



Car-use reduction in 15-Minute Cities. A matter of modal shift or shorter travel distances?

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ABSTRACT

Policies such as the 15 Minute City seek to reduce car use by ensuring the spatial concentration and proximity of everyday activities. This paper examines how proximity to nearby services in Barcelona affects car use and analyzes whether proximity to everyday destinations affects modal choice and car trip durations differently. By matching self-reported travel behavior data and a series of GIS-based minimum walking travel times to 25 distinct everyday destinations, we are able to assess the links between proximity availability and actual car use. Our findings indicate that closer everyday destinations influence car usage by reducing the frequency of car-based modal choices, though they do not alter travel distances for those who continue to use cars. This study contributes to evidencing the effect of the 15 Minute City's premise regarding car usage reduction.

1. Introduction

Fifteen-minute city (15 Minute City) plans aim to use the built environment design to nudge people towards more sustainable travel patterns (Moreno et al., 2021). Central to the 15 Minute City model is the principle of geographic proximity, intending to enable residents to meet most of their daily needs within a short walk or bike ride from home (Allam et al., 2022; Graells-Garrido et al., 2021; Moreno et al., 2021). These initiatives have proliferated in recent years due to their potential to address a broad range of social, equity, justice, and health issues. However, in both literature debates and the minds of policy-makers, the capacity of 15 Minute Cities to reduce car use remains highly relevant (Buehler et al., 2017). So prevalent is that association between 15 Minute Cities and car-use reduction that car use anxieties have turned into the most prominent criticisms raised against minute-city policies (Marquet et al., 2024a, 2024b). Well-known externalities of our car-dependent transportation systems include traffic congestion, acoustic pollution, air pollution, and increased traffic accidents, which negatively impact the health of communities and individuals (Nieuwenhuijsen & Khreis, 2016; Parry et al., 2007; Saeidizand et al., 2022; van Wee et al., 2019). Globally, extensive car usage plays a significant role in greenhouse gas emissions, with transportation being the fourth source of worldwide CO₂ emissions (Saeidizand et al., 2022). Pressured by the climate emergency and the

need for innovative solutions, cities worldwide have sought to implement new programs that aim to use city design and the built environment to effectively modify travel behavior towards more sustainable practices. Among such policies Superblocks, Low-Traffic Neighborhoods (LTN) or the 15 Minute City movement, are continuing the trends set up by New Urbanism and Transportation Oriented Development (TOD), in their aim to create more walkable, non-car dependent environments (Pozoukidou & Chatziyiannaki, 2021).

The growing popularity of the 15 Minute City model in city councils around the world has been accompanied by a proportional interest in the planning and transportation academic literature, with a growing body of case studies and methodological discussions focused on the optimal ways to gauge 15 Minute City conditions (Correa-Parra et al., 2020; Di Marino et al., 2022; Ferrer-Ortiz et al., 2022a; Gaglione, 2021; Glock & Gerlach, 2023; Guzman et al., 2021; Hosford, 2022; Li et al., 2019; Noworol et al., 2022; Staricco, 2022). In recent years, the 15 Minute City concept has evolved beyond its original formulation by Moreno becoming synonymous with proximity-based accessibility planning (Silva et al., 2023a) and serving as a focal point for discussions on how urban design can influence travel behavior to reduce car use and Vehicle Kilometers Traveled (VKT) (Yu & Higgins, 2024). This broader interpretation aligns with earlier debates on the role of built environment features in containing urban mobility and promoting sustainable transportation (Burton et al., 2003; Eldér, 2020; Næss, 2022).

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However, empirical evidence regarding the 15 Minute City's effectiveness in reducing car usage and VKT remains scarce. Therefore, it is important to measure the potential for modal shift in urban environments that already offer the required physical preconditions to be considered 15 Minute Cities. By focusing on such settings, we can observe how proximity and accessibility influence individuals' transportation choices, particularly the shift away from car use toward more sustainable modes.

To that end, this study sets to explore how accessibility levels—defined by the proximity of everyday destinations—affect the frequency of car use and the amount of car travel, estimated through driving time as a proxy for VKT. Thus, we employ a hurdle model to examine how the availability of services within a 15 Minute walk from residences influences individuals' modal choices and their overall car usage, using driving time as a proxy for VKT. This analysis aims to provide insights into the potential effectiveness of the 15 Minute City model in moderating car dependency and minimizing associated negative impacts. This is investigated specifically within the context of Barcelona, a city with primary conditions for walkability (Marquet & Miralles-Guasch, 2015a) and a high presence of utilitarian short-distance walking (Marquet & Miralles-Guasch, 2014a).

2. Background

The central tenet of 15 Minute City proposals is that most residents may fulfill their daily needs and activities within 15 Minute of walking or cycling (Pozoukidou & Chatziyiannaki, 2021). These basic social functions typically include housing, work, commerce, health, education, and entertainment (Moreno et al., 2021). This approach highlights the importance of living near to the different social functions in urban areas (Pozoukidou & Chatziyiannaki, 2021), as the main way to access spatially distributed opportunities in the urban environment (Church et al., 2000).

