15-minute caring neighbourhoods* through an empirical examination of the mid-cited city of Hamilton, Canada. These neighbourhoods are then interpreted on the continuum of having (and not having) the region-relative land-use and transportation infrastructure to support *completely caring* access. Who currently resides in which neighbourhood is examined, and ways to further expand the care accessibility story are discussed.

Due to it’s popularity, the 15-Minute Concept is moving city planning towards a more people-centered approach focusing on accessibility to basic needs. While an aspirational ideal, the concept has faced criticism as a inadequately providing a way forward to address structural inequalities. In this context, we bridge the 15-Minute City with the Mobility of Care concept, to add significance to what destinations and associated trips matter for all, but especially along gendered and socio-economic lines. We apply the “Caring 15-Minute City” concept to measure what neighourhoods in the mid-size Canadian city of Hamilton have the potential to be “caring 15 minute neighbourhoods”. Making use of the tools reviewed and applied in the transportation research, the objectives of the paper are completed as follows:

1. The cumulative accessibility measure and the entropy measure are used to quantify both the level of access and the diversity of access to care destinations within a 15-minute walk.
2. Based on these accessibility and diversity outputs, “Completely Caring 15-Minute Neighbourhood” typologies are generated using the SOM algorithm.
3. A decision tree is then applied to these typologies and socio-economic variables of populations who reside in these neighbourhoods. This is done to delineate data-driven profiles on which groups have the potential to benefit from what Completely Caring 15-Minute Neighbourhood.

# Data

## Case study context

This work focuses on Hamilton, Ontario, a mid-sized city on the shore of Lake Ontario. Hamilton has a heterogenous land-use, with a populated and dense urban core, surrounded by suburban development, which is itself surrounded by rural communities. The Niagara Escarpment runs through Hamilton, and results in a city with two key elevations: a more dense lower city that contains the downtown core and the elevated suburban development referred to as ‘the Mountain’. In this work, we analyse the residential parcel centroids, 143,882 locations. We aggregated the points at the level of Canadian Census Dissemination Area (DA) along with the population and population per parcel plots in [Figure 1](#fig-Fig1).

|  |
| --- |
| Figure 1: The number of residential parcels per DA in 2020 (top), the population (middle) retrieved from the 2021 Canadian Census, and the rate of population per parcel per DA (bottom). All scales in quartiles. Basemap shapefiles are sourced from the Open Data Hamilton Portal (Hamilton 2023b) and the USGS (USGS 2010). |

Hamilton also exhibits spatial disparities in social and economic indicators; their spatial distribution is visualised in [Figure 2](#fig-Fig2). The densely populated inner city is characterised by lower average incomes, and a higher prevalence of households living under the low-income cutoff thresholds (LICO). Noteably, the suburban areas of the city tend to have a greater proportion of children and a lower proportion of one parent households.

|  |
| --- |
| Figure 2: Socio-economic and demographic variables that characterise accessibility to care destinations retrieved from the 2021 Canadian Census. All scales in quartiles. Basemap shapefiles are sourced from the Open Data Hamilton Portal (Hamilton 2023b) and the USGS (USGS 2010). |

