# Studying the Interrelationship Between Telecommuting During COVID-19, Residential Local Accessibility, and Active Travel: A Panel Study in Montréal, Canada.

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**ABSTRACT**

The COVID-19 pandemic led to a substantial increase in the number of people working from home (*telecommuting)*, in turn leading to unprecedented changes in mobility patterns worldwide. Due to the changing context of the pandemic, there is still a significant gap in knowledge regarding the effects of working from home on workers' travel patterns. The main goal of this work is to unravel the interrelationship between telecommuting during the COVID-19 pandemic, frequency of active travel for non-work utilitarian purposes, and local accessibility levels around workers' homes. This study uses travel and telecommuting behavior data from a two-wave survey administered in the Greater Montreal in 2019, pre-pandemic, and 2021, during COVID-19 (n=452). Through a set of weighted multi-level linear regressions, we study the effects of telecommuting on the frequency of active travel for non-work utilitarian purposes, mediated by local accessibility around the household. Results show that the effect of telecommuting on non-work active travel for utilitarian purposes is highly dependent on local accessibility levels around the person's household. For workers living in high local accessibility areas, an increase in telecommuting during the pandemic has induced an increase in active trips for non-work utilitarian purposes. On the other hand, for workers residing in low local accessibility neighborhoods, the effect is the opposite. This research provides insights on the effects of telecommuting on non-work active travel, an area that is currently of interest to policy makers and practitioners working towards increasing the level of physical activity among individuals through travel.

**Keywords:** Telecommuting, active travel, local accessibility, COVID-19, panel analysis.

## 1 INTRODUCTION

The COVID-19 pandemic has led to unprecedented changes in mobility patterns worldwide due to lockdowns and various health intervention measures. Almost all regions around the world experienced a substantial increase in the number of people working from home (*telecommuting)* and participating in various activities remotely (*1*). Since the beginning of the pandemic, it has been speculated that these large impacts in travel patterns can be a pivotal point for the renaissance of active modes of travel (*2*). Although nowadays there is considerably less travel to work, with many employers still encouraging telecommuting, the use of private vehicle for various purposes has nearly recovered compared to pre-pandemic levels (*3*). In this context, it is still not clear if the large increase in telecommuting during the lockdown periods has truly led to more use of active modes of travel for non-work purposes or the opposite.

Due to the changing context of the pandemic and the different manner in which telecommuting affects several dimensions of workers' lives, there is still a significant gap in knowledge regarding the effects of working from home on workers' general wellbeing (*4*). While telecommuting eliminates the necessity to travel to work and previous to COVID-19 had been linked to increases the likelihood of walking and biking (*5*), it is not yet clear what the specific impact of incurring in telework on active travel is in term of purpose in the context of increased telecommuting during the pandemic. This is of particular relevance, since active travel has been shown to be a good way to increase people's physical activity and mental health (*6; 7*).

While some studies suggest that the higher levels of telecommuting during COVID-19 have increased active travel for leisure (*8*), to our knowledge there are no studies that focus on non-work utilitarian purposes. Moreover, since active travel has been shown to be highly dependent on local accessibility levels (*9; 10*), we speculate that the effects of telecommuting on active mode use is mediated by the local accessibility levels of the neighborhoods in which workers live. In this context, the main goal of this work is to unravel the interrelationship between telecommuting, frequency of active travel for non-work utilitarian purposes, and local accessibility levels around workers' homes, specifically during the COVID-19 pandemic.

To achieve this goal, we take a panel approach using a two-wave survey administered in the Greater Montreal Area. To unravel the interrelationship between active travel, telecommuting, and local accessibility, while also taking the specific context of increased telecommuting during COVID-19 into account, we estimate three weighted multi-level linear regressions. With a first set of two models, we study the frequency of travel for non-work utilitarian purposes as a response of (i) frequency of telecommuting, and (ii) the interrelated effect of telecommuting and local accessibility. Subsequently, we use a third model to study (iii) the interrelated effect of telecommuting and local accessibility on the frequency of travel for non-work utilitarian purposes, specifically in the context of increased telecommuting during the COVID-19 pandemic.

## 2 LITERATURE REVIEW

In a matter of weeks, the spread of COVID-19 and imposition of non-pharmaceutical measures to combat the pandemic changed mobility patterns worldwide. One of the most relevant aspects in the evolution of mobility patterns throughout the pandemic is that reduction in travel has not been uniformly distributed across transport modes (*11*). While public transit has suffered steep declines in ridership (*12*), the use of private vehicle for various purposes has nearly recovered compared to pre-pandemic levels (*3*). Within this context, since the beginning of the pandemic, it has been speculated that COVID's large impact on mode split can be an opportunity for increasing the use of active modes, such as walking and cycling (*2*).

