The urban quest for happiness

Do transit-friendly neighborhoods make for healthier and happier residents?

À la recherche du bonheur urbain

Les quartiers favorables à l'utilisation des transports publiques promeuvent-ils le bien-être et la santé de leur population?

Supervised Research Project Report

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Policy Brief

The issue

At the urban level, sustainability-oriented plans promote compact development and increased investments on transit and active travel modes. Objective indicators used to evaluate them provide a partial understanding of their success. Subjective measures of happiness and health can provide a more complete understanding of the social impact and attractiveness of policies. The present document explores the impacts of land use, accessibility, and travel behaviour on happiness, quality of life, and health of Montrealers.

Data and methods

In 2019, the Transportation Research at McGill (TRAM) Group and Sphere lab carried out a comprehensive travel survey as part of project aimed at understanding the impacts of the *Réseau Express Métropolitain* (REM). With 4,148 responses, the survey included questions on subjective indicators of subjective wellbeing (SWB), quality of life (QOL) and self-reported health (SRH). Visual representations of relevant variables and chi-squared tests were used to develop hypotheses on variables posited to affect health and happiness. Based on these, a cumulative links model was designed to understand whether travel behavior and accessibility influence SWB, QOL or SRH.

Findings

- Personal attributes and socio-economic status play a central role in defining health and happiness.
- Commutes above one hour reduce SWB and QOL but not SRH.
- Active commutes improve QOL and SRH; transit commutes reduce SWB.
- Indicators of compact development related to higher SRH, but access to jobs reduced SWB and QOL.

Policy Recommendations

- **Encourage** active commutes to improve SWB, QOL and SRH.
- **Communicate** health advantages of compact urban development to improve SWB.
- **Ensure** proximity to health facilities from as many locations as possible.
- **Monitor** impact with subjective measures to ensure long-term success of urban settings.

Synthèse

Problèmatique

Les plans urbains sont de plus en plus axés sur le développement durable et priorisent conséquemment les investissements dans les modes de transport actifs et en commun. Des indicateurs objectifs utilisés pour évaluer la durabilité des plans urbains offrent une compréhension partielle des enjeux sociaux liés aux politiques urbaines. Par opposition, des indicateurs subjectifs de bien-être produisent une représentation plus nuancée de l'impact social et de l'attractivité des différentes politiques. Ce document analyse l'impact de de mesures de transport sur le bien-être, la qualité de vie et la santé des montréalais.

Données et méthodes d'analyse

En 2019, le Laboratoire de Recherches en Transports de l'université McGill et le Laboratoire « Sphere » ont mené une enquête pour comprendre les impacts présents et futurs du Réseau Express Métropolitain (REM). L'enquête a recensé 4,148 répondants et a inclus des questions portant sur le bien-être subjectif (BES), la qualité de vie (QdV) et l'état de santé auto-déclaré (ESAD) des individus. Des tableaux et graphiques ainsi que des tests du chi carré ont été produits pour développer des hypothèses sur le possible effet des politiques urbaines et des politiques de transports sur le bien-être et la santé des montréalais. Ces hypothèses ont été utilisées pour définir la structure du modèle de liens cumulatifs qui explore l'effet du transport et du milieu urbain sur le BES, la OdV et l'ESAD des individus.

Principales conclusions

- Les caractéristiques socio-économiques et personnelles sont déterminantes pour le bien-être et la santé.
- Des très longs déplacements au travail diminuent le BES et la QdV, mais n'affectent pas l'ESAD.
- Se déplacer activement augmente la QdV et l'ESAD; utiliser le transport en commun diminue le BES.
- Des indicateurs de développement urbain compact sont liés à des niveaux plus élevés d'ESAD.
- L'accessibilité à des opportunités de travail est liée à des réductions dans le BES et la QdV.

Recommandations stratégiques

- **Favoriser** les déplacements actifs pour augmenter le BES, la QdV et l'ESAD des individus.
- **Communiquer** les avantages sur la santé du développement urbain compact pour élever le BES.
- **Assurer** la proximité des établissements de santé à autant d'emplacements que possible.
- **Suivre** l'impact des politiques avec des indicateurs subjectifs pour assurer du succès à longue-terme.

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Glossary of terms

Accessibility: a combined measure of land use and transport that synthesizes the ease of reaching destinations.

CLM: Cumulative Links Model, a proportional-odds statistical model. In this document, also used to refer to the partial proportional odds models produced with the *clm* function of the "ordinal" package in R.

QOL: Quality of Life.

SRH: Self-Reported Health.

SWB: Subjective Well-Being.

Introduction

Cities have long been posited as generators of income growth and wealth through agglomeration economies (Glaeser, 2011). As the developed world becomes more affluent, an increasing amount of households reaches income satiation; however, wealth increases above a given threshold provide no utility gains (Di Tella & Macculloch, 2008; Jebb, Tay, Diener, & Oishi, 2018). Due to this, measures of happiness and quality of life indicators provide a better-suited evaluation alternative to monetary quantifications of wealth, allowing for a direct measurement of an individual's moods and emotions (Kahneman & Krueger, 2006). These measures are now often used as an economic tool to evaluate policies, both at national and sub-national levels (Di Tella & MacCulloch, 2006; Stiglitz, Sen, & Fitoussi, 2009). Sustainability evaluations, for instance, may include subjective measures of happiness, such as subjective well-being (SWB) and quality of life (QOL), to assess the long-term viability of projects (Kullenberg & Nelhans, 2015). This approach to sustainability, a "relational paradigm", stresses the relevance of enriching environmental impact measures by internalizing the well-being and health of individuals impacted in the analyzed ecosystems (Helne & Hirvilammi, 2015; Walsh, Böhme, & Wamsler, 2021). When evaluating urban sustainability, it is now commonly understood that a combination of compact city development and public transit investments is an efficient way to reduce the environmental repercussions of travel (Lee & Lim, 2018). However, it is unclear whether the relational benefits of urban communities are enough to ensure their long-term competitiveness of cities vis-à-vis the suburbs and rural areas (Morris, 2019).

The importance of subjective measures for assessing urban qualities goes beyond the need for a relational marker of long-term sustainability. The built environment and neighborhood characteristics can strongly impact health and in fact mediate the effect of the aging process on quality of life and happiness (Steptoe, Deaton, & Stone, 2015; Veenhoven, 2002). Cities and their amenities constitute "the biggest, non-genetic influence on how healthy" an individual is (Buettner, 2012). Mental health can be deeply affected by the surroundings. Poor-quality urban environments, with deteriorating infrastructure and unkept streets and sidewalks, have been associated with increased odds of experiencing depression, and it has been posited that densely populated areas may amplify stressors (Eaton, 1980; Galea, Ahern, Rudenstine, Wallace, & Vlahov, 2005). In terms of transport infrastructure, elevated commute times and traffic congestion are related to reduced happiness and health levels, whereas active commuting was found to be related to higher levels of physical wellbeing (Ballas, 2013; Humphreys, Goodman, & Ogilvie, 2013). The built environment and transport infrastructure not only affect SWB and travel behavior separately, but also interact with personal characteristics and attitudes to influence self-rated health (SRH), SWB and QOL (Ye & Titheridge, 2017).

Overall, investments encouraging public transit use and compact urban development must be followed by a thorough assessment of their sustainability. Environmental and economic measures of impact are, and will continue to be, a central determinant of long-term success. If the residents of urban areas are not satisfied with their residential environment or believe they can be healthier and happier in a different type of setting, cities will lose attractivity to rural and suburban areas. The following work bridges a gap in existing studies, providing an assessment travel behaviour and accessibility in Montreal's urban areas as it pertains to citizens' SWB, QOL and SRH.

Literature Review

The value of wellbeing measures in the urban context

In high-income countries, SWB and QOL indicators have remained stationary over the past two decades, in spite of considerable increases in income levels, a phenomenon called the Easterlin Paradox (Di Tella & Macculloch, 2008). This reality calls for a more nuanced evaluation of policies that goes beyond monetary and utilitarian assessments and introduces wellbeing measures. When defining what constitutes wellbeing, the OECD notes that: "although there is no single definition of well-being, most experts and ordinary people around the world would agree that it requires meeting various human needs, some of which are essential (e.g. being in good health), as well as the ability to pursue one's goals, to thrive and feel satisfied with their life"(Organisation for Economic Co-operation Development, 2011). Wellbeing can be categorized as affective or cognitive, with the former being an indicator of an individual's emotions and moods, and the latter addressing overall happiness or satisfaction (Diener, Suh, Lucas, & Smith, 1999; Ettema, Gärling, Olsson, & Friman, 2010). Both types of indicators are closely related to the notions of QOL and SRH, as they all describe an individual's contentment. At the city scale, the emergence of urban happiness as a research field has been followed by fast growth of the literature available on the topic (Papachristou & Rosas-Casals, 2019). Most research finds the urban environment is strongly tied to QOL (Papachristou & Rosas-Casals, 2019). From an epidemiological point of view, the built environment, neighborhood characteristics and amenities are increasingly seen as some of the main social determinants of physical and mental health (Eaton, 1980; Galea et al., 2005; Kolak, Bhatt, Park, Padrón, & Molefe, 2020).

One of the strongest ways the urban environment affects health and wellbeing is through travel and land use, which together mediate residents' access to activities and opportunities (Delbosc & Currie, 2011). Travel behavior may affect SWB through a threefold effect (De Vos, Schwanen, Van Acker, & Witlox, 2013). First, when it serves as a means of reaching a particular destination (destination-oriented), what is experienced while travelling can be associated to positive or negative emotions, such as pleasure or stress, and can influence an individual's SWB (Ravulaparthy, Yoon, & Goulias, 2013). Second, travel amenities and the built environment may encourage residents to engage in travel as a type of leisure activity and, especially in the case of active travel, increase QOL and SWB (Singleton, 2019). Finally, a reduced motility- the potential to travel- relates to whether residents of a particular area experience transport disadvantage and therefore have access to less opportunities. This type of disadvantage, which along with other vulnerabilities constitutes transport poverty, has been shown to have a negative effect on SWB (Awaworyi Churchill & Smyth, 2019).

Travel behavior, happiness, and health

Emotions experienced during destination-oriented travel may affect an individual's overall SWB. Archer et al. found that travel patterns related to subjects' feelings of happiness, and that access to activities that depend on the opportunity to travel related to feelings of meaningfulness, stress, tiredness, pain and sadness (Archer, Paleti, Konduri, Pendyala, & Bhat, 2013). When controlling for personality traits and personal characteristics, an extensive study in Xi'an found travel satisfaction had a small but significant effect on overall SWB (Gao, Rasouli, Timmermans, & Wang, 2017). Several studies sustain that commute satisfaction significantly affects a worker's wellbeing (Abou-Zeid & Ben-Akiva, 2014; Olsson, Gärling, Ettema, Friman, & Fujii, 2013). Using data from a survey carried out in Oslo, Mouratidis finds commute satisfaction has an important impact on SWB and QOL levels, and should therefore be considered a central livability indicator (Mouratidis, 2020). In most of the research mentioned, commute satisfaction, as well as QOL, SWB and SRH are all directly or indirectly affected by trip duration and mode.