## Care destination dataset

A spatial dataset of care destinations for Hamilton was carefully compiled. The dataset includes 14 types of destinations that were placed by authors in ( *work removed for double-blind review* ) into four categories: dependent-centric (e.g., the destinations for child- and elder-centric escorting trips), grocery-centric, health-centric, and errand-centric. Notably, these categories were generated following the travel purpose categories created in the mobility of care research by Sánchez de Madariaga and Zucchini (2019). Category sources of data and preparation notes are detailed in [Table 1](#tbl-Tbl1). The spatial distribution of destination type are visualised in [Figure 3](#fig-Fig3) by their category.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 1: Details on the preparation and data sources of care destinations.   | Care category | Sources | Data preparation notes | | --- | --- | --- | | Depedent-centric | (Hamilton 2022a, 2023, 2022c, 2022d; Ontario 2023b; Ontario GeoHub 2023) | Schools, daycares, and community centres, recreation centres, parks, senior centres, long-term care homes, and retirement homes: 1,265 locations are included. After manual review, all locations that typically do not serve children were removed including: Post-Secondary, Adult-Learning Centres, Group Homes, and Foster Care Centres. Further, through examination some Section 23 institutions defined as *“centres for children who cannot attend school to meet the needs of care or treatment, and rehabilitation”* (Ontario 2023a), were kept due to their innate connection to care. | | Grocery-centric | (Axle Data 2023) | Grocery stores, namely a place a household could buy groceries ranging from convenience stores to large retail stores: 381 destinations are identified. Data is filtered by Company Name, Suite Number, Address, City, Province, Phone Number and Postal Code. The type was then identified e.g., grocers specialty foods, grocers retail, grocer health food, grocer wholesale, grocer curbside, grocer delicatessen wholesale, grocer convenience. Data was cross-referenced to ensure all included locations were operational and legitimate grocery stores. | | Health-centric | (Ontario GeoHub 2023; HNHB Healthline 2023) | Hospitals, pharmacies, clinics, and dentist offices: 421 destinations are identified. Hospitals and pharmacies were retrieved while clinics and dentistry clinics were manually scraped from a healthcare services database and checked via Google Maps to remove non-operational locations and confirm dentistry-orientation. | | Errand-centric | Hamilton libraries (Hamilton 2022b), post office locations (Axle Data 2023; Canada Post 2023), and datasets of all national bank chains (BMO 2023; HSBC 2023; National Bank 2023; RBC 2023; Scotiabank 2023; TD Bank 2023). | Libraries, post offices, and banks: 158 destinations are identified. Post offices are retrieved from a mix of databases, and duplicates are removed. Banks are also derived from Data Axle and then cross-referenced to ensure data quality with a Bank Locator website for all national banking firms. | |
| Figure 3: The locations of care destinations in Hamilton separated by the author-generated categories of: dependent-, errand-, grocery- and health- centric care categories. Basemap shapefiles are sourced from the Open Data Hamilton Portal (Hamilton 2023b) and the USGS (USGS 2010). |

## Travel time to care estimations

Summarized in the literature review, empirical travel behaviour to care-oriented destinations is often uncounted and thus travel time is unavailable. Hence in this work, travel time from the residential parcel locations and care destination locations is approximated for walking assuming an average speed (3.6 km/hr) using the ‘travel\_time\_matrix()’ function from the {r5r} package (Pereira et al. 2021). The inputs into the function are: the 143,882 locations of residential parcels as origins, the 2,225 care locations as destinations, and a OpenStreetMap road network including walking infrastructure (Geofabrik 2023). In theme with what destinations can be reached within 15-Minutes, a maximum walking travel time of 15 minutes is selected, and an origin-destination travel time matrix of the shortest travel time from origin to destination is calculated. The resulting matrix contains 2,014,502 rows, representing walking travel times from each parcel to reachable care destinations within 15 minutes.

# Methods

In the following sections, the methods taken to calculate the accessibility to each of the 14 destination types from each of the 143,882 residential parcel locations are detailed. Then, the entropy measures used to calculate the diversity of accessibility to each of the care categories is described. Subsequently, the accessibility and diversity of accessibility values associated with each residential parcel location are fed into a self-organizing map (SOM) algorithm. The resulting output is then classified into 7 superclusters the amount of “caring access” and “completeness” of this access. A Decision Tree, using the superclusters as features and socio-economic variables for the populations who reside in the city as lavels, is generated to identify patterns on who may benefit (or be excluded from) the potential of Completely Caring 15-Minute Neighbourhoods.

In sum, this methodology presents a data-driven approach to examine what neighbourhoods in a city have the potential to provide 15-minute caring access, at what level of intensity and completeness, as well as in who may be residing in areas that benefit the most.

## Accessibility: the cumulative opportunity measure

To capture the quantity of access to each type of destinations, a cumulative opportunity accessibility score is calculated. 14 scores for each type of care destination is calculated for every parcel . The calculation takes the following mathematical form:

Where:

* is a set of parcel point origin locations.
* is a set of care destination locations of type .
* is a number of opportunities of category type at .
* is the travel cost between and .
* is an impedance function of ; within the cumulative opportunity approach, it is a binary function that takes the value of 1 if is less than a selected value (S. L. Handy and Niemeier 1997).
* is the cumulative opportunity accessibility score, the sum of weighted opportunities reachable within , at each for each .

## Diversity in opportunity accessibility: the entropy measure

To represent the diversity of care destination accessibility, the entropy measure is used. A value is calculated for each parcel that ranges between 0 to 1, where 1 represents total evenness in the number of care opportunities in each category that can be reached.

The mathematical formulation of takes the following form:

Where:

* is a set of parcel point origin locations.
* is a set of care destination types (e.g., school, grocery, park, etc.)
* is the count of care destination types . In this work, this value is 14.
* is the cumulative opportunity accessibility score, the sum of weighted opportunities reachable within a 15-minute walk from .
* is the diversity score. As represents evenness in type of categories, so if a parcel has a access score of =0.5 for all types of destinations it will be assigned = 1 in the same was as if it had a score of =10 for each type of destination. Contrariwise, a parcel can be assigned a low score if it has low but different accessibility scores for each category as well as if it has high but different scores for each category.