Active modes of transport have been a relevant topic for travel behavior research and urban planning alike, as their use has shown to beget several benefits for people's general wellbeing. For instance, the use of active modes is known to have a positive impact on physical health (*6*), mental health (*7*), general quality of life (*13*), and trip satisfaction levels (*14*) when compared to motorized mode use. For these reasons, promoting active travel is widely seen as a desirable outcome of transport planning. However, there is still no general consensus on the effect of the pandemic over current and future mode share for active modes. For instance, Doubleday et al. (*8)* have shown that the pandemic has had a reduction effect on walking and cycling, except for the purpose of leisure, for which active mode use has increased. On the other hand, Thombre and Agarwal (*15)* showed that, although active mode use has presented a relative decrease due to the pandemic, the effect hasn't been as steep due to mode switching as a result of public transport avoidance.

The changes in urban mobility patterns brought by the pandemic are largely related to changes in activity patterns, with increasing performance of remote activities (*1; 16*). In this context, the popularity of remote working (or *telecommuting*) has largely increased and is expected to persist even after the COVID-19 pandemic is over (*17*). However, even before the pandemic there has been an interest in the effect of telecommuting on mobility patterns, as well as on mental and physical health (*18*). Previous research has shown that telecommuting has positive impacts on workers performing it, such as increased perceived quality of life (*19*). On the other hand, other studies have shown that telecommuting can also result in negative impacts to physical health, as it increases time spent sitting and reduces performance of physical activities (*20*). Moreover, due to the changing context of the pandemic and the different manner in which telecommuting affects several dimensions of workers' lives, there is still a significant gap in knowledge regarding the effects of working from home on workers' physical activity and health (*4*).

In particular, the impact of telecommuting on worker health can be mediated through its impact on the use of active modes of transport, given the multiple benefits that their use has been shown to beget (*6; 7; 13*). What past studies have shown in the pre-pandemic context, when telecommuting was less widespread and restricted to a more limited fraction of workers (*1; 21*), is that teleworkers have a higher probability of using active modes (*5*) which is also linked to the performance of shorter trips (*22*). While telecommuting eliminates the necessity to travel to work, it has been shown that teleworkers have an increased frequency of travel for non-work purposes (*23*). It is this context that has led to the speculation that the increasing frequency of telecommuting due to the COVID-19 pandemic can result in more frequent use of active modes of transport (*2*). However, given that the changes brought by the COVID-19 pandemic go further than only an increase in the frequency of telework, analyses of the relationship between active travel for non-work purposes and telecommuting need to be revisited.

Previous analyses have shown that factors related to the built-environment are key predictors of active mode use frequency (*9*). Improving local accessibility of an urban area has been strongly linked to increasing the likelihood that people will incur in active travel (*10*), as well as the equity in active travel among genders and different age groups (*24*). One popular measure of local accessibility is WalkScore, which focuses on the number and diversity of activities that can be reached within walking distance, has been tested repeatedly in the land use and transport literature (*25*) showing reliability in predicting active travel behavior (*26*).

While local accessibility has been shown to be a highly relevant factor in predicting levels of active travel, to our knowledge no previous studies have inquired into the interaction between telecommuting and local accessibility, and its joint effect on active mode use. Additionally, since eliminating the commute to work changes peoples' activity spaces, then telework also has the potential to influence telecommuters' experienced accessibility levels throughout the day (*27*). This can, in turn, affect their active travel behavior. For this reason, this work tests the hypothesis that the impact of telecommuting on active non-work utilitarian trips is mediated by residential local accessibility within the specific context of increased telecommuting due to the COVID-19 pandemic.

## 3 DATA AND METHODS

### 3.1 Data: Two-wave survey

This study uses data collected through a two-wave online survey administered in the Greater Montreal Area to participants of 18 years of age and older. The first wave of the survey collected 3,533 valid responses between October and November of 2019 (pre-pandemic), while the second wave collected 4,063 valid responses between October and November of 2021 (during the pandemic). All those who participated in wave 1 and provided their email address received an invitation to participate in wave 2. Through this process, we received 1,541 responses in wave 2 from participants who had previously answered wave 1.

To ensure the representativeness of the sample, in both waves we employed various recruitment techniques recommended by Dillman, Smyth and Christian (*28)*, including the distribution of flyers at various residences and downtown transport hubs, as well as targeted online recruitment through paid and un-paid advertisements on various social media platforms. Incentives were included in the survey such as the possibility of winning a prize based on a draw. A public opinion survey company was also hired in both waves to help in recruiting part of the sample.