Historically, transport research has viewed time spent travelling strictly as a disutility, estimating the cost of each hour spent travelling to be the equivalent of half an hour of minimum wage (Anas, 2020). Studies in various geographical contexts show that, ceteris paribus, longer commutes lower SWB (Choi, Coughlin, & D'Ambrosio, 2013; Stutzer & Frey, 2008). Recent research in higher-populated metropolitan areas in China showed longer daily travel times were equally associated with lower QOL levels (Nie & Sousa-Poza, 2018; Sun, Lin, & Yin, 2020; Zhu, Li, Chen, Liu, & Zeng, 2019). In terms of the health impact, a cross-sectional study in Hong Kong found commutes above 90 minutes were strongly associated to obesity, the posited causal relationship being lower amounts of available leisure time resulted in reduced physical activity (Sha, Li, Law, & Yip, 2019). However, not all research points in the same direction. Notably, a study using data from the Canadian General Social Survey of 2010 showed that travel times were not associated with SWB (Sweet & Kanaroglou, 2016). Recent findings show commutes can provide an important psychological buffer between home and work, indicating a non-linear association between commute duration and SWB, QOL and SRH (Novaco & Gonzalez, 2009). Commute modes can greatly impact the effect of a commute's duration in wellbeing; a study found longer car commutes related to lower SWB, but that the opposite was true for active commuters (Martin, Goryakin, & Suhrcke, 2014). The effect of commute times on SWB may be mediated by personal characteristics. For instance, English women with short commutes were found to be less satisfied with leisure time than men with similar commutes, a difference explained by multi-activity journeys related to child-caring (Wheatley, 2014). Data from the German Socio-Economic Panel data for the period 2007–2013 confirms long commutes only impact satisfaction with leisure time, a specific dimension of SWB, and that the time spent on housework mediates this effect (Lorenz, 2018). Gender may influence mode selection, with women surveyed showing stronger dependence on car use than their male counterparts, a characteristic deeply connected to commute and life satisfaction (Wheatley, 2014).

Travel mode can influence travel satisfaction and QOL through various causal pathways. However, evidence shows the context in which these mechanisms act may deeply influence their effect. Where car-use is seen as a marker of higher socio-economic status, car commutes are related to higher SWB, while this is not true for all cultural contexts (Chng, White, Abraham, & Skippon, 2016; Gan, Feng, & Yang, 2019). People surveyed in the car-friendly cities of the US had higher SWB when commuting by car, while residents of Swedish cities, better suited to walking and cycling, did not (Ettema et al., 2011; Novaco & Gonzalez, 2009). In China, both car ownership and commuting by car was found to improve SWB and QOL (Gan et al., 2019; Sun et al., 2020). In Sweden, car owners were happier when they were able to use their vehicle most often; however, car-less households were just as happy on average as their car-owning counterparts (Bergstad et al., 2011). In contrast, a study in Hong Kong found no relation between commute mode, SWB and QOL (Sha et al., 2019). While differences between the effect of motorized modes on happiness are strongly context-dependent, evidence points towards bus-users most often displaying lower SWB and QOL (Handy & Thigpen, 2019). Evidence on active transport is less heterogeneous, with studies in a variety of contexts all pointing towards a positive effect of active commutes on SWB, QOL and SRH (Chng et al., 2016; Ettema et al., 2011; Handy & Thigpen, 2019; Humphreys et al., 2013).

Policy evaluation based on happiness and health measures is particularly well-suited for analyzing active commute modes, because it captures effects often underestimated by utility-based assessments (Frank et al., 2006). Active commutes may improve SWB, QOL and SRH in several ways. First, they provide a better travel experience than most motorized modes (Singleton, 2019). They increase physical activity levels and thus improve physical wellbeing (Humphreys et al., 2013). In general, walking and cycling commutes are shorter and yet provide a better psychological buffer between the professional and private spheres (Jain &

Lyons, 2008). Indeed, the effect of an active commute on an individual's health and happiness is manifold. An extensive study in Portland, Oregon, showed walking and cycling related to higher SWB, mental and physical health (Singleton, 2019; Smith, 2017). At the metropolitan-level, an analysis of Gallup data on several US areas reported that cities with higher shares of active commute types had higher reported SWB levels (Cloutier et al., 2017). A longitudinal study in Cambridge found cycling to work was associated with greater mental wellbeing and reduced sickness absences (Mytton, Panter, & Ogilvie, 2016). Another longitudinal study in England, which followed 26,000 workers, showed walking to work raised SWB, and that walkable access to work opportunities is a strong driver of QOL (Clark, Chatterjee, Martin, & Davis, 2020). The benefits of active transport go beyond commuting. In transportation-oriented developments (TOD), walking for utilitarian trips can help individuals meet recommended levels of daily physical activity (Langlois, Wasfi, Ross, & El-Geneidy, 2016). Walking, for both utilitarian and recreational purposes, can be considered a form of therapeutic mobility due to its positive impact on mental and physical wellbeing (Gatrell, 2013). Overall, it has been proven that the land use can positively influence physical activity levels, and that more physically active individuals are happier (Lathia, Sandstrom, Mascolo, & Rentfrow, 2017; McCormack & Shiell, 2011).

Accessibility, the built environment, and wellbeing measures

From an accessibility perspective, land use and proximity to transport and other urban infrastructure can influence an individual's SWB. A person's right to partake in activities relevant to their health and happiness is strongly dependent on their ability to reach desired destinations. The lack of a suitable combination of transit infrastructure and land use mix can lead to a transport disadvantage, which, when added to social hardship, can derive in transport poverty, a robust marker of vulnerability (Lucas, 2012). In fact, a study on individuals experiencing transport poverty in Australia demonstrates that a combination of a lack of affordability and access to opportunities significantly lowers SWB (Awaworyi Churchill & Smyth, 2019). Providing a theoretical framework to understand social vulnerability, Nobel laureate Amartya Sen developed the renown "capability approach", which highlights the importance of expanding the understanding of social justice to include notions on quality of life, opportunities, access to alternatives and freedom of individuals (Sen, 1993). This concept can be directly applied to the analysis of transport equity (Beyazit, 2011). In fact, motility – an individual's ability to reach desired destinations- has been greatly researched in the context of aging, but more research is needed on its effect on a broader section of the population (Nordbakke & Schwanen, 2014). Transport infrastructure facilitates access, which enables participation in the activities that are important in life (Lucas, 2012). Improvements in an area's accessibility levels increase SWB through increased participation in activities (Currie et al., 2010; Delbosc & Currie, 2011). Areas with higher connectivity, measured by the proximity to transport infrastructure, are associated with lower mental distress, particularly for those living near train stations (Chng et al., 2016; Ettema et al., 2011). In line with the capability approach, differences in a neighborhood's travel options and their reliability may result in varying perceptions of freedom, which consequently affect SWB (De Vos et al., 2013). Exactly how and under which circumstances the effect of transport disadvantage on SWB operates is yet to be researched, and clarity is lacking on the causal pathways that lead some characteristics to produce different effects on similar indicators, such as a SWB and QOL. For instance, a study in Finland showed spatial attributes affect QOL and SWB differently- residents of pedestrian-friendly areas report higher QOL, while those living in car-friendly neighborhoods have higher SWB (Ala-Mantila, Heinonen, Junnila, & Saarsalmi, 2018). Similarly designed research in other contexts, such as in transport-oriented developments, is lacking.

Compact urban developments facilitate a better transit provision, which can make travel more environmentally sustainable (Camagni, Gibelli, & Rigamonti, 2002). In hand, a higher concentration of population allows for a land use mix, which encourages utilitarian walking trips (Hajna, Ross, Joseph, Harper, & Dasgupta, 2015). Happiness-wise, Mouratidis finds that there are synergies between compact urban living and SWB, as long as this type of urban environment enables shorter commutes and encourages active transit (Mouratidis, 2019). However, evidence on the relation between population density, accessibility and happiness is very heterogenous, particularly since accessibility and population density are so closely related. Recent research in Sydney found a positive relation between neighborhood density and

SWB, but most studies find that urban environments are related to unhappiness and lower satisfaction with life, particularly in the North American context (Easterlin, Angelescu, & Zweig, 2011; Glaeser, Gottlieb, & Ziv, 2016; Ma, Kent, & Mulley, 2018; Veenhoven, 2002). In the US strictly rural areas report higher SWB than urban ones; however, the "happy suburbanite" myth was found to be untrue as early as in the 1970s, when suburban dwellers in Detroit did not report higher SWB or QOL than their urban counterparts (Adams, 1992; Berry & Okulicz-Kozaryn, 2011). When diving into the causal pathways relating urban characteristics to happiness, evidence can be contradictory and be deeply influenced by the geographic context. Okulicz-Kozaryn and Mazelis found that, in the US, essential urban characteristics, such as higher population density, particularly reduce SWB (Okulicz-Kozaryn & Mazelis, 2016). On the contrary, a study in Oslo found that, when issues like noise and air pollution are addressed, compact neighborhoods can provide as much SWB as lower-density ones (Mouratidis, 2019). Once urban-related nuisances are overcome, more densely populated areas can provide stronger community links and higher social cohesion, both of which improve mental wellbeing (Adams, 1992; Mouratidis, 2019; O'Campo, Salmon, & Burke, 2009).

The impact of the built environment on physical and mental health is complex. Travel behavior can improve or reduce physical activity levels, population density may improve mental health through higher social cohesion but can amplify stressors, deteriorating infrastructure may increase the odds of experiencing depression and longer commutes can relate to a higher prevalence of obesity (Eaton, 1980; Galea et al., 2005; McCormack & Shiell, 2011; Sha et al., 2019). In Sydney, higher population density and transport disadvantage both related to lower health levels (Ma et al., 2018). A study in Washington state, in the US, used a walkability index, which accounted for features such as land use mix and intersection density, to assess the effect of the built environment on travel behavior and health. It found that a 5% increase in the walkability score led to a 32.1% rise in time spent in physically active travel, and a 0.23-point reduction in body mass index (BMI) values (Frank et al., 2006). Proximity to different types of social infrastructure, such as schools, sports areas and health facilities, was found to positively affect health levels (Davern et al., 2017). In new urban developments, the stage at which travel infrastructure is implemented can significantly influence health outcomes (Gunn et al., 2020). Overall, an individual's health is strongly related to SWB and QOL, so any urban or mobility feature that influences a wellbeing indicator is likely to affect SRH too. This relation is bidirectional, with SWB strongly relating to longevity, and QOL assessments positively associating to SRH (Ngamaba, Panagioti, & Armitage, 2017; Veenhoven, 2008).