## Machine learning classification: self-organizing maps and decision trees

In this work, we use two machine learning techniques. First, SOM is an unsupervised technique implemented to reduce the data dimensional and create interpretable clusters related to the intensity and completeness of caring access. This is done by imputing each parcel as an observation with its associated accessibility and diversity attributes, and the data being rearranged onto a two-dimensional space based on its minimizing dissimilarity in its neighbourhood. Then, a decision tree is run to characterise the socio-economic profile of who resides in neighbourhoods associated with certain (in)complete and (un)caring accessibility clusters. Together, this combined approach leverages the unsupervised data-driven classification power of the SOM with the interpretation of decision trees. The procedure used in this work is similar to the approache used in Victoriano, Paez, and Carrasco (2020). However, instead of each observation representing an individual’s daily mobility behaviour (with associated variables), here each observation represents a parcel location with calculated care accessibility and diversity of type of care accessibility scores.

For the SOM step, the SOM implementation in the function ‘trainSOM()’ from {SOMbrero} R package is used (Villa-Vialaneix 2017). The input variables include the 143,882 parcels, each as individual observations along with 15 variables: the 14 calculated accessibility scores $S\_i^$, normalized to the min-max range score within each , and one diversity value . Otherwise, defaults for all other parameters are assumed, relying on the data-driven heuristics embedded in the ‘trainSOM()’ function. Consequently, a 100 node (10 by 10 grid) SOM structure using euclidean distance and square topology is produced. Simply put, the SOM algorithm proceeds as follows: a 2D grid of nodes is created (in our case 100 nodes) as specified by the analyst, where each node will represent a point in the reduced-dimensional space. Upon initialization, each node is assigned a random weight vector of the same dimension as the input data (in our case, 15). From the input data, a random observation with its associated weight vector (i.e., one parcel point with 15 variables) is selected and the Euclidean distance between its weight vector and all nodes in the grid is calculated. The node with the smallest distance (i.e., the smallest dissimilarity) is labelled the ‘best matching unit’ as it is the node that best represents the input observation. After this best matching unit is identified, its own weight and its neighbouring nodes are updated to become more like the input observation. The process of finding best matching units and updating their weights is repeated for every observation, multiple times, until the results converge. As mentioned, this competitive learning process produces a 100 node SOM structure where each observation (parcel) is assigned to 1 node with an associated dissimilarity index. The SOM output is typically examined through a dissimilarity dendogram and an associated dissimilarity variance explained plot to select an appropriately representative ‘superclusters’ (Villa-Vialaneix 2017; Victoriano, Paez, and Carrasco 2020).

For the decision tree step, the supercluster-classified parcels identified in the SOM step are used as *labels* and socio-economic and demographic indicators available from the most recent Canadian Census related to the mobility of care literature are used as *features*. This step is used to profile the superclusters so we may explore who reside in what supercluster in a data-driven way. To estimate the decision tree, the ‘rpart()’ function in the {rpart} R package is used (Therneau and Atkinson 2023); default parameters for classification splitting along with each value being weighted by the population present in the associated DA is assumed. To summarize the decision tree algorithm, it is a supervised learning technique that begins by splitting a subset of the input data into branches based on a selected feature with the lowest impurity score (i.e., the least mixing of label membership within a branch). This process is recursively repeated for each data subset, selecting the next best features. Ultimately, the data is classified into distinct classes, with class membership explained by traversing the branches defined by the features that characterise the partitions within the decision tree. Notably, the absence of features from the decision tree does not necessarily imply they are irrelevant for classification, rather, they are just less relevant than other features. Put another way, when considering features that are highly correlated, such as income level and LICO, not all relevant variables may be present in the tree (Victoriano, Paez, and Carrasco 2020).

–> –>

–>

–>

–>

–>

–>

–>

# References

Allam, Zaheer, Mark Nieuwenhuijsen, Didier Chabaud, and Carlos Moreno. 2022. “The 15-Minute City Offers a New Framework for Sustainability, Liveability, and Health.” *The Lancet Planetary Health* 6 (3): e181–83.

Axle Data. 2023. “Consumer Data.” Aggregated Database. <https://www.data-axle.com/our-data/>.

Bastiaanssen, J, D Johnson, and K Lucas. 2022. “Does Better Job Accessibility Help People Gain Employment? The Role of Public Transport in Great Britain.” *URBAN STUDIES*. <https://doi.org/10.1177/00420980211012635>.