The same data cleaning process was applied to both waves of the survey to ensure consistency in the exclusion criteria of unreliable responses. Some of these exclusion criteria were related to responders' time in filling the survey, multiple responses being filled by the same e-mail or IP address, and invalid age and height changes between 2019 and 2021. In terms of the time in which the respondent filled the survey, the fastest 5% were excluded from the sample depending on the number of questions answered in each wave. It must be noted that different groups of respondents, depending on their answers, got different sets of questions. Each of these groups were cleaned according to their own respective top 5% speed. Those who placed a pin representing their home, school and/or work location outside the Montreal metropolitan region were also excluded. This led to a final sample of 870 valid and complete responses answering both waves, out of which 452 were working in both waves of the survey and indicated a valid primary work location.

The two waves of the survey included the same questions pertaining to travel behavior information such as frequency of travel, telecommuting, and mode choices. Respondents' sociodemographic and economic characteristics, as well as residential choice factors, which allow to control for residential self-selection, were collected in both waves. For each person in the sample we know their individual pre-pandemic behavior, as well as their current behavior (during the pandemic), allowing us to assess the impacts of new telecommuting that respondents adopted due to the pandemic on travel behavior for non-work utilitarian purposes, namely grocery shopping and attending healthcare facilities. Since this work focuses on the effect of telecommuting, we only analyze and model the responses of the 452 workers in the sample with a valid primary work location, excluding students and retirees. Table 1 includes the description of the sample in terms of their sociodemographic characteristics and modelling variables, while Figure 1 presents the geographical location of the 452 respondents' households within the Greater Montreal Area.

**Table 1.** Sample description by survey wave

| Variable | | Wave 1 (2019) | Wave 2 (2021) |
|---|---|---|---|
| | | **Mean (std. dev.)** | **Mean (std. dev.)** |
| **N** | | 452 | 452 |
| **Sociodemographic** | | | |
| Gender | *[% men]* | 53.3% | 53.3% |
| Age | *[years]* | 42.1 (11.3) | 44.7 (11.3) |
| Household Income | *[$1000/year]* | 101.5 (49.3) | 110.7 (47.6) |
| **Telecommuting** | | | |
| Weekly days telecommuted | *[days/week]* | 0.61 (1.23) | 2.81 (2.26) |
| **Non-work travel** | | | |
| Non-work active trips | *[trips/week]* | 1.34 (1.23) | 1.36 (2.25) |
| **Local accessibility** | | | |
| Home-location WalkScore | *[1-100]* | 56.4 (27.6) | 56.4 (27.0) |
| **Car ownership** | | | |
| At least 1 car in the household | *[%]* | 75.2% | 77.9% |
| **Residential self-selection factors** | | | |
| Neighborhood car-friendliness | *[5 levels]* | 3.33 (1.42) | 3.24 (1.44) |
| Familiarity with the neighborhood | *[5 levels]* | 3.66 (1.13) | 3.72 (1.07) |
| Near the work/school of household member | *[5 levels]* | 3.48 (1.28) | 3.44 (1.23) |
| Being near family and friends | *[5 levels]* | 3.25 (1.21) | 3.38 (1.16) |
| Being near bicycle infrastructure | *[5 levels]* | 3.25 (1.22) | 3.20 (1.23) |

### 3.2 Methods: Weighted multi-level linear regressions

To achieve this work's main goal of unraveling the interrelationship between active travel for non-work utilitarian purposes, telecommuting, and local accessibility in the context of increased telecommuting during COVID-19, we estimate three weighted multi-level linear regressions. In our first model, we use a panel three-level linear regression with the number of weekly trips conducted by an active mode for non-work utilitarian purposes. In this context, active modes include walking and biking, and non-work utilitarian purposes include grocery shopping and going to healthcare facilities. The main independent variables of Model 1 are frequency of telecommuting and the home-location local accessibility measured through WalkScore. Since Model 1 assumes that the effects of telecommuting frequency and home-location local accessibility are independent, in Model 2 we consider the interaction between these two effects. In this context, Model 2 is identical to Model 1 except for the inclusion of the interaction variable constructed from multiplying weekly telecommuting frequency by home-location WalkScore.