The rise of the 15 Minute City concept has coincided in time with a "proximity turn" in the field of urban planning (Handy, 2020; Proffitt et al., 2019). This paradigm shift in the science of accessibility and politics has moved away from the focus on accessibility gained by ease-of-travel to proximity-based accessibility (Gil Solá et al., 2018; Gil Solá & Vilhelmson, 2022; Levine et al., 2012; Marquet & Miralles-Guasch, 2015a; Silva et al., 2023b). Proximity has been studied at the territorial level, analyzing densities, and built environments only (Boyko & Cooper, 2011; Brownstone & Golob, 2009), trying to determine the density of the city that can have a beneficial impact on transportation patterns, or the diversity needed to generate proximity trips (Ewing et al., 2011; Geurs & van Wee, 2004). While proximity has an important spatial aspect, it is also necessary to incorporate contextual factors, such as travel time or the built environment where activities take place (Brennan & Martin, 2012). Thus, proximity must be understood as a combination of specific spatial and temporal attributes, a double condition that can be observed through the analysis of mobility patterns (Marquet & Miralles-Guasch, 2015a). Travel and accessibility can be treated as a temporal attribute defined by travel time since time is as inherent to accessibility as spatial distance is to proximity (Banister, 2011). In other words, the dynamics of proximity only appear in those places that meet both the proximity between origin and destination with manageable accessibility for the local population (Marquet & Miralles-Guasch, 2015a). Changing the priorities of urban and transportation planning from increasing potential mobility to strategies that encourage local living and the decentralization of services are completely consistent with the core principles of the 15 Minute City concept (Khavarian-Garmsir et al., 2023; Pajares et al., 2021).

2.1. Analyzing proximity dynamics

While the 15 Minute City concept is relatively recent (Moreno et al., 2021), its fundamental mechanism — the connection between built

environment characteristics and travel behavior — positions it as an evolution of previous debates and trends in urban planning and travel behavior studies. Notably, 15 Minute City discussions parallel the compact city debate (Burgess, 2000; Burton, 2000; Burton et al., 2003). Moreover, it aligns with broader research on the links between travel behavior and the built environment (Nkeki & Asikhia, 2019).

A significant part of the most recent literature has been attracted to the 15 Minute City concept through exploring the concept as a tool for sustainability transitions. Several studies have elaborated on the potential of the plan to generate the necessary travel behavior changes to have an impact on transport-related emissions (Allam, Bibri et al., 2022a, 2022b; Da Silva et al., 2020; Lobner et al., 2021). However, it is worth noting that these studies attribute the anticipated reduction in car usage and kilometers traveled to the concept's core principle of reducing distances (Allam, Bibri et al., 2022a, 2022b; Da Silva et al., 2020). Allam et al. (2022b) identify proximity as the main pathway between the 15 Min City and reduced emissions through decreased travel needs and shorter physical distances to essential services.

While the consensus in the literature is that the built environment is a key aspect in determining individual travel behavior, to date no consensus exists on how exactly this built environment interacts with sociodemographic and cultural factors to shape travel behavior. This is especially poignant in the case of predicting car use and car distances travelled. Because car travel is so highly dependent on travel habits and nonfunctional values such as status, convenience and comfort (C. F. Chen & Lai, 2011; C.F. Chen & Chao, 2011; Eriksson et al., 2008; Minnen et al., 2015) it is difficult to estimate the exact effect of walkable built environments in dissuading car use.

Thus, there is a gap in the literature regarding the knowledge of the interaction between the built environment and the behavior of transportation of individuals has made it difficult for decision-makers to assess the policies and land use plans based on their impact on the behavior of the displacements and, therefore, of its effect in reducing VKT and reducing greenhouse gas emissions (Zhang et al., 2012). In this context, the 15 Minute City policy offers a perfect experiment to analyze how car users behave in a context of urban areas that have not only the adequate conditions to be considered walkable, but also that grant minimum access in short walking times. Analyzing car use in the context of a true 15 Minute City allows us to observe how car users behave in the context of optimal walkability and accessibility conditions allowing us to measure superfluous car use or car use that is not based on need. To do so, the context of Barcelona offers an ideal study site as it is both widely considered a walkable and highly accessible city (Ferrer-Ortiz et al., 2022b; Graells-Garrido et al., 2021) Thus allowing for studying what is known as subjective car dependence, this being those car trips that could be done in alternative modes of transportation due to their competitive travel time and costs (Jeekel, 2016).

3. Methods

3.1. Study setting

Barcelona, the capital of Catalonia and Spain's second-most populous city, served as the primary setting for this research. Located on the northeastern coast of the Iberian Peninsula, its urban fabric presents a mix of historic districts and more modern urban designs. Barcelona's built environment and morphology have long attracted researchers interested in understanding travel behavior in the context of a highly dense, mixt and connected European city (Codina et al., 2022; Marquet & Miralles-Guasch, 2014b, 2015b). Recently, the city has been labeled as fully compliant with the 15 Minute City principles, as accessibility is consistently high across its municipal boundaries and the vast majority of citizens have access to everyday destinations in less than a 15 Minute walk from their homes (Ferrer-Ortiz et al., 2022a; Graells-Garrido et al., 2021).

Additionally, in recent times, Barcelona has gained attention for its

innovative urban interventions, most notably the Superblocks (Anguelovski et al., 2023). This urban design strategy, which restricts vehicular traffic in designated areas, has been at the forefront of attempts to reclaim public spaces and reduce vehicular emissions. Furthermore, the city boasts an extensive multimodal transport network that includes metro, bus, tram, and a growing network of bicycle lanes, offering a layered context for the study. This combination of optimal built environment design and high-quality public transport network makes car use in Barcelona not a necessity for most everyday trips. This non-car-oriented environment is put even more into effect when we focus only on those trips that have both a starting and end point within the municipal boundaries and thus do not step on the metropolitan area, an area with higher transportation and design deficits. Despite these conditions, daily car use for internal trips in Barcelona is still above 15 %, the motorization rate was of 416.7 private vehicles per 1,000 inhabitants in 2021, which is one of the least motorized cities in Europe with 644.709 daily internal trips made by car by local residents as of data from 2021 (Ajuntament de Barcelona, 2021a; Institut Metropolí, 2022).