SRH as an indicator of health

Unlike for SWB and QOL, health can be measured through objective indicators as well as subjective ones. Understanding health outcomes of travel behavior, accessibility and urban characteristics is complex and often requires several objective indicators measured over extended periods of time. While the limitations of a cross sectional study cannot be easily overcome, SRH can be a useful indicator for assessing health and controlling its effect on SWB and QOL. There are limitations to the validity of SRH as a health indicator, as socio-economic status can contribute to different health expectations and mediate the effect of the same observed disease on an individual's SRH (Delpierre, Lauwers-Cances, Datta, Lang, & Berkman, 2009). However, a recent study with 18,000 responses found an association between the prevalence of diseases and lower SRH, particularly for individuals suffering from cardio-vascular diseases, visual impairment, and mental illnesses. Health-related risk factors also contributed to lower SRH (Wu et al., 2013). Overall, the existing literature tends to indicate that SRH can act as a global indicator of health status in a population (Vaillant & Wolff, 2012).

Overview and knowledge gaps

Overall, the existing literature proves that subjective indicators are a useful type of measure of policy success. This is particularly true when assessing the sustainability and long-term viability of compact urban development and other policies aiming to encourage environmentally friendly modes of travel. However, for some of the variables explored, the existing literature provides a heterogenous set of evidence, suggesting context-specific causal pathways tying subjective measures of happiness to the urban landscape and travel behaviour. While shorter and active commutes seem to unanimously make people happier and healthier, it is unclear under which conditions car use and ownership lead to changes in SWB and QOL levels. In a similar manner, while transport disadvantage is clearly related to lower SWB, it is not clear whether this effect holds true for accessibility to specific types of destination, such as employment opportunities, or to a set of possible activities. Overall, most of the literature assessed does not provide a comprehensive assessment linking transport and land use, and most of it focuses either on health or happiness parameters. This is division is fictitious, as health, happiness and quality of life are strongly related and interdependent and should therefore be assessed collectively. Finally, there is a knowledge gap pertaining to these issues in the Canadian context, as the few existing Canadian studies either specifically focus on the health impacts of travel or provide outdated evidence. This lack of Canadian-specific wide assessment is particularly relevant as the effect of the urban environment and travel behavior on wellbeing indicators is context-specific and mediated by cultural values. The following study attempts to bridge a current knowledge gap in the context of Montreal, one of Canada's most compact and transit-friendly urban poles, and the largest city in francophone North America.

Data

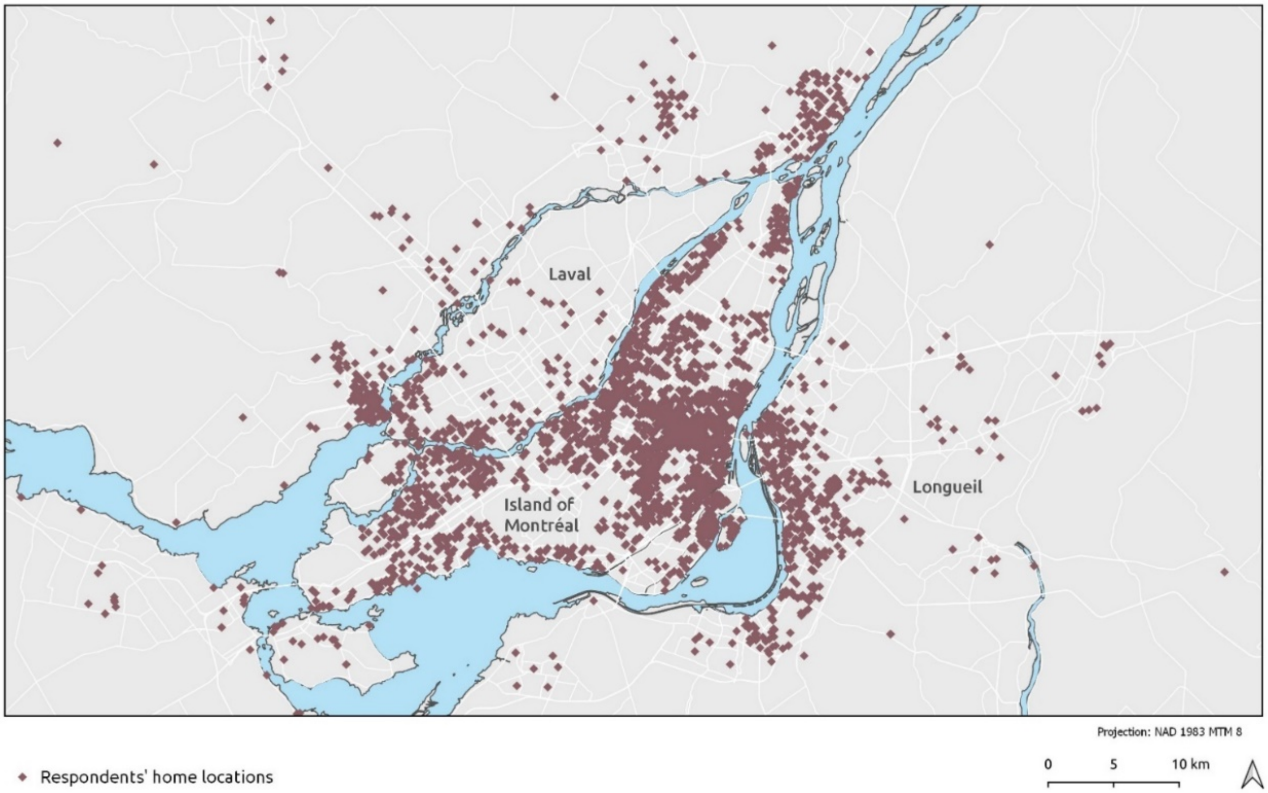
In 2019, the Transportation Research at McGill (TRAM) Group and the "Sphere" lab conducted a comprehensive travel survey. It was carried out as a benchmark for a project titled "Impact of the new *Réseau Express Métropolitain* (REM) on mobility, health and equity: A pre-post intervention study" funded through the Collaborative Health Research Projects (CHRP) program. It was developed after obtaining an ethics approval (REB File 99-0719) in both French and English. Besides several questions oriented at understanding respondents' perceptions on the REM project, others addressed information ranging from travel behavior to wellbeing and health.

Various recruitment strategies were put in place to ensure a diverse and representative sample of the Greater Montreal Area. On October 17th, 2019, Leger, a company specialized in surveys and public opinion, began data collection. This company provided 1,800 complete responses from individuals located throughout Montreal. In parallel to Leger's efforts, two separated URLs were set up to host the survey in

English and in French, www.mobility-montreal.ca and www.mobilite-montreal.ca. The survey links were uploaded onto the Reddit r/Montreal channel, and Facebook adds were placed from October 25-26, November 21-27, and December 12, 2019. These strategies were complemented with in-person recruitment activities carried out on November 6th, 2019, at rush-hour, from 4pm to 6pm at Gare Central, Montreal, as well as near the connection between the Montreal Metro and Place Bonaventure. In addition, the research team worked with McGill media relations to promote the survey, and a raffle with prizes was used as an incentive to encourage respondents.

Overall, in-person and digital recruitment strategies resulted in a collection of a total of 4,148 completed survey responses. As part of the data cleaning process, survey responses were grouped, and responses deemed too fast for a given question path were removed. Unreasonable answers to questions on age and time spent on commute were used as markers of careless survey responses. Once these were removed, the sample left had 3,683 complete responses. Map 1 shows the geographical distribution of survey respondents' home locations. Answers are well distributed throughout the Greater Montreal Area, albeit slightly concentrated around the future REM station locations and Mascouche line stations. To ensure the sample was as representative of the general Montreal population as possible, a weighting system was developed to account for personal characteristics, commute modes and residential locations. With the weighting taken into consideration, and leaving only survey responses that had an answer for all the variables considered, the final sample used throughout this document contains 1,454 responses.

Table 1 shows sample characteristics structured around the categories used in analyses in later sections of the document. Income levels were divided into three sections. Households with annual incomes below $60,000 were considered "low income", those with incomes from $60,000 to $120,000 were categorized as "middle income", and those with incomes above $120,000 as "high income". In addition to these objective categories, a subjective indicator was included to portray respondents' answer to the question "[T]o what extent does this annual household income allow you to satisfy your household needs?", thus dividing respondents into those self-identifying as with sufficient or insufficient income. Commute modes and commute duration were both clustered into simplified groups to streamline analyses. Using proximity data made available by Statistics Canada, responses were divided depending on whether the respondents' residential location was in a dissemination area with or without health facilities. Access to employment was determined as the number of jobs accessible by a 45-minute transit ride from a home location's census tract. The summary data table shows that, once adjusted using the weighting variable, responses are balanced and resemble the general population characteristics of Montreal. However, there is a slight over-representation of more educated households, as well as of public transit users.



Map 1- Geographical distribution of survey respondents

Sample Characteristics

Table 1 – Summary of Sample Characteristics (weighted values)

Personal Characteristics		
Age		
	Age (mean ± SD)	40 ± 15 years
	18 to 34	37% (533)
	35 to 54	47% (685)
	55 and above	16% (234)
Relationship Status		
	Married	52.5% (763)
	Not Married	47.5% (689)
Income		
	Low	30% (440)
	Middle	38% (547)
	High	32% (465)
	Insufficient	19% (247)
	Sufficient	81% (1074)
Educational Attainment		
	Completed university-level studies	65% (950)
	Did not complete university-level studies	35% (502)
Commute and Accessibility Measures		
Commute Mode		
	Car (passenger or driver)	33% (486)
	Public Transit	52% (754)
	Active Transport	15% (212)
Commute Length		
	Duration (mean ± SD)	43 ± 24 min
	Duration above 60 minutes	81% (1180)
	Duration below 60 minutes	19% (272)
Access and proximity		
	Jobs accessible from CT (mean ± SD)	371,171 ± 308,290
	Health Facilities Available within DA	77% (1118)
	Health Facilities Not Available within DA	23% (334)

Figures 1 to 4 illustrate the distribution of the dependent and independent variables included in the analyses that follow in later sections of the document. Figure 1 shows the distribution of commute times. Most values are situated in the 20-to-40-minute interval, and there is a right skew in the data distribution. All the while, there is still a considerable proportion (19%) of respondents with commutes above 60 minutes.