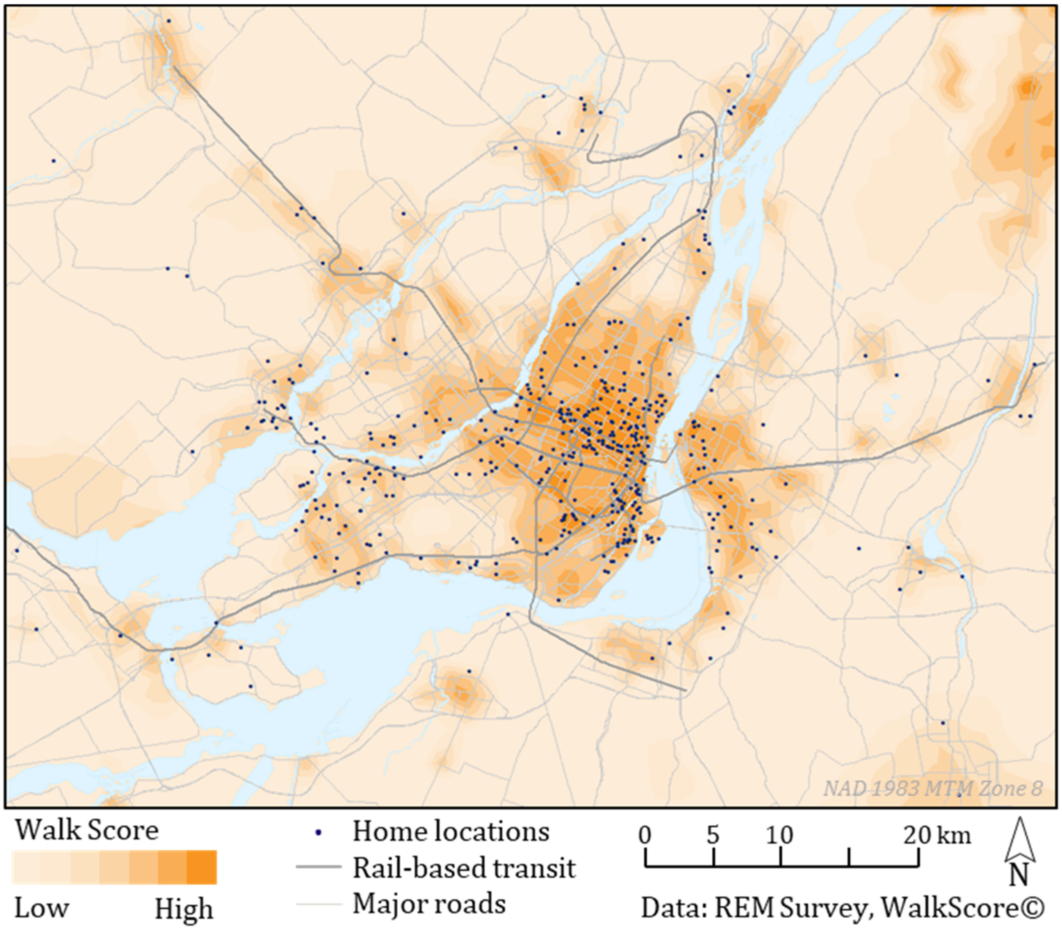


**Figure 1.** Home location of survey participants and WalkScore levels

Model 1 and Model 2 use a three-level approach in which we use the census tract of the home location as the higher level to control for common characteristics shared in a neighborhood that are otherwise unaccounted for. The second and lowest levels of the models, person-level and person-wave-level respectively, give the model its longitudinal component. That is to say, this model takes the dataset in long format (i.e., each row is one time point per person) and the second-level random effects control for the fact that observations in different waves can correspond to a same respondent. However, it must be noted that when using this three-level panel format, we assume that the effect of telecommuting on non-work utilitarian active travel frequency is the same in 2019 as it is in 2021.

To study the effect of frequency of telecommuting on non-work utilitarian active travel specifically in the context of COVID-19, our third model uses a different modeling approach. In this third model, we use the number of weekly trips conducted for non-work utilitarian purposes by an active mode in 2021 as the dependent variable. In this context, the model is specified as a two-level weighted linear regression, where the higher-level is the census tract of the home location and the dataset is introduced in its wide format (i.e., each row consists of a person's repeated responses). Here, the longitudinal component is considered by predicting behavior in 2021 by factors from both 2019 and 2021.

To evaluate the effect of increased telecommuting during the pandemic, we used the difference in weekly telecommuting between 2021 and 2019 to measure its impacts on the non-work utilitarian active travel. The relevance of using this difference in telecommuting between the two survey waves is that it allows us to measure the impact of telecommuting specifically during the COVID-19 pandemic, as opposed to most previous research on telecommuting (e.g., *22; 23*). Since, in this third model, the dependent variable relates to behavior in 2021 and is being predicted by factors that relate to both current and pre-pandemic behavior, in order to control for past active mode use, we also introduced the number of weekly non-work utilitarian active trips reported in 2019.

