

Mobilities of care and cognitive labour: Can urban proximity reduce the organisational burden of everyday mobility?

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ABSTRACT

Urban proximity is increasingly recognised as a fundamental planning principle; however, its social implications remain insufficiently explored. Existing mobility-of-care research primarily focuses on observed travel behaviour and single-destination accessibility, offering limited insight into the cognitive processes that underlie care mobility. This study addresses this gap by examining how proximity relates to the organisational demands of care-related mobility. The analysis considers three outcomes: the cognitive labour involved in planning care-related travel, the integration of personal, household, and caregiving trips within daily routines, and conflicts between personal and care responsibilities. Drawing on geolocated survey data from 823 caregivers in the Barcelona metropolitan area, the study develops a multidimensional proximity index incorporating travel time to destinations, service density, and spatial clustering. Regression models estimate associations between proximity and the three outcomes, controlling for socio-demographic and household characteristics. Findings indicate that greater proximity is associated with reduced cognitive burden, more seamless trip integration, and fewer conflicts. These associations are attributable to travel time to destinations and destination density, while spatial clustering has a limited effect. However, proximity alone does not directly address care-related structural inequities embedded in existing social structures. By linking spatial configuration to lived mobility experiences, this study conceptualises proximity as an organisational resource that reduces the effort required to coordinate daily life. Urban planning should therefore move beyond traditional accessibility metrics to include organisational and cognitive dimensions. Policies promoting dense, mixed-use environments around key care destinations, such as schools and health services, may reduce coordination burdens, supporting more equitable everyday mobility.

1. Introduction

Over the past decade, urban proximity—defined as residents' opportunity to access everyday destinations and activities within short distances or travel times (Silva et al., 2025)—has emerged as a central theme in academic and policy discourse. The 'X-minute city' model exemplifies this approach by advocating a polycentric urban structure in which essential destinations are accessible within an X-minute walk or bicycle ride (Sepehri and Sharifi, 2025). This model contrasts with car-centred planning, which emphasises centralisation and motorised

transport, by instead prioritising proximity-centred planning, decentralised services, and active modes of transport (Silva et al., 2025). Such strategies are increasingly adopted worldwide as cities seek to improve environmental and health outcomes and address spatial and transport inequalities (Teixeira et al., 2024).

While the environmental and health benefits of urban proximity are well documented (Allam et al., 2022; Neves and Brand, 2019), its social dimensions remain insufficiently explored. This gap is partly methodological, as proximity is frequently measured using one-dimensional indicators such as travel time or distance to specific destinations. Such

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indicators assume simplified, individualised, and single-destination travel patterns, which limit their ability to capture the complexity of everyday mobility. Additionally, proximity is experienced unevenly, shaped by individuals' routines, responsibilities, and constraints. More nuanced methodologies are required to understand how different groups experience and benefit from proximity in daily life (Maciejewska et al., 2025; Marquet and Maciejewska, 2024).

These methodological limitations are particularly evident in the context of care-related mobility. Care mobilities encompass all travel undertaken for caring and home responsibilities, including escorting children, supporting older adults, and shopping for household necessities (Sánchez de Madariaga, 2013). These activities involve complex trip chaining, coordination across multiple locations, and ongoing negotiation of personal and care responsibilities. They also impose considerable cognitive demands related to managing daily routines and supporting dependents (Daminger, 2019; Gilow, 2020; Jirón et al., 2020; Ravensbergen et al., 2023). Addressing these dynamics requires a broader conceptualisation of proximity that accounts for the diversity, density, and spatial arrangement of destinations.

Most research on mobilities of care has focused on identifying and quantifying care-related trips (Gómez-Varo et al., 2024; Murillo-Munar et al., 2023; Ravensbergen et al., 2023) or measuring accessibility to care destinations (Soukhov et al., 2025a). While these studies offer valuable insights, they often overlook the organisational dimension of care mobility. Care-related travel encompasses not only observed trips but also the time and effort required to plan, coordinate, and integrate multiple activities within constrained daily schedules (Gilow, 2020). Evidence on the influence of urban proximity on these organisational practices remains limited.