Blumenberg, E, and G Pierce. 2017. “The Drive to Work: The Relationship Between Transportation Access, Housing Assistance, and Employment Among Participants in the Welfare to Work Voucher Program.” *JOURNAL OF PLANNING EDUCATION AND RESEARCH* 37 (1): 66–82. <https://doi.org/10.1177/0739456X16633501>.

BMO. 2023. “Bank of Montreal (BMO) - Branch and ABM Locator.” Web Page. <https://branchlocator.bmo.com/index.html>.

Brody, Jason. 2013. “The Neighbourhood Unit Concept and the Shaping of Land Planning in the United States 1912–1968.” *Journal of Urban Design* 18 (3): 340–62. <https://doi.org/10.1080/13574809.2013.800453>.

Burke, Jeremy, Ramon Gras Alomà, Fernando Yu, and Jordan Kruguer. 2022. “Geospatial Analysis Framework for Evaluating Urban Design Typologies in Relation with the 15-Minute City Standards.” *Journal of Business Research* 151 (November): 651–67. <https://doi.org/10.1016/j.jbusres.2022.06.024>.

Canada Post. 2023. “Canada Post Office Locator.” Web Page. <https://www.canadapost-postescanada.ca/information/app/fpo/personal/findpostoffice>.

Cheng, Jianquan, and Luca Bertolini. 2013. “Measuring Urban Job Accessibility with Distance Decay, Competition and Diversity.” *Journal of Transport Geography* 30 (June): 100–109. <https://doi.org/10.1016/j.jtrangeo.2013.03.005>.

Cheng, Long, Freke Caset, Jonas De Vos, Ben Derudder, and Frank Witlox. 2019. “Investigating Walking Accessibility to Recreational Amenities for Elderly People in Nanjing, China.” *Transportation Research Part D: Transport and Environment* 76: 85–99. <https://doi.org/10.1016/j.trd.2019.09.019>.

d’Ottawa, Ville. 2021. “Quartier Du Quart d’heure Nouveau Plan Officiel Participons Ottawa.” <https://participons.ottawa.ca/nouveau-plan-officiel/news_feed/quartier-du-quart-d-heure>.

Dai, Te-qi, Zheng-bing Liu, Cong Liao, and Hong-yu Cai. 2018. “Incorporating Job Diversity Preference into Measuring Job Accessibility.” *Cities* 78 (August): 108–15. <https://doi.org/10.1016/j.cities.2018.02.003>.

Delmelle, Elizabeth C. 2017. “Differentiating Pathways of Neighborhood Change in 50 u.s. Metropolitan Areas.” *Environment and Planning A: Economy and Space* 49 (10): 2402–24. <https://doi.org/10.1177/0308518X17722564>.

Di Marino, Mina, Elisabete Tomaz, Cristina Henriques, and Seyed Hossein Chavoshi. 2023. “The 15-Minute City Concept and New Working Spaces: A Planning Perspective from Oslo and Lisbon.” *European Planning Studies* 31 (3): 598–620. <https://doi.org/10.1080/09654313.2022.2082837>.

Duarte, Leandro Batista, Raul da Mota Silveira Neto, and Diego Firmino Costa da Silva. 2023. “The Influence of Job Accessibility on Individual Labor Income: Evidence for the City of Recife, Brazil.” Journal Article. *Journal of Transport Geography* 112. <https://doi.org/10.1016/j.jtrangeo.2023.103684>.

EIGE. 2016. “Gender in Employment.” <https://eige.europa.eu/sites/default/files/documents/ti_pubpdf_mh0216898enn_pdfweb_20170124124440.pdf>.

Ewing, Reid, and Robert Cervero. 2010. “Travel and the Built Environment: A Meta-Analysis.” *Journal of the American Planning Association* 76 (3): 265–94. <https://doi.org/10.1080/01944361003766766>.

Farber, Steve, and Jeff Allen. 2019. “The Ontario Line: Socioeconomic Distribution of Travel Time and Accessibility Benfits.” Report. Metrolinx. <https://metrolinx.files.wordpress.com/2019/10/read-the-full-report-here.pdf>.

Ferrant, Gaëlle, Luca Maria Pesando, and Keiko Nowacka. 2014. “Unpaid Care Work: The Missing Link in the Analysis of Gender Gaps in Labour Outcomes.” Journal Article. *Boulogne Billancourt: OECD Development Center*.

Frank, Lawrence D., Thomas L. Schmid, James F. Sallis, James Chapman, and Brian E. Saelens. 2005. “Linking Objectively Measured Physical Activity with Objectively Measured Urban Form.” *American Journal of Preventive Medicine* 28 (2): 117–25. <https://doi.org/10.1016/j.amepre.2004.11.001>.