Each model considered additional independent variables to control for sociodemographic characteristics and residential self-selection. In the case of sociodemographic characteristics, gender, age, and household income were tested but were not statistically significant in any of the models. Car ownership at the household level was also tested and included in the models in which it had statistical significance. To control for residential self-selection, we incorporate respondent's reported importance factors for neighborhood choice. These factors were reported in a five-level likert scale and are also described in Table 1. Moreover, to assess non-linear effects of local accessibility, we tested the squared value of the home-location WalkScore as an independent variable. This variable was only included in model 3 as it was not statistically significant for other models.

Considering the census tract of the home location as the higher level in each model allows us to control for common characteristics shared in a neighborhood that are otherwise unaccounted for. This could include, for instance, built-environment factors which are not captured by the WalkScore. All of the weighted multi-level linear regressions were estimated using the lme4 R package (*29*). The weightings in the model were calculated for all valid responses in the panel using the anesrake R package (*30*). The weights were calculated to match our sample to census tract information of age, income, and gender from Statistics Canada 2016 census (*31*), retrieved through the cancensus R package (*32*). This weighting process is key to ensure that the resulting effects of telecommuting and local accessibility on active travel are not biased by the sampling of the survey.

## 4 RESULTS AND DISCUSSION

The results for models 1 and 2 are presented in Table2, in which the dependent variable is the weekly number of active trips for non-work utilitarian purposes. In Model 1, from the wave 2 coefficient we can conclude that, when keeping all else constant, people had a lower frequency of active travel for non-work utilitarian purposes, with 0.21 trips less in 2021 than in 2019. From this model we can also conclude that telecommuting has a small but statistically significant positive effect of 0.1 additional non-work utilitarian active trips for each additional day of telecommuting. In terms of the effect of local accessibility, for every 10-point increase in WalkScore, weekly active trips performed for non-work utilitarian purposes increase by 0.2 trips. Having at least one private vehicle in the household reduces the dependent variable in 0.4 weekly trips, ceteris paribus. The residential self-selection factors in Model 1 show that a preference for car-friendly environments decrease non-work utilitarian travel by 0.23 trips, while the preference for neighborhoods that are near to the respondent's family and friends increases the frequency of active travel for non-work utilitarian purposes. Similarly, a preference for proximity to bicycle infrastructure also has a positive effect on our dependent variable.

**Table 2.** Models 1 and 2: Weekly non-work utilitarian active trips as dependent variable

| | Model 1 | | Model 2 | |
|---|---|---|---|---|
| **Variable** | **Coefficient** | **95% C.I.** | **Coefficient** | **95% C.I.** |
| Intercept | 0.23 | [-0.46; 0.92] | 0.40 | [-0.31; 1.11] |
| Wave 2 (Year 2021) | -0.21** | [-0.41; -0.01] | -0.22** | [-0.42; -0.02] |
| **Telecommuting** | | | | |
| Weekly days telecommuted | 0.10*** | [0.04; 0.16] | -0.001 | [-0.11; 0.11] |
| **Local accessibility** | | | | |
| Home location WalkScore | 0.02*** | [0.02; 0.03] | 0.02*** | [0.01; 0.03] |
| **Telecommuting-WalkScore interaction** | | | | |
| Telecommuting days * WalkScore | -- | -- | 0.002** | [0.000; 0.003] |
| **Car ownership** | | | | |
| At least 1 car in the household | -0.40** | [-0.72; -0.08] | -0.40** | [-0.72; -0.08] |
| **Residential self-selection factors** | | | | |
| Neighborhood car-friendliness | -0.23*** | [-0.33; -0.13] | -0.23*** | [-0.32; -0.13] |
| Being near family and friends | 0.14*** | [0.04; 0.24] | 0.14*** | [0.04; 0.24] |
| Being near bicycle infrastructure | 0.13** | [0.03; 0.23] | 0.13** | [0.03; 0.23] |
| Observations | 904 | | 904 | |
| $N_{PEOPLE}$ / $N_{CT}$ | 452 / 374 | | 452 / 374 | |
| $ICC_{PEOPLE}$ / $ICC_{CT}$ | 0.45 / 0.15 | | 0.45 / 0.15 | |
| $\sigma^2$ | 1.15 | | 1.14 | |
| $\tau_{00\ PEOPLE}$ / $\tau_{00\ CT}$ | 1.29 / 0.43 | | 1.28 / 0.44 | |
| AIC | 3524.8 | | 3534.8 | |
| BIC | 3577.6 | | 3592.5 | |
| Pseudo-R2 (fixed effects / total) | 0.25 / 0.70 | | 0.25 / 0.70 | |