3.2. Accessibility map

This map was built according to the methodology established in another paper that mapped accessibility in the city of Barcelona (Ferrer-Ortiz et al., 2022a) and following the walkability index of Frank et al.(2010). In order to build the accessibility map and calculate the minimum walking distances to a set of basic everyday destinations, we employed an orthogonal grid with a spatial resolution of 100×100m in the strictly urban area of Barcelona, demarcated using cadastral urban limits. Several everyday destinations were assessed: shopping, education, health, sports and culture, social spaces, green spaces, environmental bads (e.g., alcohol, fast food, tobacco, and gambling outlets) (Macdonald et al., 2018) and transportation. Locations of facilities were acquired from diverse sources, including municipal databases, such as the OpenData BCN portal (Ajuntament de Barcelona, 2021b), Urban Map of Catalonia (MUC is the Spanish acronym) (Mapa Urbanístic de Catalunya, n.d.), and chamber of commerce. Utilizing categories from the Census of Economic Activities, daily food and non-food shopping stores were identified and activities not oriented towards residents or of occasional use were excluded.

The Open Street Map (OSM) version 2022 served as the foundation for network analysis. The following four basic elements were used: supply points (the location of services), potential demand points (the location and distribution of Barcelona residents), the distance between supply and demand (walking time and speed), and the transport network (pedestrian-tolerant roads) (Quezada et al., 2019). The supply points were entered as vector layers of points into ArcGIS Pro. For the residents' locations, all cadastral parcels were included, and centroids were generated for each parcel to permit the calculation of the service areas of each urban function. Spatial joins were made from the residential centroids with each generated buffer to determine whether each parcel was included in the various areas of influence corresponding to the different urban functions.

Using ArcGIS Pro, a pedestrian road graph was modeled by assigning a travel cost equivalent to a walking speed of 1.25 m/s or 4.5 km/h (2.796 mi/h). This speed range corresponds to the walking speed of an adult in an urban environment and is consistent with other mobility and transport engineering studies (Sarrade et al., 2020). The road network of Barcelona was delineated, and travel times were computed based on the walkable network. An impedance of 5 km/h, corresponding to the average walking speed of an adult, was applied, and the shortest routes were selected after calibration with Google Maps. This process yielded the minimum walking access time to the facilities, serving as a partial indicator. The derived data was subsequently utilized to calculate the average times for diverse urban functions within Barcelona. The minimum distance to one of the types of urban functions is not dependent on

the facilities that each of them may have. For example, in the case of the function of education, the closest of the schools, no matter the level of schooling which it is, will mandate which is the closest educational urban function to one's residence.

3.3. Travel behavior data

The travel-related data for this study was extracted from a combined dataset of the 2018 and 2019 editions of the official travel survey of the Barcelona Metropolitan Region. This survey is an annual household travel inquiry using computer-assisted telephone interviews (CATI). Respondents are prompted to detail all trip-related information from the preceding workday, such as the number of trips, their purposes, modes of transport, and duration. Additionally, the survey gathers data on individual and household traits, as well as perceptions and preferences concerning various transportation methods. This survey serves as a primary data source for comprehending travel behavior in the region. For our study, we utilized data collected during both 2018 and 2019, which encompassed information from a significant number of individuals aged 16 and above the characteristics of the sample are presented in Table 1.

Drawing from the provided data, car usage was conceptualized utilizing a set of fundamental indicators. Regular car usage was determined from a self-reported response present in the original survey instrument. From the comprehensive log of daily travel, we derived the subsequent indicators for each respondent: (1) Total daily car journeys, (2) Ratio of journeys undertaken by car relative to the overall daily trips, (3) Cumulative minutes spent driving, (4) Ratio of driving minutes to the total time expended in transportation. Thus, allowing us to differentiate participants into habitual car drivers or not. In our analysis, driving time was used as a proxy for VKT, acknowledging that while driving time may not perfectly represent distance due to varying traffic conditions and speeds, it serves as a practical indicator of car usage when direct distance measurements are unavailable

3.4. Statistical analysis

In order to assess the effect of accessibility conditions over car-use, we first use pairwise correlations to test the associations between the main car-use indicators and the accessibility indicators (Table 2).

We then evaluate the relationship between daily driving time and proximity to amenities by employing a Cragg two-part hurdle regression model. This two-part model takes account of the fact that different underlying processes could explain the non-use of the car (0 % of daily trips

Table 1
Habitual car driver characteristics and bivariate associations (ANOVA)

| | Sample | Habitual car driver | Car trips N | Driving time |
|-------------------------------|--------|---------------------|-------------|--------------|
| | N | % | mean | mean |
| Total | 2224 | 32 | 1.61 | 41.70 |
| Gender | | | | |
| Male | 1045 | 44 | 1.66 | 42.93 |
| Female | 1179 | 22 | 1.53 | 39.40 |
| Professional situation | | | | |
| Employed | 1300 | 41 | 1.82 | 46.80 |
| Unemployed | 185 | 16 | 1.54 | 51.57 |
| Inactive | 739 | 21 | 0.93 | 22.57 |
| Age group | | | | |
| 16–29 | 379 | 19 | 1.76 | 39.41 |
| 30–64 | 1281 | 40 | 1.76 | 46.00 |
| 65+ | 564 | 24 | 0.95 | 26.47 |
| Education level | | | | |
| Primary | 369 | 16 | 3.37 | 84.50 |
| Secondary | 715 | 29 | 1.49 | 38.18 |
| College | 1134 | 40 | 1.69 | 44.67 |