Gaglione, Federica, Carmela Gargiulo, Floriana Zucaro, and Caitlin Cottrill. 2022. “Urban Accessibility in a 15-Minute City: A Measure in the City of Naples, Italy.” *Transportation Research Procedia* 60: 378–85. <https://doi.org/10.1016/j.trpro.2021.12.049>.

Gan, Zuoxian, Min Yang, Tao Feng, and Harry Timmermans. 2020. “Understanding Urban Mobility Patterns from a Spatiotemporal Perspective: Daily Ridership Profiles of Metro Stations.” *Transportation* 47 (1): 315–36. <https://doi.org/10.1007/s11116-018-9885-4>.

Geofabrik. 2023. “Ontario, Canada - Open Street Map Data.” Online Database. <https://www.geofabrik.de>.

Gil Solá, Ana, and Bertil Vilhelmson. 2022. “To Choose, or Not to Choose, a Nearby Activity Option: Understanding the Gendered Role of Proximity in Urban Settings.” *Journal of Transport Geography* 99 (February): 103301. <https://doi.org/10.1016/j.jtrangeo.2022.103301>.

Government, Portland. 2017. “The Portland Plan Progress Report.”

Graells-Garrido, E., F. Serra-Burriel, F. Rowe, F. M. Cucchietti, and P. Reyes. 2021. “A City of Cities: Measuring How 15-Minutes Urban Accessibility Shapes Human Mobility in Barcelona.” Journal Article. *PLoS One* 16 (5): e0250080. <https://doi.org/10.1371/journal.pone.0250080>.

Guzman, Luis A., Daniel Oviedo, and Victor A. Cantillo-Garcia. 2024. “Is Proximity Enough? A Critical Analysis of a 15-Minute City Considering Individual Perceptions.” *Cities* 148 (May): 104882. <https://doi.org/10.1016/j.cities.2024.104882>.

Hall, Peter. 2014. *Cities of Tomorrow: An Intellectual History of Urban Planning and Design Since 1880*. John Wiley & Sons.

Hamilton. 2022a. “Educational Institutions.” Aggregated Database. Open Data Hamilton. <https://open.hamilton.ca/datasets/cccae6f029334927856da6e20a50561f_19/explore>.

———. 2022b. “Libraries.” Aggregated Database. <https://open.hamilton.ca/datasets/67a54ea25d944cf7b66750ba57da822c_1/explore?location=43.259483%2C-79.917850%2C11.81>.

———. 2022c. “Parks Database.” Aggregated Database. <https://open.hamilton.ca/datasets/4f1b554e743b423f9574e7a3ca814cce_6/explore?location=43.273379%2C-79.919100%2C11.87&showTable=true>.

———. 2022d. “Recreation and Community Centres.” Aggregated Database. <https://open.hamilton.ca/datasets/272667665de646768db14e9fa1676405_11/explore?location=43.278136%2C-79.921850%2C11.65>.

———. 2023a. “Child Care Registry.” Aggregated Database. <https://www.hamilton.ca/people-programs/early-years-child-care/child-care-services/child-care-registry>.

———. 2023b. “City Boundary.” <https://open.hamilton.ca/datasets/dd522e1245b1461887d998c6c17edff7_13/explore?location=43.099541%2C-79.560176%2C9.73>.

Handy, S L, and D A Niemeier. 1997. “Measuring Accessibility: An Exploration of Issues and Alternatives.” *Environment and Planning A: Economy and Space* 29 (7): 1175–94. <https://doi.org/10.1068/a291175>.

Handy, Susan. 2020. “Is Accessibility an Idea Whose Time Has Finally Come?” *Transportation Research Part D: Transport and Environment* 83: 102319. https://doi.org/<https://doi.org/10.1016/j.trd.2020.102319>.

Hayden, Dolores. 1982. *The Grand Domestic Revolution: A History of Feminist Designs for American Homes, Neighborhoods, and Cities*. First MIT Press paperback edition. Cambridge, Massachusetts London: The MIT Press.

HNHB Healthline. 2023. “Amilton Niagara Haldimand Brant - Walk-in Medical Clinics.” Web Page. <https://www.hnhbhealthline.ca/listServices.aspx?id=10072&region=Hamilton>.

Hochschild, Arlie, and Anne Machung. 2012. *The Second Shift: Working Families and the Revolution at Home*. Penguin. <https://books.google.de/books?hl=de&lr=&id=St_6kWcPJS8C&oi=fnd&pg=PT25&ots=8IZZkZu4cf&sig=W1cAH6vLmc8SUYRgLvUUz3zfHWs&redir_esc=y#v=onepage&q&f=false>.