** $p < 0.05$ *** $p < 0.01$

Model 2, which is identical to Model 1 except for the inclusion of the interaction between telecommuting frequency and local accessibility, shows nearly identical results to Model 1. The effect of telecommuting frequency is not statistically significant, yet the interaction term with local accessibility is statistically significant. The best way to understand these results is through a sensitivity analysis shown in Figure 2. We calculated the number of weekly non-work utilitarian active trips for 2019 and 2021 separately, by fixing every independent variable to the sample's mean except for local accessibility and number of telecommuting days. We varied these two key variables within their possible ranges: 0 through 100 in the case of WalkScore, and 0 to 5 telecommuting days a week.

The analysis in Figure 2 shows that the effect of increasing telecommuting frequency on the number of active trips for non-work utilitarian purposes depends strongly on the worker's home-location local accessibility levels. For workers living in higher local accessibility, the effect of telecommuting is positive and larger than that predicted by Model 1. In fact, for workers living in an area with the maximum WalkScore of 100, each additional telecommuting day results in 0.2 additional weekly active trips for non-work utilitarian purposes, assuming all else remains constant. This is double the value predicted by Model 1. For workers in low local accessibility areas, the effect of increasing telecommuting frequency is almost negligible. These results show that eliminating the necessity of commuting to a workplace only results in more non-work utilitarian active travel when there is a potential for reaching a destination within a small distance from home. Ignoring the interrelated effect of telecommuting and local accessibility results in an underestimation of the increase in non-work utilitarian active trips for workers in high local accessibility areas, and an overestimation for workers in low local accessibility areas.

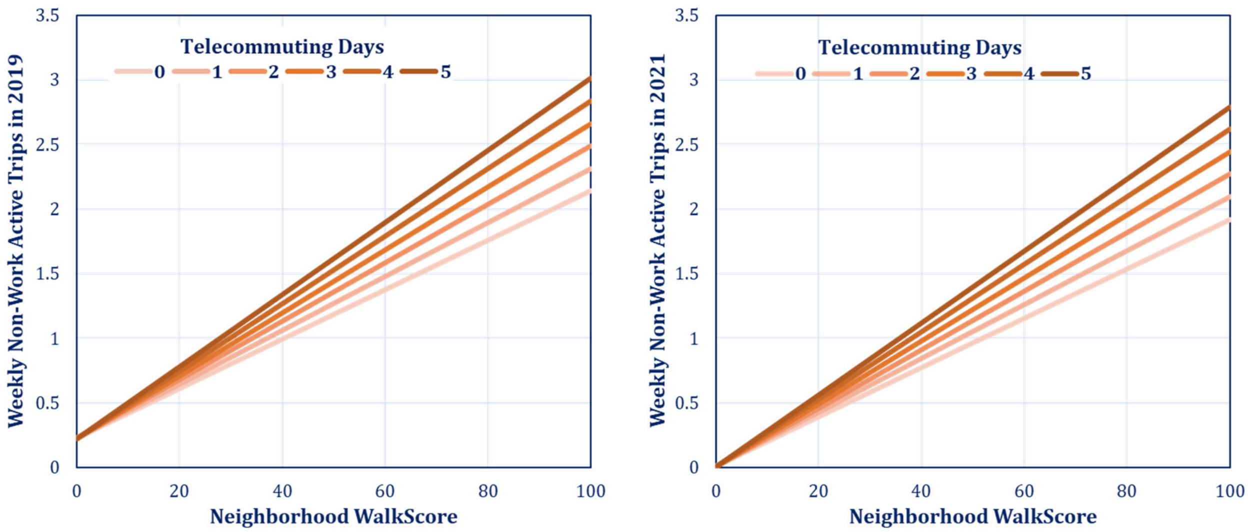


**Figure 2.** Model 2 telecommuting-WalkScore sensitivity analysis for 2019 and 2021

Table 3 presents the results of Model 3, with weekly non-work utilitarian active trips in 2021, during COVID-19, as dependent variable. Similar to results in Model 2, while the effect of change in telecommuting from 2019 to 2021 is not statistically significant, other coefficients in the model allow to understand the effect of telecommuting on active travel. In this model, both home-location WalkScore and WalkScore squared are statistically significant, indicating a non-linear effect of local accessibility on non-work utilitarian active trips during COVID-19. Additionally, the interaction between telecommuting and local accessibility implies that the effect of telecommuting is strongly dependent on the worker's home-location local accessibility levels in the pandemic context.