Table 2
Pearson Pairwise correlations

| | Average distance | Shopping distance | Health distance | Education distance | Culture and sports distance | Social distance | Environmental bads distance | Transport distance |
|------------------|------------------|-------------------|-----------------|--------------------|-----------------------------|-----------------|-----------------------------|--------------------|
| Habitual car use | 0.106 | 0.096 | 0.060 | 0.073 | 0.100 | 0.105 | 0.095 | 0.042 |
| Car trips N | 0.110 | 0.096 | 0.061 | 0.081 | 0.098 | 0.106 | 0.108 | 0.063 |
| Car trips % | 0.148 | 0.132 | 0.105 | 0.103 | 0.124 | 0.127 | 0.137 | 0.083 |
| Car minutes N | 0.067 | 0.048 | | 0.053 | 0.063 | 0.064 | 0.060 | 0.044 |
| Car minutes % | 0.135 | 0.119 | 0.094 | 0.093 | 0.113 | 0.120 | 0.125 | 0.074 |

Only pairwise correlations statistically significant at $p < 0.05$ are shown.

made as a driver). This approach is specifically designed to accommodate data sets with large numbers of zeros in the dependent variable, which, in our case, is the daily driving time. The Cragg hurdle model operates in two distinct stages. First, we model *Propensity to drive* assessing the likelihood of an individual to engage in driving. In other words, it determines the factors influencing the decision to drive for at least one minute. Second, we model the *Conditional driving time*, conditioned on the positive decision to drive from the first part, predicting the total driving time. The model thus estimates how long an individual is likely to drive once the decision to engage in driving has been made. Using a hurdle model allows us to account for the complex

nature of car use, understanding that car use is a set of consecutive decisions that consist of a modal choice, and a destination choice. Modelling these two stages separately enables a deeper understanding of the effects that built environment and accessibility conditions might have on car-related travel behavior and car-habits.

By utilizing the coefficients derived from both segments of the model, we can generate predictions for unconditional driving times at varying levels of proximity to daily amenities. This is achieved by holding all control variables at their mean values and then multiplying the probabilities of driving (from the first part of the model) by the predicted conditional driving times (from the second part of the model).