This study addresses two primary gaps: a methodological gap in measuring urban proximity and a conceptual gap in understanding care-related mobility, particularly its organisational and cognitive dimensions. The research examines the relationship between proximity and three aspects of the cognitive and organisational labour associated with care mobility. Specifically, it evaluates whether urban proximity influences (1) the cognitive burden of organising household- and care-related travel, (2) the ease of travel, defined as the ability to integrate personal, household, and caregiving trips within mobility routines, and (3) conflicts between personal activities and care responsibilities.

The analysis draws on geolocated survey data collected in Autumn 2025 from 823 adults engaged in care mobility in the Barcelona metropolitan area. Respondents' residential locations are combined with spatial data on everyday services to construct a multidimensional proximity index that includes (A) travel time to essential destinations, (B) the density of destinations within a 10-minute walk, and (C) the spatial clustering of destinations. The index is operationalised to provide a standardised, comparative measure for assessing walking-based proximity to everyday destinations from each respondent's residence, rather than to represent individual walking capacity or experienced accessibility during specific journeys. It characterises whether destinations are accessible on foot (Miller, 2018), whether multiple nearby options are available (Mouratidis, 2026), and whether these destinations are sufficiently close to each other to support walking-based trip chaining (Poudyal et al., 2023). Collectively, these dimensions are intended to capture the organisational complexity of care-related mobility, which often encompasses highly localised, short, and chained trips (Gilow, 2020; Jirón et al., 2020; Ravensbergen et al., 2023; Uteng, 2021).

Regression models are used to assess the association between proximity and three outcomes: cognitive burden, ease of travel, and conflict between competing responsibilities. These models control for socio-demographic and household characteristics, including age, gender, education, income, type of care, household size, and car availability. Interaction terms are included to examine variation across groups. By linking objective proximity measures with subjective mobility experiences, this study advances debates on proximity-based planning by

conceptualising urban proximity as an organisational resource that extends beyond access to destinations and by analysing its role in diverse caregiving contexts.

The paper is structured as follows: Section 2 reviews the literature on mobilities of care. Section 3 details the data and methods. Section 4 presents the results, while Section 5 discusses them. Section 6 concludes by outlining policy implications, acknowledging limitations, and suggesting directions for future research.

2. Literature review

2.1. Defining mobilities of care

Care-related mobility refers to travel undertaken to meet the everyday needs of others, such as escorting children, older adults, or people with disabilities, as well as to maintain the household, such as shopping for household necessities (Sánchez de Madariaga, 2013). As a core element of unpaid care work, care-related mobility is essential for the reproduction of daily life, structuring routines, enabling household functioning, and facilitating access to essential services and opportunities (Hanson, 2010; Jirón et al., 2020).

Sánchez de Madariaga, 2013 introduced the concept of mobilities of care to analytically distinguish these forms of travel from those associated with paid employment and to highlight activities that have historically been overlooked in transport research. Subsequent scholarship has expanded this perspective by emphasising the coordination required for care-related mobility. Gilow (2020) characterises mobility associated with unpaid domestic work as 'domestic mobility work' to highlight the skills and effort involved. Joelsson et al. (2025) position care-related travel within broader 'caringscapes', illustrating how care is organised through the interdependence of temporal routines and spatial arrangements. Collectively, this body of research conceptualises care mobility as a relational, co-produced, and evolving practice embedded within household dynamics and life-course trajectories.