A good way to illustrate these interrelated effects and how they differ to the results from Model 2 is through the sensitivity analysis shown in Figure 3. We calculated the number of weekly non-work utilitarian active trips in 2021 by fixing every independent variable to the sample's mean, except for local accessibility and number of additional telecommuting days during the pandemic, which we varied within their respective ranges. Through the results in Figure 3, we can conclude that the effect of increased telecommuting due to COVID-19 is strongly mediated by home-location local accessibility levels. Workers living in high local accessibility areas experienced an increase in active trips for non-work utilitarian purposes during the COVID-19 period. The results show that the effect is the opposite for workers in the lowest local accessibility areas, who decrease their active travel for non-work utilitarian purposes. Thus, while Model 2 showed that telecommuting has no statistically significant effect on the active mode use of workers in the lowest local accessibility areas, Model 3 shows that additional telecommuting days during COVID-19 has had a negative effect for the active mobility of these workers.

**Table 3.** Model 3: Weekly non-work utilitarian active trips in 2021 as dependent variable

| | Model 3 | |
|---|---|---|
| **Variable** | **Coefficient** | **95% C.I.** |
| Intercept | 0.65 | [-0.22; 1.52] |
| **Telecommuting** | | |
| Changes in telecommuting | -0.06 | [-0.19; 0.08] |
| **Local accessibility** | | |
| Home location WalkScore | -0.02** | [-0.04; 0.00] |
| WalkScore squared | 0.0003*** | [0.0000;0.0005] |
| **Telecommuting-WalkScore interaction** | | |
| Change in telecommuting * WalkScore | 0.002** | [0.000; 0.004] |
| **Pre-pandemic travel behavior** | | |
| 2019 Non-work active trips | 0.40*** | [0.34; 0.47] |
| **Residential self-selection factors** | | |
| Neighborhood car-friendliness | -0.24*** | [-0.35; -0.14] |
| Familiarity with the neighborhood | 0.11** | [0.02; 0.28] |
| Near the work/school of HH member | 0.15** | [0.00; 0.22] |
| Observations | 452 | |
| $N_{CT}$ | 315 | |
| $ICC_{CT}$ | 0.10 | |
| $\sigma^2$ | 1.58 | |
| $\tau_{00\ CT}$ | 0.17 | |
| AIC | 1711.5 | |
| BIC | 1756.8 | |
| Pseudo-R2 (fixed effects / total) | 0.47 / 0.53 | |

** $p < 0.05$ *** $p < 0.01$

**Figure 3** Model 3 telecommuting-local accessibility sensitivity analysis

Model 3 also controls for residential self-selection, showing that a preference for car-friendly environments has a negative and statistically significant effect on non-work utilitarian travel, ceteris paribus. A preference for neighborhoods who were previously familiar to the respondent increases the frequency of active travel for non-work utilitarian purposes, similar to preference for proximity to workplace or school of a household member.

It is relevant to note that, while there is no explicit control of sociodemographic variables in the model, we estimated versions of all three models which included age, gender, and income as independent variables, none of which showed to be statistically significant. This indicates that the effect of telecommuting is mediated significantly more by the worker's neighborhood characteristics than their personal characteristics. This goes against the results of Elldér *(33)*, which suggested that telework would decouple travel behavior from urban form, making only personal characteristics relevant. While it is true that there is variation in the sociodemographic characteristics of people living in areas of differing local accessibility levels, our results control for this by using a weighted sample by age, income, and gender. The use of a multilevel modeling approach with the census tracts as the higher level controlled for shared neighborhood characteristics that are otherwise unaccounted for in the model.

In terms of transport policy, the results suggest that a post-pandemic context in which high levels of telecommuting are maintained has the potential to encourage active mobility only for workers living in areas which have available activities reachable by active modes. In contrast, the effect for workers living in low local accessibility areas has been the opposite. If such high level of telecommuting is sustained in the future, then introducing land use policy changes at home location, especially in areas with low levels of local accessibility, will be a critical aspect to ensure that telecommuters are encouraged to conduct some kind of physical activity in a day, since telecommuters have been shown to be less physically active than traditional commuters (*20*). In the long-term, these results suggest that the best intervention for increasing active mobility for non-work purpose can be achieved through increasing local accessibility where needed and encouraging telecommuting by employers. Our study can be of value for practitioners advocating for integrated land use and transport planning since it confirms the role that local accessibility plays in mediating the effects of telecommuting. If policies are designed by analyzing the effect of telecommuting on active mobility on its own, ignoring the mediating effect of local accessibility, the expected positive outcomes in active mobility could be largely overestimated. Thus, considering the interaction between the increase in telecommuting due to the pandemic with local accessibility is key for effective policy design, which clearly shows the relevance of local accessibility and its positive impacts on active travel.