Hosford, Kate, Jeneva Beairsto, and Meghan Winters. 2022. “Is the 15-Minute City Within Reach? Evaluating Walking and Cycling Accessibility to Grocery Stores in Vancouver.” *Transportation Research Interdisciplinary Perspectives* 14 (June): 100602. <https://doi.org/10.1016/j.trip.2022.100602>.

HSBC. 2023. “The Hongkong and Shanghai Banking Corporation Limited (HSBC) Branch and ABM Locator.” Web Page. <https://www.hsbc.ca/branch-locator/>.

ILO. 2018. “Care Work and Care Jobs for the Future of Decent Work.” Geneva: International Labour Organization. <https://webapps.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_633135.pdf>.

Kissfazekas, Kornelia. 2022. “Circle of Paradigms? Or ‘15-Minute’ Neighbourhoods from the 1950s.” *Cities* 123 (April): 103587. <https://doi.org/10.1016/j.cities.2022.103587>.

Logan, T. M., M. H. Hobbs, L. C. Conrow, N. L. Reid, R. A. Young, and M. J. Anderson. 2022. “The x-Minute City: Measuring the 10, 15, 20-Minute City and an Evaluation of Its Use for Sustainable Urban Design.” *Cities* 131: 103924.

Lu, Yi, Yang Xiao, and Yu Ye. 2017. “Urban Density, Diversity and Design: Is More Always Better for Walking? A Study from Hong Kong.” *Preventive Medicine* 103 (October): S99–103. <https://doi.org/10.1016/j.ypmed.2016.08.042>.

MacIntyre, Sorcha. 2022. “Her 20-Minute Neighbourhood. A Critical Feminist Review of Women’s Experiences of the 20-Minute Neighbourhood in Corstorphine, Edinburgh.” Master’s thesis, University of Groningen Faculty of Spatial Sciences Research. <https://frw.studenttheses.ub.rug.nl/3996/>.

Mavoa, Suzanne, Claire Boulangé, Serryn Eagleson, Joshua Stewart, Hannah M Badland, Billie Giles-Corti, and Lucy Gunn. 2018. “Identifying Appropriate Land-Use Mix Measures for Use in a National Walkability Index.” *Journal of Transport and Land Use* 11 (1): 681–700. <https://www.jstor.org/stable/26622423>.

McBride, Elizabeth Callahan, Adam Wilkinson Davis, and Konstadinos G Goulias. 2020. “Exploration of Statewide Fragmentation of Activity and Travel and a Taxonomy of Daily Time Use Patterns Using Sequence Analysis in California.” *Transportation Research Record* 2674 (12): 38–51.

Montero, Lı́dia, Lucı́a Mejı́a-Dorantes, and Jaume Barceló. 2023a. “Applying Data Analytics to Analyze Activity Sequences for an Assessment of Fragmentation in Daily Travel Patterns: A Case Study of the Metropolitan Region of Barcelona.” *Sustainability* 15 (19): 14213.

———. 2023b. “The Role of Life Course and Gender in Mobility Patterns: A Spatiotemporal Sequence Analysis in Barcelona.” *European Transport Research Review* 15 (1): 44.

Moreno, Carlos. 2016. “La Ville Du Quart d’heure : Pour Un Nouveau Chrono-Urbanisme. La Tribune.” October 5, 2016. <https://www.latribune.fr/regions/smart-cities/la-tribune-de-carlos-moreno/la-ville-du-quart-d-heure-pour-un-nouveau-chrono-urbanisme-604358.html>.

Moreno, Carlos, Zaheer Allam, Didier Chabaud, Catherine Gall, and Florent Pratlong. 2021. “Introducing the ‘15-Minute City’: Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities.” *Smart Cities* 4 (1): 93–111. <https://doi.org/10.3390/smartcities4010006>.

Morioka, Wataru, Mei-Po Kwan, Kimihiro Hino, and Ikuho Yamada. 2023. “How Accessibility to Neighborhood Grocery Stores Is Related to Older People’s Walking Behavior: A Study of Yokohama, Japan.” Journal Article. *Journal of Transport & Health* 32: 101668. https://doi.org/<https://doi.org/10.1016/j.jth.2023.101668>.

Mulíček, Ondřej, Robert Osman, and Daniel Seidenglanz. 2015. “Urban Rhythms: A Chronotopic Approach to Urban Timespace.” *Time & Society* 24 (3): 304–25. <https://doi.org/10.1177/0961463X14535905>.