Research on care mobility demonstrates that travel associated with care work systematically differs from other forms of mobility. These journeys are typically short-distance, highly localised, and frequently involve trip chaining (Gilow, 2020; Jirón et al., 2020; Ravensbergen et al., 2023; Uteng, 2021). The literature also identifies structural inequalities in care-related mobility. Care trips, which represent a substantial share of daily travel, are disproportionately undertaken by women (Tiznado-Aitken et al., 2025), particularly in lower-income households (Murillo-Munar et al., 2023; Ravensbergen et al., 2023). These findings are consistent with feminist mobility scholarship, which documents persistent, gendered differences in travel behaviour shaped by the intersection of gender, income, age, and urban context (Castañeda et al., 2024; Jirón et al., 2020; Uteng and Cresswell, 2016).

The study of care mobilities presents considerable methodological challenges. Care-related trips often overlap with other travel purposes, such as paid employment, which complicates their identification in conventional datasets (Tiznado-Aitken et al., 2025). Despite their significance, these trips are underrepresented in standard travel surveys due to the omission of care-related motives, the exclusion of short active trips, and reliance on heads of household for reporting. These limitations highlight the need to re-evaluate data collection methods to more accurately capture the full extent of care-related mobility (Sánchez de Madariaga, 2013; Murillo-Munar et al., 2023; Ravensbergen et al., 2023).

2.2. Social implications of mobilities of care

Despite these methodological challenges, analysing care mobilities is essential for understanding travel patterns, their characteristics, and the resulting social consequences for caregivers. Care-related trips are often embedded within complex daily routines, requiring caregivers to coordinate multiple activities within limited temporal and spatial resources.

These demands often create conflicts between personal needs and care responsibilities, thereby reducing opportunities for leisure, social participation, and engagement in activities outside the household. In turn, this dynamic increases the risk of social isolation and exclusion.

These constraints are further influenced by gendered expectations surrounding caregiving. Norms of 'intensive mothering' and 'sacrificial parenting' frequently position parents, particularly mothers, as responsible for prioritising family needs over their own activities. As a result, personal leisure becomes sporadic rather than routine (McKeown, 2021; Shaw, 2008; Shaw and Dawson, 2001). Intergenerational evidence demonstrates persistent barriers to meaningful leisure for women, highlighting entrenched gender inequalities within households (Holland, 2012). Additionally, activities described as family leisure often require significant organisational effort and therefore do not constitute leisure for those responsible for their arrangement (McKeown, 2021).

These dynamics are not limited to childcare. Informal carers of older adults or individuals with disabilities encounter comparable constraints on leisure and social participation (Greenwood et al., 2018). In these situations, care responsibilities are often open-ended and intensify over time. Limited access to formal support and respite services, relative to childcare, further exacerbates these challenges (Eurocarers, 2022). Consequently, care responsibilities may contribute to social exclusion by restricting caregivers' ability to maintain social connections, pursue personal activities, and participate fully in community life.

Therefore, a comprehensive understanding of the social consequences of care mobility necessitates attention to its organisational and relational dimensions. In practice, this involves examining how caregivers coordinate care-related travel with competing demands and how these daily mobility arrangements influence caregivers' participation, wellbeing, and social inclusion.

2.3. Mobilities of care and urban proximity

Previous research has examined care-related travel in relation to urban proximity, defined as the opportunity to access everyday destinations and activities within short distances or travel times (Silva et al., 2025). Most studies, however, focus on access to specific types of destinations, such as schools (Napier et al., 2011; Omura et al., 2019; Yu and Zhu, 2016) or grocery stores (Morioka et al., 2023; Negron-Poblete et al., 2016). This limited selection overlooks the range of destinations associated with care and how this diversity shapes caregiving practices. Soukhov et al. (2025a, 2025b) represent a notable exception by linking care mobility to the X-minute city framework through the concept of 'caring 15-minute neighbourhoods', which are defined as areas where multiple care-related destinations are accessible within a 15-minute walk. By utilising cumulative opportunity and accessibility measures, their research advances a more care-oriented understanding of urban proximity.