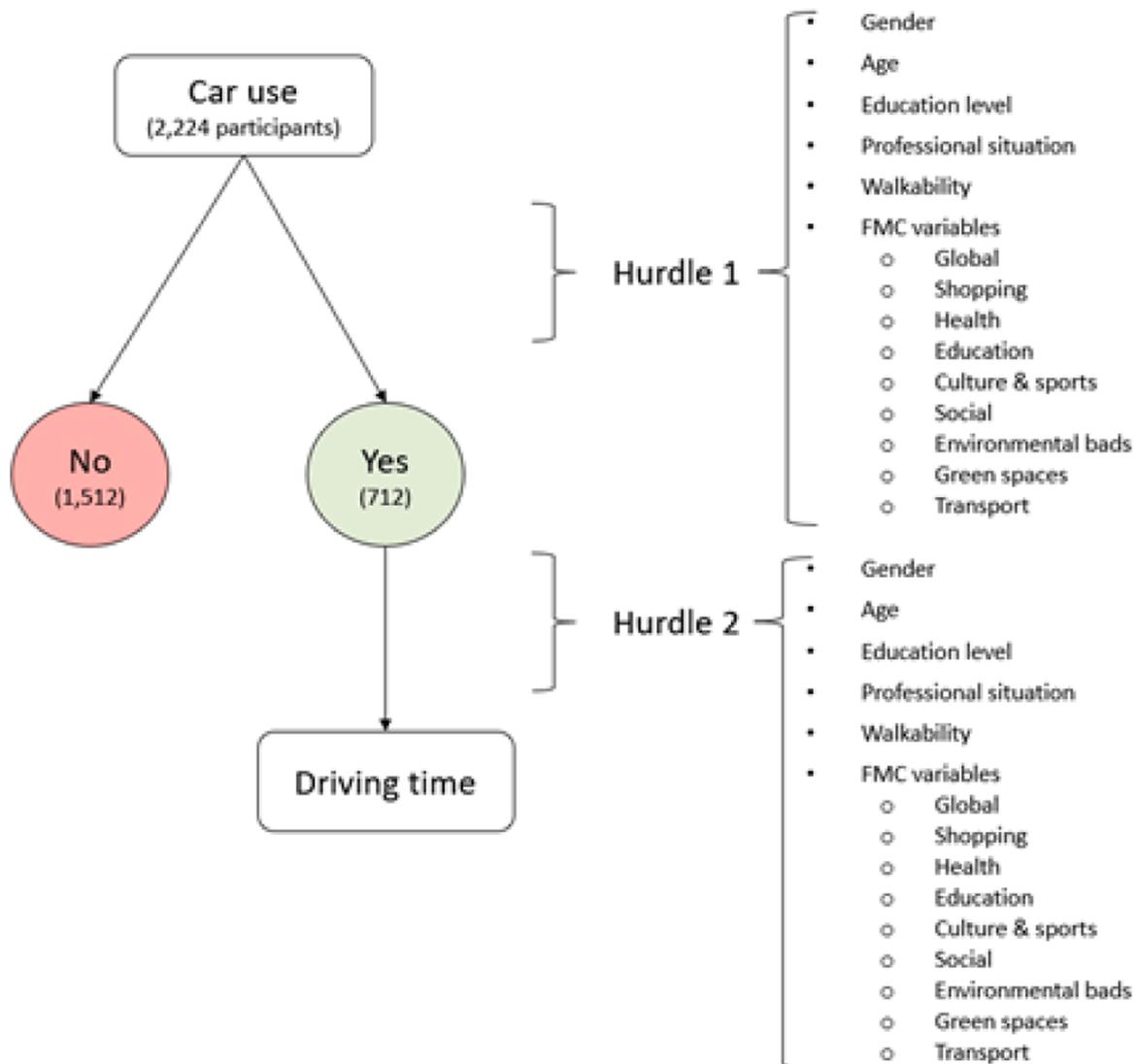


Fig. 1. Hurdle Model basic structure.

This methodological approach aligns with the findings and recommendations proposed by Panik et al. (2019).

To render our results more interpretable, we compute predicted unconditional driving times for hypothetical individuals who have representative values for the independent variable of interest, driving minutes. Because generating predictions requires an assumption about the values of the covariates, we use the marginal effects at the means method (i.e., the covariates are all held at their mean values).

Fig. 1.

4. Results

Out of the 2,224 individuals that composed our representative sample, 32 % of them self-reported to be habitual car drivers. On average, survey respondents took 0.77 daily trips by car, which represents 20 % of their total daily trips. In terms of time spent driving, our participants spent on average 18.9 min per day driving, which represented 22 % of their total daily time spent on transportation.

As expected, some major differences were observed in terms of the sociodemographic characteristics of the individuals. Men were twice as likely to report being habitual car drivers than women, and they took almost double the number of daily trips by driving. Driving represented 26 % of all trips taken by men, while it only represented 15 % of all female mobility. In the end, this is translated also in car-use minutes, with men logging 24.6 daily minutes, and women only 13.7. In terms of age group, similar differences were found when comparing youngsters and seniors with the group of adults (30–64y.o.). Also to be expected, employed people had car-driving rates much higher than those unemployed or inactive, and there was a clear relationship between education level and car use with those with college education being 2.5 times more likely to self-report as habitual car drivers, logging 2.6 more daily car trips, and spending 2.7 times more minutes driving than those with only primary education.

In order to assess the effect of accessibility conditions over car-use, we use pairwise correlations to test the associations between the main car-use indicators and the accessibility indicators (Table 2). While significant, most of the correlations appear to be weak. Interestingly, the larger effect sizes are found between the car-use indicators and the overall average distance to all destinations, measured as walking times. As such, there was a positive, statistically significant correlation ($r = 0.106, p < 0.001$) between being a habitual car user and the average the average walking times to all destinations. Meaning that as distances to daily destinations around a participant’s home increase, so do the odds

of that participant self-reporting as a habitual car driver. Specific distances to shopping facilities, health, education, culture and sports, social centers or even environmental bads were also found to be significantly associated with higher chances of reporting being a habitual car user.

Similar patterns can be found concerning the number of car trips, the proportion of car trips relative to total daily trips, the amount of time spent driving, and the proportion of driving time relative to total daily transport time. The strongest effect size was found between the average distance to all-destinations and the share of car trips ($r = 0.148, p < 0.001$). That indicates that living in areas with short distances to everyday destinations may be associated with lower reliance on car use compared to other modes of transportation. Living in such areas, that can be considered as 15 Minute City- is also associated with driving fewer minutes, although the effect size of this association is the lowest observed and is almost negligible ($0.067 p < 0.001$). In contrast, the association with the share of driving minutes in relation to the total time invested in transport is stronger ($0.135 p < 0.001$) which might indicate that while living near daily destinations might not be affecting the total amount of driving minutes it may be affecting the time spent more generally in other modes of transport.

Table 3 presents the results of a Cragg hurdle model, which provides insights into the factors associated with the likelihood of engaging in at least one car trip and the conditional driving time. The model identifies several positive associations that contribute to understanding the factors influencing car use behavior. For instance, the model shows a positive association between the average distance to all destinations and the likelihood of engaging in at least one car trip (probit coefficient = 0.17, $p < 0.0001$). This suggests that as the distances to daily destinations around a participant’s home increase, the odds of that participant self-reporting as a habitual car driver also increase.

In terms of sociodemographic factors, age is positively associated with both the likelihood of engaging in at least one car trip (probit coefficient = 0.007, $p = 0.001$) and the time spent driving (OLS coefficient = 1.325, $p = 0.001$). This indicates that older individuals are more likely to use cars and spend more time driving. On the other hand, the fact that the model predicting driving time, fails to find a significant association between gender and driving time (OLS coefficient = -15.138, $p = 0.129$) suggests that there is no strong evidence for a difference in driving time between men and women among car users.