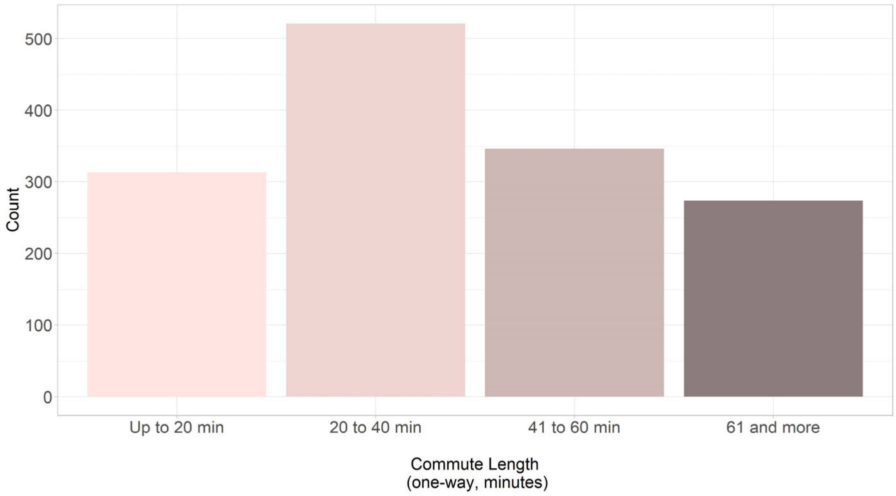


Figure 1- Commute Duration

Figure 2 provides a more detailed breakdown of the data shown in Table 1. The figure highlights that most of the individuals with an active commute (70%) walk to their work locations. The elevated number of pedestrian commutes is highlighted by the fact that they equal the number of workers using commuter train services to travel to work. Of people commuting by transit, more than half do so by metro, and these commuters constitute almost a third of all observations (27%), not far from car commutes, which make up one third (33%) of all observations considered.

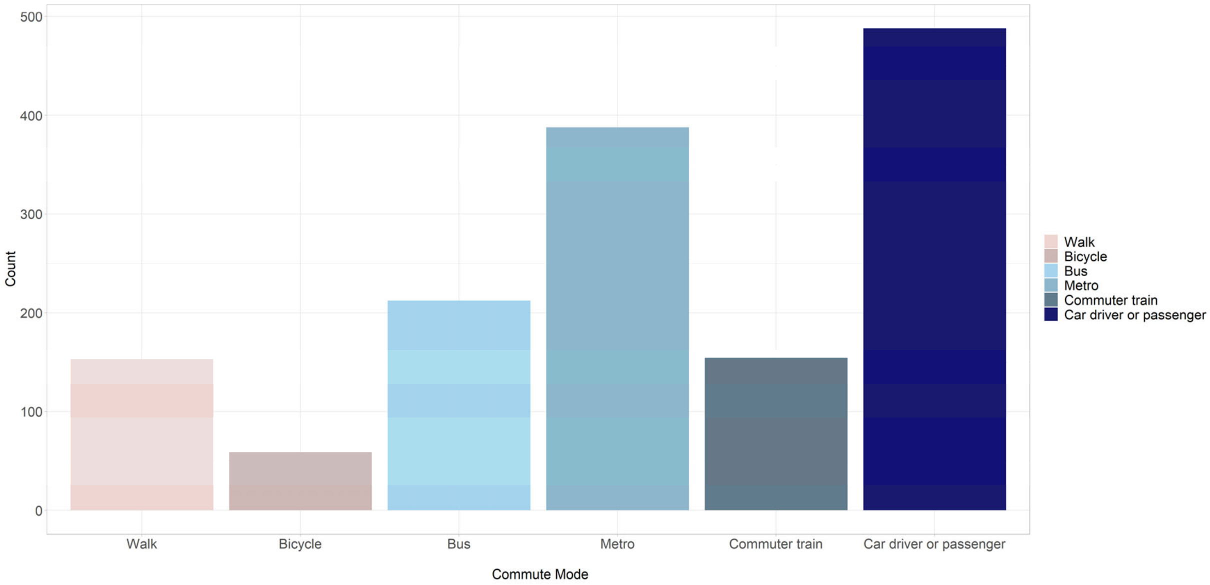


Figure 2- Commute Mode

Figure 3 combines data portrayed in Figure 1 and Figure 2 and illustrates the frequency of commute duration for each of the three mode categories defined in Table 1. The most noticeable trend visible in Figure 3 is the similar distribution of commute duration frequencies for active transport and car drivers, suggesting public transit users have a distinct type of travel behavior. While it is rational to expect shorter active commutes, it is surprising to see a significant number of 5-minute commutes by car. This would point towards the existence of many car commutes that could be replaced with active modes. For longer trips, there is a higher proportion of transit users than car passengers or drivers. This could indicate that transit users have a higher tolerance for long commutes than car users. On the other hand, it could point towards a lack of residential location choice from socially disadvantaged citizens, who may be captive transit users. Overall, Figure 3 shows transit passengers have longer commute times than those choosing to commute with active modes or by car.

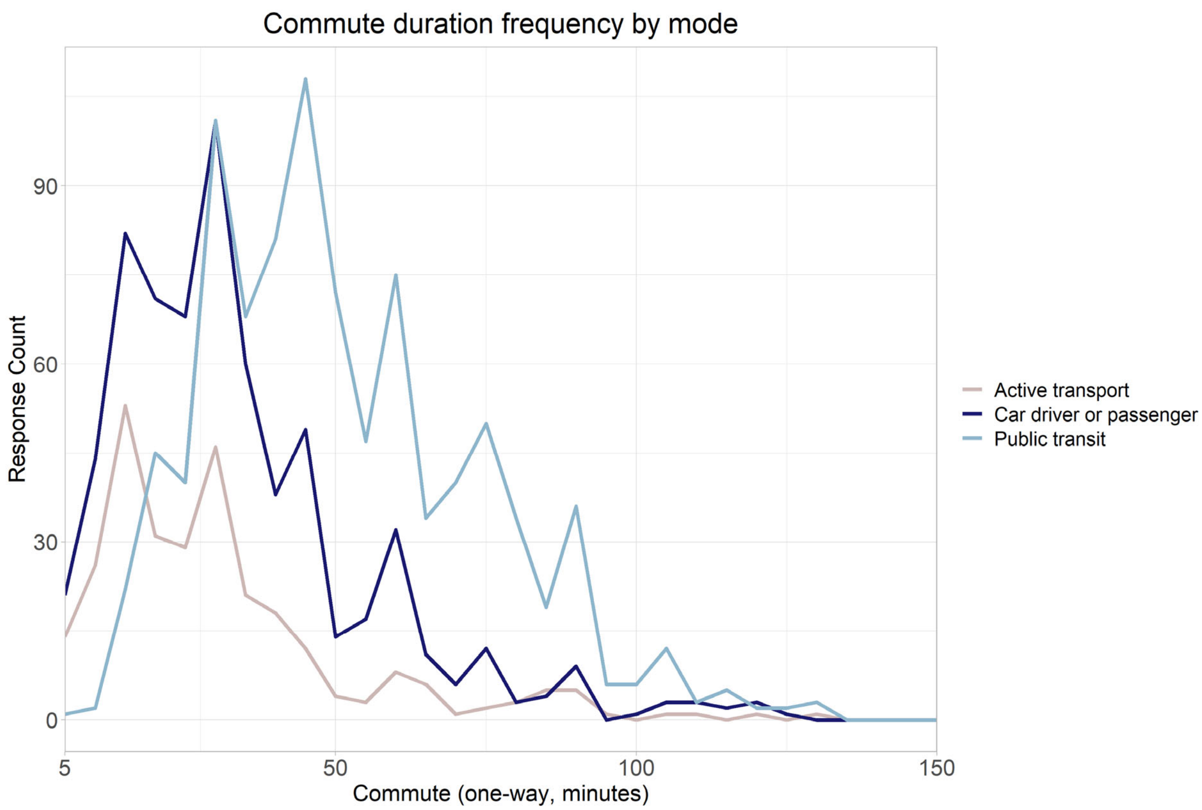


Figure 3- Commute duration by mode

Finally, before analyzing the relationship between different personal characteristics, travel behavior and urban features, it is important to understand the overall distribution of the three main dependent variables - SWB, QOL and SRH. These indicators were measured through the following three questions: for SWB- "[T]hinking about your own life and personal circumstances, how satisfied are you with your life as a whole?"; for QOL - "[H]ow satisfied are you with your standard of living?" and for SRH- "[H]ow satisfied are you with your health?". Responses ranged from "0 - completely dissatisfied" to "10 – completely satisfied". These answers were later clustered into 5 categories ranging from "Very Low" to "Very High". These intervals were divided equally except for the "Very Low" category, which includes values from "0" to "2". The three subjective indicators of wellbeing show a similar right-skew distribution. Interestingly, SWB has a relatively higher number of "High" responses than QOL and SRH, which follow a similar response distribution.

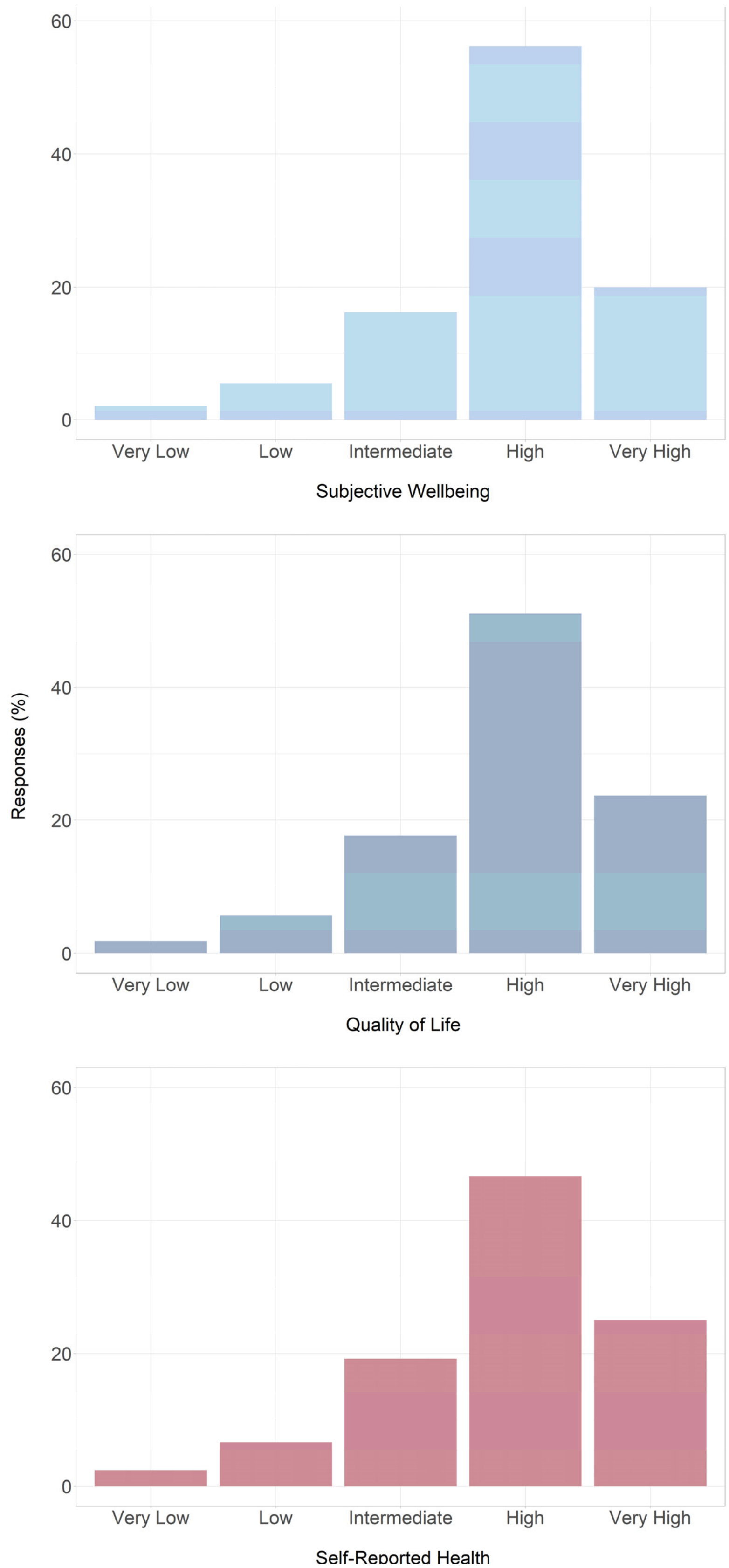


Figure 4- Distribution of main dependent variable

Methodology

The document's aim is to understand whether travel behavior and accessibility measures relate to happiness and health indicators. The main independent variables pertain to travel behavior and accessibility. Travel behavior was measured through commute mode and duration, while accessibility measures included proximity to health facilities and accessibility to employment opportunities. As mentioned in the previous section, the assessments had three dependent variables: SWB, QOL and SRH.