## 5 CONCLUSIONS

In this work, we inquired into the interrelationship between telecommuting during the COVID-19 pandemic, frequency of active travel for non-work utilitarian purposes, and local accessibility levels around workers' homes. Using a set of weighted multi-level linear regressions, we analyze a two-wave survey administered in the Greater Montreal Area in the years 2019 and 2021, allowing us to study the specific context of increased telecommuting frequency due to the COVID-19 pandemic.

Through our first model, we conclude that increasing telecommuting frequency has a positive average effect on the frequency of active travel for non-work utilitarian purposes. However, through our second model, we conclude that this positive effect is strongly dependent on the local accessibility levels of workers' home locations. More specifically, we conclude that this effect increases with higher local accessibility levels, and that there is no effect of telecommuting on non-work utilitarian active trip frequency for workers living in the lowest local accessibility areas. The results of these two models lead us to conclude that ignoring the interrelationship between telecommuting frequency and local accessibility levels result in an overestimation of the effect of telecommute on active travel for workers in low local accessibility areas, and an underestimation for workers in high local accessibility areas.

Through our third and final model we study the interrelated effect of change in telecommuting during the COVID-19 period and local accessibility levels on active travel. For this specific context, we corroborate that the effect of telecommuting on non-work active travel for utilitarian purposes is highly dependent on workers' home-location local accessibility levels. More specifically, for workers living in high local accessibility areas, our modelling results suggest that an increase in telecommuting during the pandemic has also induced an increase in the number of active trips for non-work utilitarian purposes. On the other hand, for workers who live in low local accessibility neighborhoods, results suggest that the effect is the opposite. We speculate that, for workers living in higher local accessibility areas, not having to travel to work gave them more time to interact with their local context.

These results are valuable for travel behavior research for multiple reasons. First. these results complement past studies which have concluded that teleworkers have a higher frequency of active travel (*5; 22*). This is by specifying that, for the case of utilitarian purposes, this is only the case when the worker's home has available destinations by active modes. Moreover, to our knowledge, these are the first results to show the effect of increased telecommuting on active travel specifically during the COVID-19 pandemic. Additionally, these results' conclusions suggest that, at least for active non-work utilitarian purposes, neighborhood local accessibility showed to be more relevant than sociodemographic characteristics. This goes against the line of past results suggesting that telework would weaken the relationship between travel behavior and urban form, making personal characteristics most relevant (*33*).

In terms of policymaking, the two main implications of our results are that, first, if telecommuting is meant to be promoted with a goal of increasing active travel, then it should be mostly incentivized for people living in higher local accessibility areas, while for people living in lower local accessibility areas it should be accompanied by land use policies that encourages positive changes in local accessibility. Secondly, improving neighborhood local accessibility increases the likelihood that people will incur in active travel, which goes in line with past results (*9; 10*). Our results suggest that this is especially the case in a context of increased telecommuting. Thus, our results additionally suggest that the benefits of increasing local accessibility in the COVID-19 context are larger than in pre-pandemic years.

One limitation of this work is that we assume a linear effect of every telecommuted day on non-work utilitarian active trips. However, previous works have shown that there could be an exponential effect, as more telecommuting allows for larger changes in mobility strategies and lifestyle (*34*). Another limitation is that we don't take into account trip-chaining behavior, which has been shown to be more prevalent in workers living in lower accessibility areas (*35*).

As a future line of work, it would be interesting to inquire into a similar analysis for active trips for non-utilitarian purposes, *i.e.*, recreation and socialization. The effects of telecommuting and the mediation of local accessibility on these purposes is not intuitive, since walking and biking for recreation is not as dependent on availability of destinations as utilitarian purposes, or even socializing. Another possibility for future work would be to corroborate the effects found in this work in the future, as COVID-19's effect on daily behavior starts to decrease, including a wider time gap and potentially more survey waves in future studies. Future results will depend on the prevalence of telecommuting in a post-COVID world, as well as on workers' adjustments towards voluntary telecommuting.

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**Author contribution**

The authors confirm contribution to the paper as follows: Study conception and design: Victoriano-Habit & El-Geneidy; Data collection: Victoriano-Habit & El-Geneidy; Analysis and interpretation of results: Victoriano-Habit & El-Geneidy; Draft manuscript preparation: Victoriano-Habit & El-Geneidy. All authors reviewed the results and approved the final version of the manuscript.

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