One non-significant result in the model predicting the likelihood of car use is the walkability variable (probit coefficient = 0.429, $p = 0.165$). This provides no strong evidence to suggest that walkability has a meaningful influence on the decision to drive. This could be an area for

Table 3
Cragg hurdle model results predicting minutes of daily car use

| Independent variable | Model prediction likelihood of car use | | | | Model predicting time spent driving, for those using car | | | |
|-------------------------------|--|---------|---------------------|-------|--|---------|---------------------|--------|
| | Estimated probit coefficient | $P > z$ | 95 % conf. interval | | Estimated probit coefficient | $P > z$ | 95 % conf. interval | |
| Distance to all destinations | 0.17 | <0.0001 | 0.11 | 0.24 | -3.59 | 0.423 | -12.37 | 5.19 |
| Household size | 0.061 | 0.023 | 0.01 | 0.11 | 2.92 | 4.22 | 0.69 | 0.489 |
| Professional situation | | | | | | | | |
| Employed (=ref) | | | | | | | | |
| Unemployed | -0.520 | 0.000 | -0.76 | -0.28 | 15.378 | 0.463 | -25.73 | 56.48 |
| Inactive | -0.735 | 0.000 | -0.91 | -0.56 | -51.208 | 0.004 | -85.59 | -16.83 |
| Age | 0.007 | 0.001 | 0.00 | 0.01 | 1.325 | 0.001 | 0.52 | 2.13 |
| Education level | | | | | | | | |
| Elementary (=ref) | | | | | | | | |
| Bachelor | 0.237 | 0.030 | 0.02 | 0.45 | 15.186 | 0.457 | -24.79 | 55.16 |
| College | 0.404 | 0.000 | 0.20 | 0.61 | 15.057 | 0.441 | -23.28 | 53.40 |
| Mobility impairment | | | | | | | | |
| Yes (=ref) | | | | | | | | |
| No | 0.073 | 0.553 | -0.17 | 0.31 | -15.570 | 0.455 | -56.44 | 25.30 |
| Gender | | | | | | | | |
| Men (=ref) | | | | | | | | |
| Women | -0.366 | 0.000 | -0.49 | -0.24 | -15.138 | 0.129 | -34.69 | 4.41 |
| Walkability | 0.429 | 0.165 | -0.18 | 1.04 | 14.698 | 0.756 | -77.98 | 107.37 |
| _cons | -1.693 | 0.000 | -2.26 | -1.13 | -38.498 | 0.448 | -137.91 | 60.91 |

further investigation, as other factors, such as neighborhood design or individual preferences, might be more influential in determining car use.

All models have been controlled for household size, professional situation, age, education level, mobility impairment, gender, and walkability. To ease interpretation Table 4 offers a summarized view of the results from all nine hurdle models, differentiating between coefficients depicting the decision to drive (left) and coefficients related to driving time (right).

The model reveals several notable positive associations. For example, the decision to drive is positively associated with the average walking time to all destinations (coefficient = 0.171, $p < 0.001$). This suggests a relatively strong positive relationship between longer walking times to reach all destinations and the likelihood of deciding to drive. Similar dynamics are observed with the distance to shopping facilities (coefficient = 0.136, $p < 0.001$), health distance (coefficient = 0.092, $p = 0.003$), education distance (coefficient = 0.12, $p < 0.001$), culture and sports distance (coefficient = 0.147, $p < 0.001$), social distance (coefficient = 0.146, $p < 0.001$), and environmental bads distance (coefficient = 0.156, $p < 0.001$). This implies that participants living further away from various types of destinations are more likely to decide to drive. The transport distance variable also shows a significant positive association with the decision to drive (coefficient = 0.121, $p < 0.001$), suggesting that an increased distance to public transport stops is associated with a higher likelihood of choosing to drive. Interestingly, the two weaker associations are found in distance to health and distance to education. On the other hand, the association between green areas distance and the decision to drive is non-significant (coefficient = -0.027 , $p = 0.395$), indicating no strong evidence to support a relationship between the distance to green areas and the decision to drive.

The coefficients representing the associations between the respective distance variables and the driving time for those who decide to drive show a general lack of associations across all distance types. For example, the average distance to all destinations' variable has a coefficient of -3.59 and a p -value of 0.423, indicating no strong evidence for an association between the average distance to all destinations and driving time among car users.

Similarly, other distance variables, including shopping, health, education, culture and sports, social, environmental bads, green areas, and transport distances, do not show any significant associations with driving time.

Fig. 2 includes the expected driving minutes for all trips, across the distance to all types of destinations. These expected driving minutes are the result of combining the odds of driving and the estimated driving minutes among those who drove. All sets of destinations have a clear upward trend, by which when distances increase so do the estimated driving minutes. The only exception is the distance to green spaces, which shows no trend in regard to driving minutes.

The X-axis displays the value of the distance to amenity type after standardization.

The color strip represents standard errors.

Table 4
Margins and predicted values

| | Decision to drive | | | Driving time | | |
|--------------------|--|-----------|---------|--------------------|-----------|---------|
| | <i>(Driving minutes ≥ 1)</i> | | | <i>(N Minutes)</i> | | |
| | Estimated probit coefficient | Std Error | $P > z$ | Coefficient | Std Error | $P > z$ |
| 15 Min City Global | 0.171 | 0.033 | <0.001 | -3.59 | 4.481 | 0.423 |
| Shopping | 0.136 | 0.033 | <0.001 | -6.639 | 4.696 | 0.157 |
| Health | 0.092 | 0.031 | 0.003 | -2.579 | 4.307 | 0.549 |
| Education | 0.12 | 0.031 | <0.001 | 0.182 | 4.374 | 0.967 |
| Culture & Sports | 0.147 | 0.032 | <0.001 | -1.46 | 4.681 | 0.755 |
| Social | 0.146 | 0.031 | <0.001 | -3.442 | 4.398 | 0.434 |
| Environmental Bads | 0.156 | 0.032 | <0.001 | -2.699 | 4.511 | 0.55 |
| Green spaces | -0.027 | 0.031 | 0.395 | 0.676 | 4.79 | 0.888 |
| Transport | 0.121 | 0.031 | <0.001 | -3.909 | 4.674 | 0.403 |