A structured approach was chosen to develop an understanding of the extensive dataset at hand. First, to synthesize the characteristics of the available data, a summary table of sample characteristics was developed. This was followed by figures illustrating the distribution of observations for dependent and independent variables. Then, several figures were designed to combine variables and highlight possible associations. This was done for each of the main indicators of travel behavior and accessibility – commute duration and mode, proximity to health facilities and access to employment opportunities. These figures, combined with sample characteristics, were used to develop preliminary findings and intuitions on the possible effects of travel behavior and access on individuals' happiness, quality of life and health.

With the intention of testing preliminary findings developed with the visual representation of variables, several chi-squared tests were carried out comparing levels of SWB, QOL and SRH for different sets of individuals. These tests included personal and socio-economic characteristics, such as age and income, which previous research found to be determinant for health and happiness levels (Dolan, Peasgood, & White, 2008). These tests were carried out comparing the weighted proportions of "very high" SWB, QOL and SRH results for different groups of respondents. For comparisons related to accessibility, the outcome variables were divided into three categories (high, intermediate, and low) instead of the previous five. For all independent variables tested, chi-squared tests comparing results were carried out for both "very high" or "high" categories alone and for the full set of outcome categories. This simple approach is an efficient way to explore results of extensive surveys and has been used in similar research pertaining to travel behavior (Mella Lira & Paez, 2021). However, findings at this methodological stage can only portray differences for one independent variable at a time. Chi-squared tests do not allow to consider possible interrelations between independent variables. Statistically significant differences in dependent variables only provide preliminary findings on the relationship between travel behaviour, accessibility and subjective measures of health and happiness. Thus, the next methodological stage was to develop a comprehensive statistical model that would provide a more precise understanding of the relationships between mobility-related variables and individuals' health and happiness.

A well established regression model, the cumulative links model (CLM), developed as part of the R package *ordinal,* provides an alternative to linear regression models and is a better suited methodology for modelling ordinal dependent variables, which aligns with the case at stake (Haubo Bojesen Christensen & Brockhoff, 2013). CLMs are often used in research related to QOL measures, as it is very useful at analyzing data quantified in Likert scales. It assumes an ordinal scale is an ordered category range produced by applying thresholds to a latent continuous variable (Ning et al., 2021). Its use is particularly relevant for variables such as SWB, QOL and SRH because, although initial categories range from "0" to "10", discrete breaks of a given value between categories do not necessarily indicate the same distance or change in perceived wellbeing, quality of life or self-perceived health (Ning et al., 2021). In such a way, a CLM model overcomes important limitations of the alternative linear regression model, not entirely suited for interpreting ordinal data. A CLM, often referred to as a *proportional odds model*, assumes that all thresholds are equidistant. Notably, threshold parameters are not allowed to depend on regression variables. The *clm* function in programming language R allows a more flexible approach by allowing for a partial proportional odds model, which is achieved by adding the "nominal" specification for those variables that may violate the equidistant thresholds assumption (Christensen, 2018). Variables under the "nominal" specification are no longer interpreted as ordinal variables but rather as categorical ones. Threshold values for these nominal variables vary with them. Nominal values make model interpretation more complex, but adding them helps control for their effect on other independent variables. However, it does not allow to understand their effect on the dependent variables analyzed. This complexity means that, in cases where a CLM model is used for exploratory purposes (as opposed to for prediction), it is permissible to limit their use to situations in which the variable significantly deviates from the proportional odds – or "equal slopes"-assumption and threshold values significantly deviate from 0.

Overall, the CLM model designed included several independent variables, as well as control variables related to individual characteristics. These include age, educational attainment, and sufficiency of income. Based on existing literature, variables such as educational attainment and age were converted into dichotomous or categorical scales. For instance, since age has been previously found to have a non-linear relationship with SWB, the models included three age categories for comparison and control (Dolan et al., 2008). It has been proven health and happiness are often interrelated, so SRH status was used as a control variable for both SWB an QOL (Veenhoven, 2008). To keep the models' explanatory value as high as possible, some variables that were not statistically significant and that reduced model accuracy were removed. For example, marital status and commute length, which both improved model precision for SWB and QOL, did not do so for SRH, and were consequently removed from the SRH model.

Results

The visual analysis of the survey results was structured around the main independent variables on travel behavior and accessibility. The impact of travel behavior on happiness and health was explored with figures contrasting commute duration and travel modes with subjective indicators of wellbeing and health. Then, the effects of accessibility were explored with figures depicting SWB, QOL and SRH for different levels of accessibility to employment and proximity to health facilities.

Commute Duration

Figure 5 illustrates the average perception of SWB, QOL and SRH for each commute duration quartile. In doing so, it combines information on the distribution of observations for commute times with happiness and health perceptions. The different distances between quartiles highlights the left skew in the distribution of commute times previously seen in Figure 1. Overall, the combined sets of data show there might be a negative association between the health and happiness and longer commute times. Throughout, QOL is consistently higher than SWB, and both follow a very similar negative trend. Differences in perception averages between the 3rd and 4th quartile threshold of commute times are lower than differences between the 2nd and 3rd quartiles, signalling a diminishing impact of each added commute minute on wellbeing.

SRH behaves differently to happiness measures. First, for shorter commute times, longer travel times seem to be rewarded - the average SRH is higher for the second quartile of commute duration than for the first. However, after the 2nd quartile, SRH averages penalize added commute times more strongly than SWB and QOL. This ambiguous effect of commute times on SRH might be related to individual and travel characteristics such as commute mode choice, age, or income. It is unclear whether the differences observed between commute quartiles are significant or whether other individual and travel characteristics might significantly influence the observed averages. In such a way, further analysis with chi-squared tests and the CLMs might prove particularly useful in determining the validity of the described observations and confirm the negative association between commute duration and happiness.

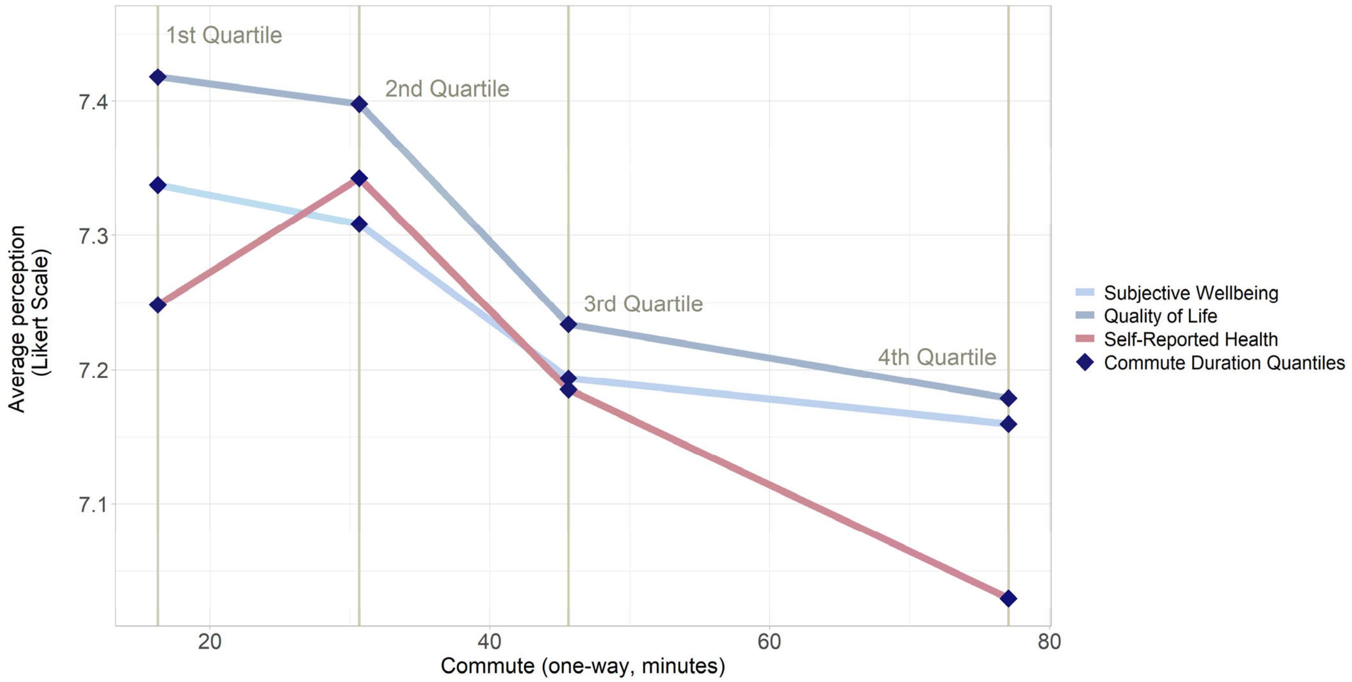


Figure 5- Average perceptions of SWB, QOL and SRH by commute duration quartiles

Commute Mode

To explore how commute modes relate to happiness and health, Figure 6 depicts the proportion of each level of perception constituted by responses from users of each commute mode. The Likert scales for each of the observed outcome variables were regrouped into 5 categories ranging from "very low" to "very high". This way of illustrating the mode distribution for each satisfaction level allows to observe a few interesting trends. First, there is a higher proportion of car users for "very high" SWB levels, and there seems to be a graded relation between the proportion of car users and the level of SWB. However, the relation does not carry over to QOL, for which the proportion of car users remains constant at all perception levels. For SRH the association seems to reverse. The proportion of car users (46%) reporting their health status as "very low" is above the average proportion of car commuters in the sample (33%). In terms of active transport, higher levels of QOL have a higher proportion of respondents walking to work, and the same is true for higher SRH levels. Among public transit users there is a higher proportion of commuter train users at higher levels of SWB and QOL, while the proportion of bus and metro users diminishes at higher levels of QOL and SWB.