Napier, Melissa A., Barbara B. Brown, Carol M. Werner, and Jonathan Gallimore. 2011. “Walking to School: Community Design and Child and Parent Barriers.” Journal Article. *Journal of Environmental Psychology* 31 (1): 45–51. https://doi.org/<https://doi.org/10.1016/j.jenvp.2010.04.005>.

National Bank. 2023. “National Bank Branches Locator.” Web Page. <https://locator.nbc.ca/?=&referrerPageUrl=https%3A%2F%2Fwww.google.com%2F&query=&facetFilters=%7B%7D&filters=%7B%7D>.

Negron-Poblete, Paula, Anne-Marie Séguin, and Philippe Apparicio. 2016. “Improving Walkability for Seniors Through Accessibility to Food Stores: A Study of Three Areas of Greater Montreal.” Journal Article. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability* 9 (1): 51–72. <https://doi.org/10.1080/17549175.2014.990916>.

Omura, John D., Eric T. Hyde, Kathleen B. Watson, Sarah A. Sliwa, Janet E. Fulton, and Susan A. Carlson. 2019. “Prevalence of Children Walking to School and Related Barriers—United States, 2017.” Journal Article. *Preventive Medicine* 118: 191–95. https://doi.org/<https://doi.org/10.1016/j.ypmed.2018.10.016>.

Ontario. 2023a. “Ministry of Education - Funding for an Education and Community Partnership Program (ECPP).” Web Page. <https://efis.fma.csc.gov.on.ca/faab/Section%2023.htm>.

———. 2023b. “Ontario Data Catalogue.” Web Page. <https://data.ontario.ca/>.

Ontario GeoHub. 2023. “Ministry of Health Service Provider Locations.” Aggregated Database. <https://geohub.lio.gov.on.ca/datasets/ministry-of-health-service-provider-locations/explore?showTable=true>.

Palm, Matthew, and Steven Farber. 2020. “The Role of Public Transit in School Choice and After-School Activity Participation Among Toronto High School Students.” *Travel Behaviour and Society* 19 (April): 219–30. <https://doi.org/10.1016/j.tbs.2020.01.007>.

Paris, Ville de. 2022. “Paris Ville Du Quart d’heure, Ou Le Pari de La Proximité.” <https://www.paris.fr/dossiers/paris-ville-du-quart-d-heure-ou-le-pari-de-la-proximite-37>.

Pereira, Rafael H. M., Marcus Saraiva, Daniel Herszenhut, Carlos Kaue Vieira Braga, and Matthew Wigginton Conway. 2021. “R5r: Rapid Realistic Routing on Multimodal Transport Networks with R5 in r.” Journal Article. *Findings*. <https://doi.org/10.32866/001c.21262>.

Portland, City of. 2010. “20-Minute Neighborhoods.” *Portland Plan*. <https://www.portlandonline.com/portlandplan/index.cfm?c=52256&a=288098>.

Pozoukidou, Georgia, and Zoi Chatziyiannaki. 2021. “15-Minute City: Decomposing the New Urban Planning Eutopia.” *Sustainability* 13 (2): 928. <https://doi.org/10.3390/su13020928>.

Randall, Todd A, and Brian W Baetz. 2015. “A <Span Style="font-Variant:small-Caps;">GIS</Span> ‐Based Land‐use Diversity Index Model to Measure the Degree of Suburban Sprawl.” *Area* 47 (4): 360–75. <https://doi.org/10.1111/area.12182>.

Ravensbergen, Léa, Juliette Fournier, and Ahmed El-Geneidy. 2023. “Exploratory Analysis of Mobility of Care in Montreal, Canada.” *Transportation Research Record* 2677 (1): 1499–509.

RBC. 2023. “Royal Bank of Canada (RBC) - Branch and ABM Locator.” Web Page. <https://maps.rbc.com/rbcbank/>.

Ritschard, Gilbert, and Matthias Studer, eds. 2018. *Sequence Analysis and Related Approaches: Innovative Methods and Applications*. Vol. 10. Life Course Research and Social Policies. Cham: Springer International Publishing. <https://doi.org/10.1007/978-3-319-95420-2>.

Ryan, Jean, Rafael H. M. Pereira, and Magnus Andersson. 2023. “Accessibility and Space-Time Differences in When and How Different Groups (Choose to) Travel.” Journal Article. *Journal of Transport Geography* 111. <https://doi.org/10.1016/j.jtrangeo.2023.103665>.

Sánchez de Madariaga, Inés. 2013. “Mobility of Care: Introducing New Concepts in Urban Transport.” Book Section. In *Fair Shared Cities: The Impact of Gender Planning in Europe*, edited by Sánchez de Madariaga I. and M. Roberts.