5. Discussion and conclusions

The 15 Minute City is an urban design ideal where all essential amenities are reachable within a 15 Minute walk or bike ride from residents' homes (Allam, 2022; Moreno et al., 2021). This model has been proclaimed as a potential solution to various urban challenges, such as air quality and transport justice (Da Silva et al., 2020; Saiz, 2022; Willberg et al., 2023). Our research aimed to provide empirical evidence on the influence of this urban model on transportation behaviors, particularly concerning car use, by analyzing data from 2,224 individuals living in a highly accessible urban environment such as Barcelona.

Our analysis revealed that, despite most participants living in highly accessible, walkable, and transit-friendly areas, nearly a third (32 %) still identified as habitual car users. While this figure may seem high given Barcelona's dense urban fabric, excellent public transit, and limited parking, it highlights that car ownership in this context is more a matter of preference than necessity (Ferrer-Ortiz et al., 2022b; Graells-Garrido et al., 2021). In contrast, prior results from the literature point to less dense cities, such as in Sweden and some areas in Latin-america, where relative increases in proximity to amenities results in potentially large car use reduction (Eldér, 2020; Eldér et al., 2022; Heroy et al., 2023).

The Cragg hurdle model offers insights into how car use behaviors align with the concept of 15 Minute City. Using a hurdle model allows us to account for the complex nature of car use, understanding that car use is a set of consecutive decisions that consist of a modal choice, and a destination choice. Modelling these two stages separately enables a deeper understanding of the effects that built environment and accessibility conditions might have on car-related travel behavior and car-habits.

A central finding from our modeling approach is that while living in 15 Minute City conditions might influence residents' decisions about whether to drive, it doesn't seem to reduce the amount of driving time among those who choose to drive. Living near everyday destinations affects modal choice, leading a significant number of people to rely on active modes or public transport for their transportation needs. This is supported by similar studies that have analyzed the effect of urban environments with policies such as the 15 Minute City on car use and the shift to public transport or walking (Ding et al., 2017; Poorthuis & Zook, 2023). However, it does not affect the car travel time driven by those who still use their cars, as proximity to destinations seems to have no relationship with the amount of driving time among drivers.

Some of these results can be explained by the Travel Time Budget mechanism (Ahmed & Stopher, 2014), where a reduction in travel times due to closer destinations actually generates additional trips or further destinations for those who still choose to drive. However, it is also possible that individuals who remain committed to car use may not be taking advantage of the closer facilities provided. Instead, they continue to drive to their traditional destinations, thereby not reducing their

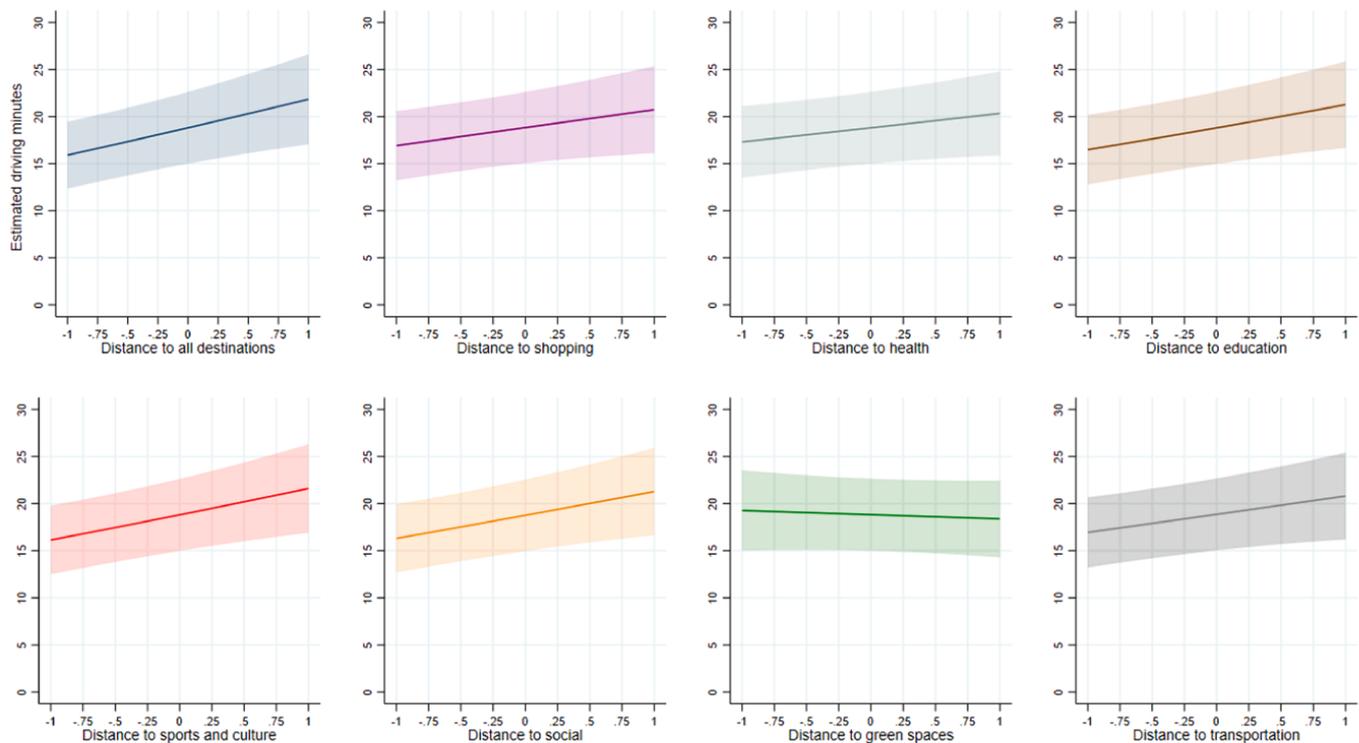


Fig. 2. The estimated driving minutes per distance to several destinations.