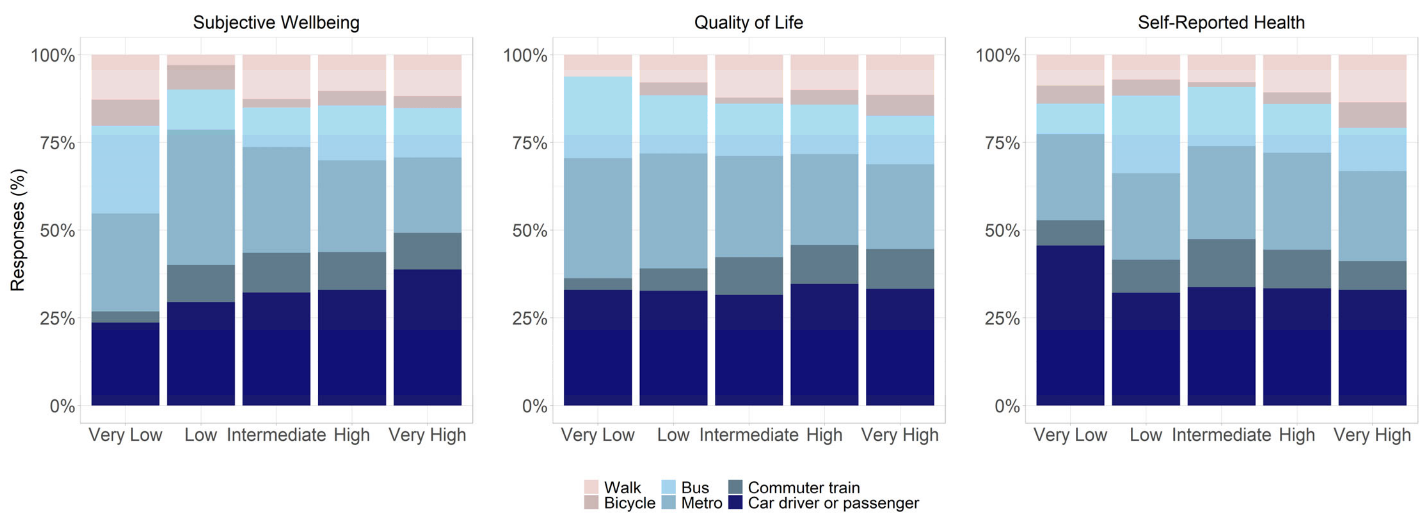


Figure 6- Mode composition by response level

Figure 7 presents the same data in a different manner, showing the proportion of each level of perception for each commute mode. This was done to further understand how commute modes may influence happiness and health, particularly for the less commonly used commute modes, such as cycling. In fact, the first noticeable observation is that those cycling to work have a higher proportion of "very high" levels of QOL and SRH. Compared to users of motorized modes, pedestrians, like cyclists, display higher levels of QOL and SRH. However, unlike cyclists, those walking to work display a higher proportion of "high" and "very high" SWB levels. When combined, all active modes consistently have a higher proportion of positive perceptions of SWB, QOL and SRH. All public transit modes display similar levels of happiness or health.

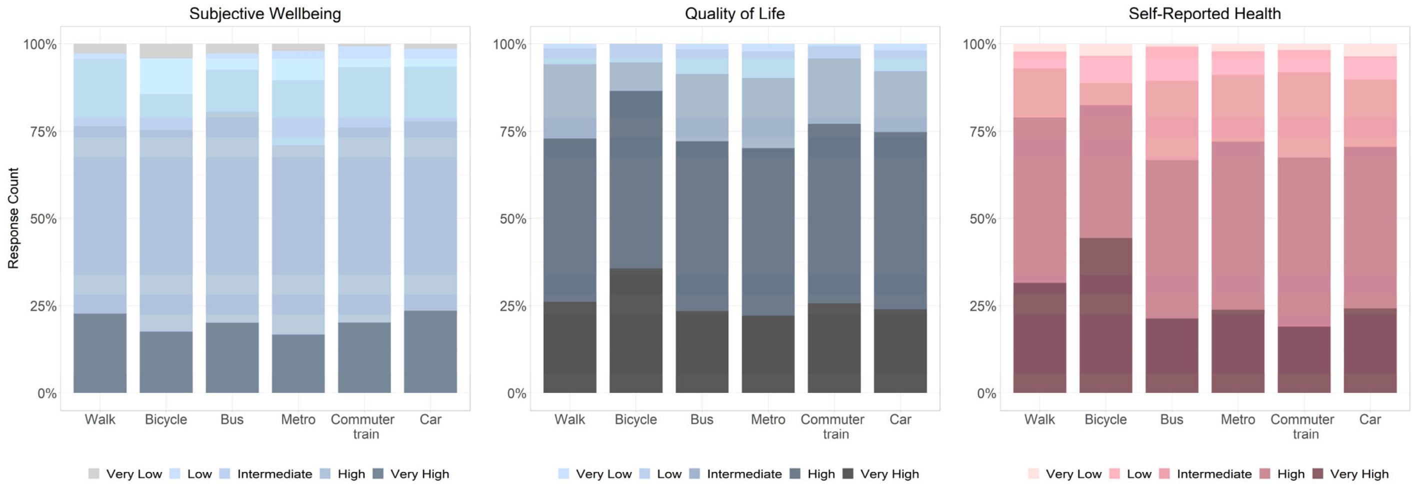


Figure 7 - Proportion of responses by mode

Overall, visual representations of travel behaviour point towards a negative relationship between longer commutes and perceptions of happiness and health. Among other findings, figures 5 to 7 outline a positive association between active commutes and happiness and health, while car commutes appear to improve SWB but reduce SRH. In terms of commute length, lengthier commutes reduce SWB and QOL, but differences between long and very long commutes are not very stark, and the effect of travel times on SRH is ambiguous. However, it is quite possible mode choice and commute duration intertwine, and that visual interpretations of their effect on outcome indicators remains inexact.

Proximity to infrastructure

As explored in the literature review section, the urban landscape and available infrastructure may influence health and happiness levels. Residential proximity to social infrastructure and accessibility, a combined measure of land use and transport, are two indicators that were chosen to help gauge the effect of the urban setting on SWB, QOL and SRH.

Figure 8 compares the distribution of responses for individuals located in dissemination areas with or without health facilities. This is a measure of proximity to relevant health infrastructure, and while not strictly illustrating accessibility, it is a useful way to understand how the urban environment caters to residents' needs. Data on health facility location throughout the greater Montreal area was derived from Statistics Canada's proximity measures database (Statistics Canada, 2020). For ease of readability, outcome variables were regrouped into three categories - "low", comprising answers from 0 to 3, "intermediate", ranging from 4 to 6, and "high", from 7 (the mode) to 10.

For all three indicators of happiness and health, responses for users located in dissemination areas without health facilities have a higher proportion of "low" and "intermediate" responses. Surprisingly, the presence of health facilities in a dissemination area does not result in more elevated levels of "high" responses for SRH compared to QOL or SWB. For "low" perception values, the absence of health facilities affects SRH more strongly than other satisfaction measures. Overall, the presence of health facilities in a respondent's dissemination area seems to derive in lower satisfaction levels, but the strongest visible effect is on QOL. This suggests the presence of health facilities may be related to other urban environment characteristics that impact QOL perceptions particularly strongly. The chi-squared tests showcased in Table 2 will help determine the relevance of the observed differences in the distribution of responses for dissemination areas with or without health facilities. It is important to clarify that the presence of health facilities in an area may relate to other variables, such as income, which can also affect SWB, QOL and SRH values. This possible overlap means the visual interpretation of differences in response distribution may be insufficient to infer a relation between the variables.

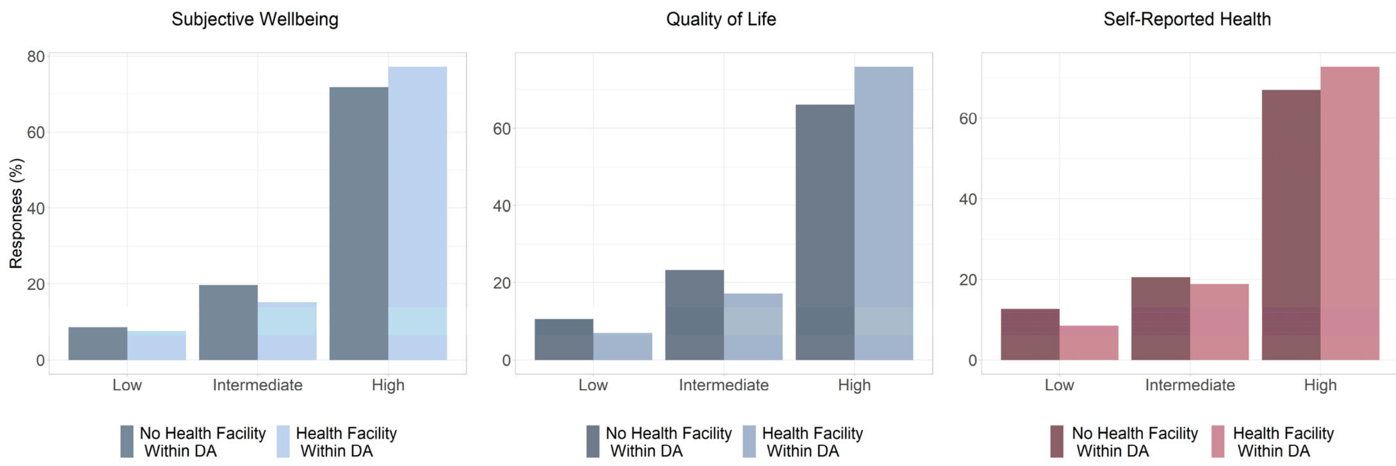
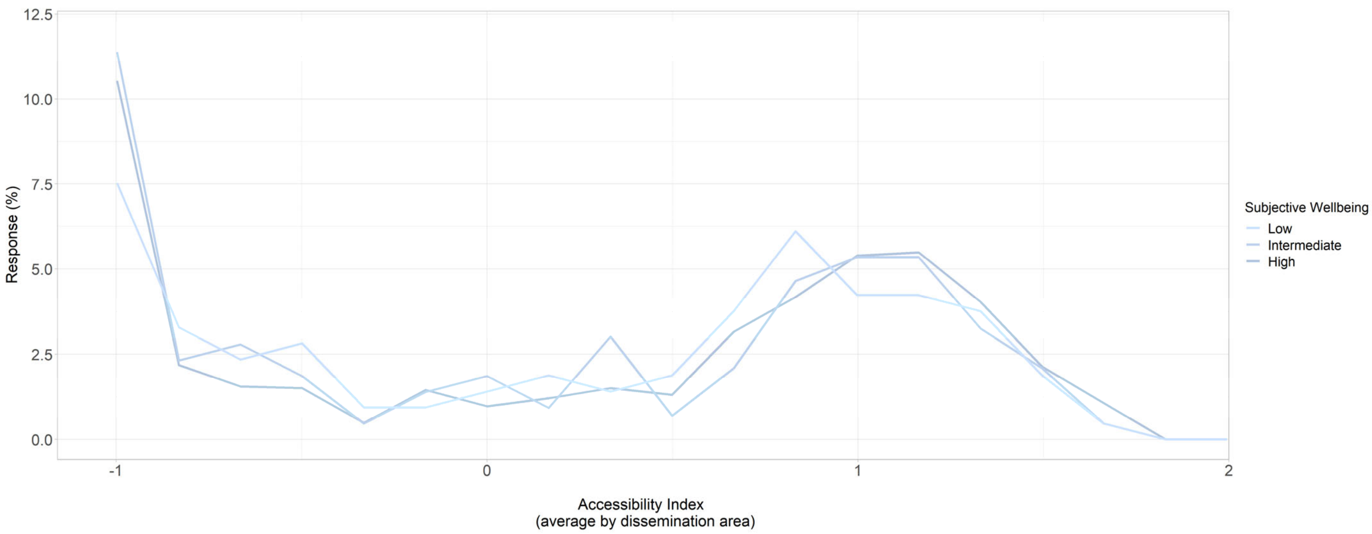