Sánchez de Madariaga, Inés, and Elena Zucchini. 2019. “Measuring Mobilities of Care, a Challenge for Transport Agendas.” Book Section. In *Integrating Gender into Transport Planning*, edited by T. Joelsson C. L. Scholten.

Scotiabank. 2023. “Scotiabank ABM and Branch Locator.” Web Page. <https://maps.scotiabank.com/locator/index.html>.

Silva, Cecília, and Marcelo Altieri. 2022. “Is Regional Accessibility Undermining Local Accessibility?” *Journal of Transport Geography* 101 (May): 103336. <https://doi.org/10.1016/j.jtrangeo.2022.103336>.

Silva, Cecília, Benjamin Büttner, Sebastian Seisenberger, and Anna Rauli. 2023. “Proximity-Centred Accessibility—a Conceptual Debate Involving Experts and Planning Practitioners.” *Journal of Urban Mobility* 4 (December): 100060. <https://doi.org/10.1016/j.urbmob.2023.100060>.

Solow, Anatole A, Clifford C Ham, and E Owen Donnelly. 1969. *The Concept of the Neighborhood Unit: Its Emergence and Influence on Residential Environmental Planning and Development*. Graduate School of Public; International Affairs, University of Pittsburgh.

Talen, Emily. 2017. “Social Science and the Planned Neighbourhood.” *Town Planning Review* 88 (3): 349–73. <https://doi.org/10.3828/tpr.2017.22>.

TD Bank. 2023. “The Toronto Dominion Bank (TD) - Bank Branch and ABM Locator.” Web Page. <https://www.td.com/ca/en/personal-banking/branch-locator#/>.

Teixeira, João Filipe, Cecília Silva, Sebastian Seisenberger, Benjamin Büttner, Bartosz McCormick, Enrica Papa, and Mengqiu Cao. 2024. “Classifying 15-Minute Cities: A Review of Worldwide Practices.” *Transportation Research Part A: Policy and Practice* 189 (November): 104234. <https://doi.org/10.1016/j.tra.2024.104234>.

Therneau, Terry, and Beth Atkinson. 2023. *Rpart: Recursive Partitioning and Regression Trees*. <https://github.com/bethatkinson/rpart>.

USGS. 2010. “Great Lakes and Watersheds Shapefiles.” <https://www.sciencebase.gov/catalog/item/530f8a0ee4b0e7e46bd300dd>.

Vale, David, and André Soares Lopes. 2023. “Accessibility Inequality Across Europe: A Comparison of 15-Minute Pedestrian Accessibility in Cities with 100,000 or More Inhabitants.” *Npj Urban Sustainability* 3 (1): 55.

Victoriano, Rodrigo, Antonio Paez, and Juan-Antonio Carrasco. 2020. “Time, Space, Money, and Social Interaction: Using Machine Learning to Classify People’s Mobility Strategies Through Four Key Dimensions.” *Travel Behaviour and Society* 20 (July): 1–11. <https://doi.org/10.1016/j.tbs.2020.02.004>.

Villa-Vialaneix, Nathalie. 2017. “Stochastic Self-Organizing Map Variants with the r Package SOMbrero.” In *Proceedings of the 12th International Workshop on Self-Organizing Maps and Learning Vector Quantization, Clustering and Data Visualization (WSOM 2017)*, edited by Lamirel JC, Cottrell M, and Olteanu M, 1–7. IEEE, Nancy, France.

Whittaker, Robert H. 1972. “Evolution and Measurement of Species Diversity.” *Taxon* 21 (2-3): 213–51.

Willberg, Elias, Christoph Fink, and Tuuli Toivonen. 2023. “The 15-Minute City for All? – Measuring Individual and Temporal Variations in Walking Accessibility.” *Journal of Transport Geography* 106 (January): 103521. <https://doi.org/10.1016/j.jtrangeo.2022.103521>.

Yin, Zijuan, Yan Zheng, and Wenquan Li. 2024. “Incorporating Facility Diversity into Measuring Accessibility to Transit: A Case Study in Beijing.” *Journal of Urban Planning and Development* 150 (3): 05024018. <https://doi.org/10.1061/JUPDDM.UPENG-4935>.

Yu, Chia-Yuan, and Xuemei Zhu. 2016. “From Attitude to Action: What Shapes Attitude Toward Walking to/from School and How Does It Influence Actual Behaviors?” Journal Article. *Preventive Medicine* 90: 72–78. https://doi.org/<https://doi.org/10.1016/j.ypmed.2016.06.036>.