travel times or distances. This suggests that for those committed to car use, the increased proximity of destinations does not necessarily lead to shorter driving distances or times. Instead, these individuals may continue to drive to their usual destinations, not taking advantage of the closer facilities. These findings indicate that the positive effect of 15 Minute City policies lies in reducing overall car use, rather than in altering driving distances among those who continue to drive.

Based on these results, and the fact that car use reductions are primarily driven by modal choice rather than shorter travel distances, planners should not expect that simply developing closer destinations will lead to significant reductions in car use in environments where effective alternatives to driving are absent. Our models suggest that once the decision to drive is established, the 15 Minute City model does not significantly reduce car use. However, our results also indicate that the proximity of destinations inherent in the 15 Minute City can make sustainable travel possible without having to rely on complex multi-modal systems, as walking and cycling are prominently available as substitutes for car trips. This aligns with Naess’s (2022) comments that the true transformative power of 15 Minute Cities relies not on their direct effect on travel patterns but on the fact that, by providing universally accessible walking trips, they enable cities to develop additional and often more advanced transportation policies that can disincentivize car travel. At the end, it is the combination of advanced land-use policies and restrictions on private car use that drives the observed changes.

Considering these, we hypothesize that the Travel Time Budget mechanism, through the implementation of 15 Minute City policies and chronourbanistic designs might help consolidated and dense cities continue to progress in their quest to reduce car use. In car-dependent settings on the other hand, investing in necessary conditions to grant car use alternatives might prove a more impactful strategy than merely shrinking car travel time to destinations. This has been supported by other studies which argue that people who choose to drive a car are not always dependent on them (Dastestaninejad et al., 2023). However, our findings are specific to Barcelona—a dense, mixed-use urban environment where car dependence is often subjective rather than a necessity. Therefore, caution should be exercised when generalizing these

results to more car-dependent environments, where different strategies might be required to reduce car use. Additionally, improving public transportation and cycleable infrastructure can make people switch their transportation mode of choice due to the perceived costs from traffic congestion (Sweet & Chen, 2011). However, there is disagreement in the literature over what should be the policy implications as other authors (Birkenfeld et al., 2023; Hosford et al., 2022) have proposed it would be more suitable to increase the number of grocery store locations and households in order to be able to change the household dynamics and travel behavior.

Our models also demonstrate that overall accessibility, represented by cumulative walking times to all key destinations, appears to exert a more pronounced influence on the decision to drive compared to walking times to specific, individual destinations. Planners should thus not focus on improving accessibility to only one type of destination, as it is the mixture of combined accessibility what makes people to avoid driving daily. This is not a new idea, as others have recommended packages of policies in order to promote the 15 Minute City emphasizing the importance of active modes of transportation, density and land use mixture (Papadopoulos et al., 2023; Winters et al., 2017). However, even within these individual destination categories, there are variances worth noting. For instance, the car travel time to shopping destinations demonstrates a stronger influence on driving behavior than car travel time to health facilities. This could suggest that the convenience of proximity to retail outlets may be a more potent determinant of car use compared to healthcare accessibility.

Finally, the fact that even in the context of Barcelona and extreme accessibility conditions 32 % of participants self-identified as habitual car users indicates the need to regulate car use and introduce specific push policies to reduce a share of car use that is resistant to the conditions of the built environment or the need to travel to inaccessible locations.

5.1. Limitations

This study is not without limitations. For once, the nature of our data

does not allow us to account for any self-selection or residential preferences. Thus, it would be possible that those who want to lead a car-free lifestyle specifically to choose areas with higher proximity rates. This would negate the effect of proximity at changing travel behavior as the results of our models would be partially explained by housing decisions made by individuals. However, in the context of Barcelona, with a highly tensioned real estate market and within a Spanish culture that is characterized by very low housing mobility, these effects are likely to be minor. Second, the use of self-reported measures of driving times are prone to reporting bias, with driving times being slightly underreported as a result. Additionally, we recognize that our methodological choice to consider the closest distance to the first activity type may not be appropriate always for all types of activities, such as shopping, since people might choose to go to further locations depending on the availability of options that each shop has. Finally, the authors acknowledge that focusing solely on driving times does not fully capture the wide range of potential benefits of 15 Minute City policies. We recognize that this approach is overly focused on the potential environmental impacts of such policies, potentially overlooking other important outcomes like improved quality of life, enhanced community resilience, and greater accessibility to essential services.

CRedit authorship contribution statement

Marta-Beatriz Fernández Núñez: Writing – review & editing, Writing – original draft, Conceptualization. **Monika Maciejewska:** Conceptualization, Data curation, Methodology, Writing – review & editing. **Laia Mojica:** Methodology, Data curation, Conceptualization. **Oriol Marquet:** Supervision, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors of this manuscript have no conflicts of interest to disclose.

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