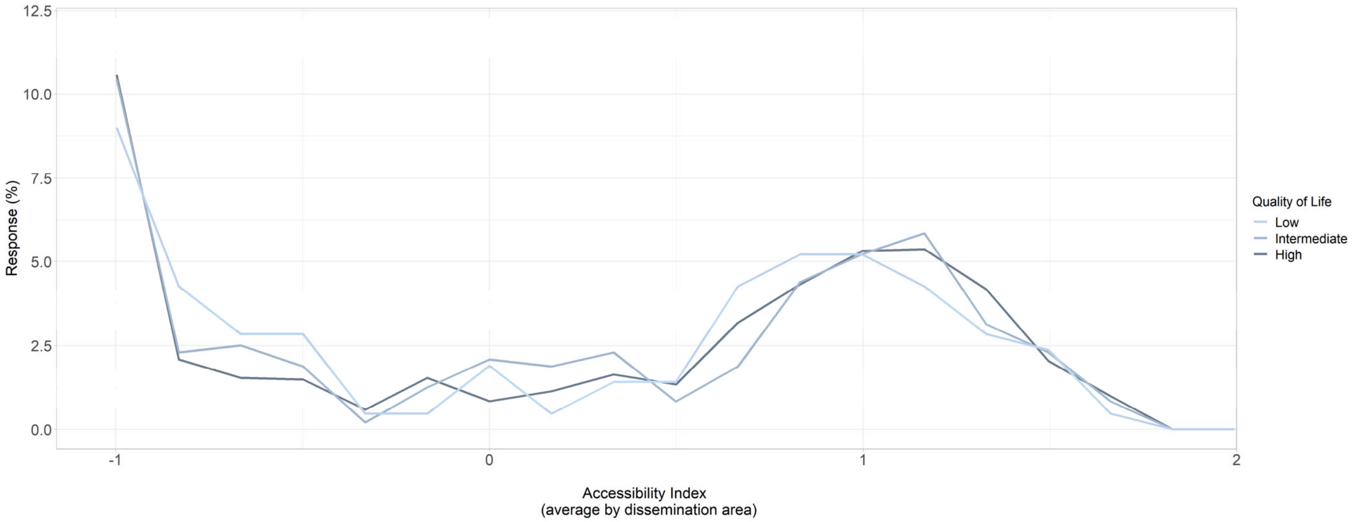
Figure 8- Response distribution by presence of a health facility in DA

Accessibility

Accessibility to employment is an essential indicator to further understand the relation between land use, transit, happiness, and health. The accessibility data used proceeded from previous research made by TRAM. It shows the number of employment opportunities available from any given census tract through a 45-minute transit ride on a weekday. Figure 9 show the distribution of responses for SWB, QOL and SRH, ordered by the accessibility levels of respondents' home locations. The figure's x-axis shows the accessibility to employment z-score, which was calculated with data from census tracts in Montreal.

Figure 9 shows that the distribution of perception levels for SWB, QOL and SRH does not vary strongly based on the census tract's employment accessibility levels. Nevertheless, areas with less access to employment opportunities have a lower prevalence of "high" perception levels for the three outcome variables. This trend does not seem to follow through to higher levels of accessibility, where the prevalence of "high" responses is not stronger for SRH and QOL. In the same high-accessibility census tracts, SWB behaves differently, showing a slightly higher prevalence for "high" SWB responses. Overall, the effect of accessibility on SWB, QOL and SRH looks very weak throughout all access levels. Later stages of the analysis might be more useful in determining whether there is an effect of accessibility on happiness and health measures. Chi-squared tests may provide a better-suited, more systematic approach to compare response groups from different accessibility levels and determine whether observed differences are statistically significant.





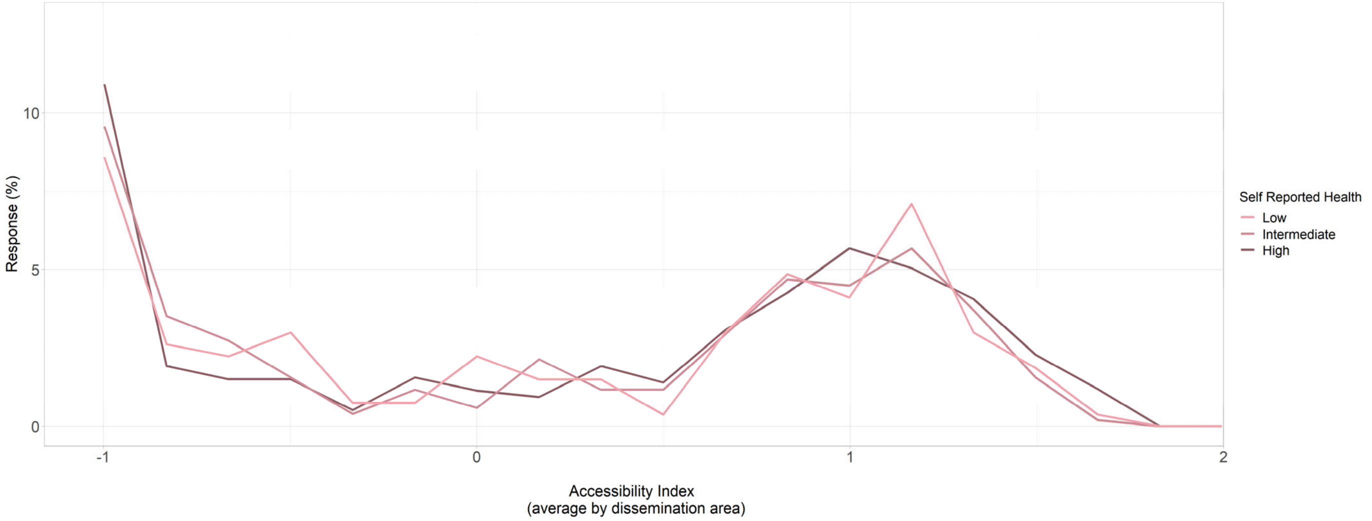


Figure 9- Frequency of observations by accessibility to employment (SWB, QOL, SRH)

Statistical significance tests

The figures outlined show that it is fair to expect that commute behavior, land use and accessibility relate to changes in SWB, QOL and SRH levels. Table 2 portrays a set of chi-square tests evaluating whether the difference in the distribution of responses for SWB, QOL and SRH vary for any given population characteristics, ranging from age and income to commute mode and times. Five outcome categories were considered for individual attributes and commute characteristics, while only three categories were considered for accessibility indicators.

Existing literature on wellbeing measures shows that the effect of urban environments on happiness and health is often mediated by personal characteristics, which therefore also need to be analyzed as pertains to their impact on the three main outcome indicators. Responses were correspondingly grouped by personal characteristics to understand if there were statistically significant differences between groups. For "very high" perceptions of SWB, QOL or SRH, age does not have a statistically significant effect. However, when looking at the overall distribution of values, including the five outcome categories, age increases result in higher SWB, QOL and SRH. These differences are statistically significant, with the lowest p-value for SRH. For income, results are in line with existing literature. A greater proportion of higher-income individuals have "very high" SWB and QOL. There is a gradient effect to these differences – any group richer than the previous contains more satisfied individuals. Interestingly, while the overall distribution of response proportions for SRH is affected by income, there is not a statistically significant difference in the number of individuals reporting their health as "very high" at different income levels.

Regarding travel behavior, Table 2 confirmed some of the observations deriving from figures 5, 6 and 7. Compared to other commute modes, active commutes result in a significantly more elevated proportion of a "very high" perception of SRH. In line with this, the overall distribution of SRH perceptions is significantly different between different modes. Transit users have a slightly lower proportion of "very high" SRH than car commuters. However, when looking at SWB and QOL, differences between commute modes are not significant for any response category. Proportions displayed on Table 2 point towards a commute length gradient in the proportion of “very high” perceptions of SWB and QOL. However, these differences, as well as those observed for SRH, are not statistically significant. It is important to note that the effect of commute duration may be masked through interaction with other variables. For instance, some longer commutes may happen in modes that have a positive impact on wellbeing indicators and mediate the effect of travel times.

Finally, the two indicators chosen to represent accessibility were assessed. First, it was evaluated whether respondents living in areas with or without health facilities had different levels of SWB, QOL or SRH. Differences in the proportion of respondents with a “very high” perception of their happiness and health are negligible. In line with Figure 8, the presence of health facilities does relate to QOL. Results depicted in Table 2 show that the presence of health facilities in a dissemination area changes the overall distribution of QOL responses in a statistically significant manner. Additionally, the chi-squared tests confirmed the counterintuitive findings of Figure 8 – living near health facilities has a negligible effect on SRH. Finally, access to employment does not result in statistically significant differences between answer groups, with lower accessibility quantiles corresponding to negligibly higher proportions of “high” QOL and SRH. This might be explained by limitations related the chi-square tests, particularly since dividing access measures into quartiles may reduce the validity of tests and hide meaningful patterns in intermediate values.

Overall, results shown in Table 2 confirmed several intuitions developed through the observation and analysis of figures 5 to 9. For instance, the differences in levels of SWB, QOL and SRH between commute mode groups are statistically significant. In line with previous literature on the topic, income influences health and happiness perceptions. Age had a positive relation with all three outcome variables. However, different indicators of health and happiness often behaved differently. The presence of health facilities in a dissemination area, for instance, affects the distribution of QOL responses but not SWB or SRH. Commute modes, on the other hand, impact the distribution of SRH responses but do not influence happiness and wellbeing indicators.

Table 2 – Chi-squared tests

Variable	Very High SWB	χ^2 p-val	Very High QOL	χ^2 p-val	Very High SRH	χ^2 p-val	All Values' Distribution	χ^2 p-val
Age								
18 to 34	18.3%		20.3%		17.3%		SWB	0.001
35 to 54	19.9%		24.7%		21.9%		QOL	0.0062
55 an over	28.0%	0.0210	31.4%	0.0143	25.5%	0.0210	SRH	<0.001
Income								
Low	15.9%		16.4%		21.9%		SWB	<0.001
Middle	19.9%		21.9%		23.6%		QOL	<0.001
High	25.3%	0.0073	34.2%	<0.001	28.4%	0.1186	SRH	0.0068
Mode								
Active Transit	21.4%		28.8%		35.1%		SWB	0.2938
Public Transit	18.2%		23.0%		22.0%		QOL	0.6194
Car (passenger or driver)	23.6%	0.1151	24.0%	0.3204	24.2%	0.0031	SRH	0.0039
Commute duration								
Up to 20 min	23.8%		27.0%		23.8%			
20 to 40 min	21.6%		25.5%		29.4%		SWB	0.5357
41 to 60 min	18.2%		22.8%		22.7%		QOL	0.3816
61 min and above	17.3%	0.2352	20.3%	0.3331	18.7%	0.0251	SRH	0.1115
Land use and transport measures (3 outcome categories)								
	High SWB	χ^2 p-val	**High QOL**	χ^2 p-val	**High SRH**	χ^2 p-val	**All Values' Distribution**	χ^2 p-val
Health Facilities							SWB	0.1150
Health Facility in DA	77.1%		75.8%		72.7%		QOL	0.0021
No Health Facility in DA	71.7%	0.3263	66.1%	0.0734	66.9%	0.2787	SRH	0.0533
Employment Access							SWB	0.9735
Highest Quartile Employment Access	77.8%		75.2%		74.7%		QOL	0.6668
Lowest Quartile Employment Access	77.5%	0.9649	77.3%	0.7416	69.4%	0.4049	SRH	0.2737

Cumulative Logit Models

The final step in exploring possible relationships between travel behavior, land use, transport, and wellbeing was to develop a statistical model capable of controlling for personal characteristics and possible interactions between independent variables. The CLM model results displayed in Table 3 explore several of the observations and hypotheses developed through the figures and chi-square tests in previous sections.

Personal characteristics such as age, marital status, and income were included to control for their effect on subjective indicators of health and happiness. As expected from results of chi-square tests displayed in Table 2, being over 55 years old has a statistically significant positive effect on both SWB and QOL. However, the effect on SRH is not statistically significant. On the other hand, being younger than 35 has a significantly negative effect on QOL but not on SWB or SRH. As expected from existing evidence on the topic, marital status has a significantly positive effect on SWB and QOL. However, the effect on SRH is not significant and the variable was removed to avoid reducing model accuracy. In a similar way, gender was not included because first iterations of the CLM that included the variable found it to reduce model accuracy. A dichotomous measure of income was incorporated. In line with preliminary findings in Table 2, insufficient income has a statistically significant negative effect on SWB and QOL. In the SRH model, insufficient income was used as a nominal control variable since it significantly deviated from the "equidistant thresholds" assumption. Further proving the existence of a social gradient in health and happiness, university-level studies have a positive and statistically significant effect on the three observed variables. SRH levels above average have a positive and statistically significant effect on SWB.

After controlling and assessing the effect of personal characteristics on health and happiness, the intuitions on the effect of travel behavior were explored. The CLMs proved very long commutes significantly reduce SWB and QOL. However, countering preliminary findings of figure 5, the effect of commute times on SRH was not statistically significant. In terms of commute modes, transit commutes had a significantly negative influence on SWB but not on QOL. In an opposite direction, transit commutes had a positive but statistically negligible effect on SRH. For both QOL and SRH, the effect of active commutes was positive and significant.

Nevertheless, the variable for active commutes was removed from the SWB model because it did not have a statistically significant effect and reduced model accuracy by violating the equidistant thresholds assumption.

Finally, it was important to understand whether transit-related features of the urban landscape and land uses were relevant for self-reported happiness and health. Not easily visible in previous exploratory analysis stages, living in areas with higher access to employment has a significantly negative effect on SWB and QOL, but a positive effect on SRH. Another marker of urban infrastructure and access, the presence of health facilities in a respondents' dissemination area significantly improves their odds of having higher SRH and reported QOL, but not SWB. Neither the proximity to health facilities nor the accessibility to employment from a respondent's residential area relate to higher SWB levels. The effect of transit-friendly neighborhoods on QOL is ambiguous, but clearly relates to higher SRH levels. Overall, QOL and SWB access results align with existing evidence on compact urban development in North America (Winters & Li, 2016). However, positive findings related to SRH are encouraging and prove that there is policy-making potential in improving perceptions of transit-friendly urban features.

Table 3 – Cumulative Links Models

	Subjective Well-Being	Quality of Life	Self-Reported Health
Age (over 55)	0.688***	0.428***	0.116
Age (below 35)	0.091	-0.005	0.034
Married	0.468***	0.352***	----
Insufficient income	-1.003***	-1.695***	nominal
Completed university-level studies	0.197**	0.290***	0.222**
Commute by transit	-0.181*	-0.032	0.125
Active commute	---	0.292*	0.299**
Commute over 60 minutes	-0.252*	-0.244*	---
Access to jobs (z-score)	-0.09*	-0.090*	0.092*
Health Facilities within DA	-0.015	0.219*	0.238**
Self-reported health above average	1.675***	nominal	---
Threshold coefficients for nominal variables (expressed as difference from intercept threshold coefficients)			
		Health Above Average	Insufficient Income
0|1		-1.444	1.360
1|2		-0.493	1.455
2|3		-1.029	1.240
3|4		-1.176	1.312
4|5		-1.677	1.236
5|6		-2.048	1.382
6|7		-1.667	1.242
7|8		-1.748	0.889
8|9		-1.543	0.730
9|10		-1.354	0.873
Log Likelihood	-4570.02	-4543.10	--5144.58
AIC	9180.04	9146.21	10341.17
BIC	9297.89	9322.98	10494.37

p-value below 0.0001 '***', 0.001 '**', 0.01 '*', 0.05 '(1)'

Conclusion

Healthy transit-friendly urban environments

The current health crisis has exposed deficiencies in the way society caters to citizens' needs. It has also provided an opportunity for policymakers and researchers alike to redefine priorities. Subjective indicators are an essential tool in doing so - at any geographical scale. This document portrays a phased approach that explores possible effects of personal, behavioral, and environmental characteristics on happiness and health.

The results of the analysis prove personal characteristics remain the strongest predictors of SWB and QOL. For instance, being married and over 55 both increase the odds of having a high perception of SWB and QOL. Markers of socioeconomic status, such as income and educational attainment, demonstrate the existence of a social gradient for SWB, QOL and SRH. Respondents whose health status is above average also have higher levels of SWB, confirming the relation between perceptions of health and happiness.

While personal characteristics are central, transit-related measures can significantly influence health and happiness. An individual's travel behavior plays an important role in determining their perceptions on SWB, QOL and SRH. Respondents with commutes over 60 minutes have lower perceptions of their SWB and QOL. Commuting by transit has a negative effect on SWB, but no significant impact on QOL or SRH. On an encouraging note for those promoting walkable and bicycling-friendly neighbourhoods, active commutes relate to higher QOL and SRH scores. In terms of compact urban development, residential location in a census tract with higher access to employment opportunities has a negative effect on SWB and QOL but improves SRH. In a similar way, the presence of health facilities in a respondent's home dissemination area results in higher SRH and QOL. Overall, the effect of transit-friendly urban development on happiness is ambiguous but its effect on SRH levels is decidedly positive.

Policy relevance

The results of the data analyzed should help policymakers determine future strategies regarding urban development.

1. **Promote and invest in active transport**. The positive effect of compact and transit-friendly urban development on SRH demonstrates environmental sustainability and public health objectives align. Policymakers should rest assured it is meaningful to encourage active commutes, which have a positive impact on QOL and SRH.

2. **Shift perceptions – if transit-friendly environments are good for health, they should be good for wellbeing too.** The negative relation between SWB and accessibility may be improved through communication strategies aimed at shifting perceptions through an emphasis on health benefits of urban environments and travel behaviour.

3. **Continue monitoring subjective indicators of policy success.** As work-related travel patterns change, future studies should continue to look at subjective indicators to ensure transit and land use policies cater to the development of a healthier and happier society.

Strengths, limitations, and further research

This document outlines the phased strategy used to explore the possible associations between travel behavior, accessibility and health and happiness. The various figures designed, the chi-squared difference tests and the CLMs provide a structured approach to explore and understand survey results. However, there are some innate limitations related to the methodology and data.

First, the indicators used to understand respondents' health and happiness are subjective and therefore provide a partial understanding of reality. Future analyses may choose to combine them with objective measures of health and satisfaction to provide a more complete understanding of health and wellbeing. Notably, SRH would benefit from being paired with a longitudinal analysis of objective health status indicators. Regarding objective measures included in the research, the accessibility data used did not have the same level of granularity as other data used, which may have reduced the precision of the effects described. In terms of travel behavior, subjective indicators such as indicators on mode dissonance and travel satisfaction may provide a more nuanced understanding of the relation between travel behaviour and wellbeing.

In terms of the methodology, the two preliminary stages of analysis through visual representation of variables and chi-square tests helped develop intuitions and hypotheses to be tested at later analytical phases. However, visual interpretation of observed values and chi-square tests do not accurately portray the relations between dependent and independent variables, possibly masking the way in which some variables may interrelated. The CLMs help overcome these limitations but pose other methodological complexities. First, the type of model used assumes that variables have a linear relationship with outcome variables, which is not necessarily true. For some variables, such as age, this shortcoming was overcome by producing dichotomous categories for different age groups. However, other variables may have a linear relation with dependent variables for some but not all value ranges. The CLMs respond to the difficulty of dealing with discrete ordinal scale but, in doing so, operate on the assumption of equidistant thresholds. Some of the variables included in the displayed models slightly violated this assumption but were kept. This choice was made because the models were devised as an exploratory tool do not aim to have a predictive value. In addition, it was considered acceptable to keep variables that violated the equidistant thresholds assumption when deviations were negligible, and values oscillated around zero. Future works exploring similar datasets might choose to use more flexible models, such as unconstrained partial proportional odds models. Further, this document's findings do not prove causality but rather show which variables may be related. In this sense, it does not prove that travel behavior, proximity or accessibility measures make respondents happy or healthy, but rather that they might be related.

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