Despite these contributions, most of the quantitative literature relies on one-dimensional measures of proximity, typically defined by travel time or distance to selected destinations. While these metrics provide useful information, they do not fully capture the complexity of everyday care mobility. A more comprehensive conceptualisation of urban proximity, incorporating destination diversity, density, and trip chaining, is necessary to better understand how caregivers experience and benefit from it in daily life (Maciejewska et al., 2025; Li et al., 2024; Marquet and Maciejewska, 2024).

2.4. Cognitive labour in mobilities of care

While quantitative research on mobilities of care has primarily focused on identifying and measuring care-related trips (Gómez-Varo et al., 2024; Murillo-Munar et al., 2023; Ravensbergen et al., 2023), qualitative studies have shown that care-related mobility extends beyond observable travel by exploring the substantial organisational

and temporal work occurring before, during, and after trips (Gilow, 2020).

Within the broader care literature, this work is referred to as cognitive or mental labour, which includes the ongoing processes of anticipating needs, organising activities, and coordinating daily life (Aviv et al., 2025; Daminger, 2019; Dean et al., 2022; Robertson et al., 2019). Offer (2014) likens this to maintaining a 'mental spreadsheet'. In the context of mobility, cognitive labour involves planning dependents' movements, coordinating schedules and pick-ups, arranging appointments, and managing overlapping responsibilities. This continuous coordination imposes a substantial, often invisible mental burden that restricts flexibility, influences decision-making, and limits opportunities for personal activities, especially in environments with limited accessibility and transport options.

Cognitive labour operates alongside the physical and emotional aspects of care, yet remains analytically distinct (Daming, 2019). Its embedded nature complicates measurement and often obscures gendered inequalities. Although some survey-based studies report limited gender differences in overall cognitive workload (Daming, 2019), qualitative research consistently finds that women assume a disproportionate share of coordination tasks. These disparities are reinforced by prevailing social norms, such as ideals of 'good parenting' (Dowling, 2000; Shaw, 2008), which heighten expectations to organise activities for dependents across various life stages (Wall, 2001; Warner, 2006). Comparable patterns are evident among carers of older adults and individuals with disabilities, where ongoing, frequently increasing responsibilities generate similar cognitive demands (Greenwood et al., 2019; Zygouri et al., 2021).

Despite its significance, cognitive labour remains underexplored within care-mobility research, which generally focuses on observable travel patterns and accessibility metrics. Gilow (2020) offers a notable exception, showing through interviews with mothers in Brussels that care-related travel requires ongoing coordination of household and personal routines. As she notes, "planning work is never done once and for all" (p. 3; see also Plyushteva and Schwanen, 2018).

This research gap is especially relevant in the context of urban proximity. While proximity is often linked to accessibility and travel behaviour, its influence on the organisational and cognitive demands of caregiving—and, by extension, on caregivers' opportunities for participation and social inclusion—remains insufficiently examined. Proximity can function as a strategic resource by reducing time and spatial constraints associated with care coordination (Gilow, 2020; Uteng, 2021), decreasing the cognitive demands of navigating mobility systems (Middleton and Spinney, 2019), and mitigating social exclusion among caregivers, especially those lacking access to private vehicles. To address this gap, the present study examines how multidimensional measures of proximity—including destination diversity, distance, density, and clustering—interact with the organisational dimensions of care. These dimensions include the cognitive labour involved in planning care travel, the integration of personal, household, and caregiving trips within daily routines, and the conflicts that arise between personal activities and care responsibilities.

3. Data and methods

The relationship between urban proximity and care-related mobility outcomes was examined using geolocated survey data collected in Autumn 2025 from 823 adults engaged in care activities in the Barcelona metropolitan area. Residential locations were linked to spatial data on everyday services to construct three dimensions of proximity: (A) travel time to essential destinations, (B) density of destinations within a 10-minute walk, and (C) spatial clustering of destination types. Each respondent was assigned scores for each dimension, and a composite proximity index was calculated as the unweighted mean of these scores. These measures were associated with three outcomes reflecting the organisational load of care mobility: (1) cognitive labour involved in

planning and coordinating trips, (2) ease of travel, defined as the ability to integrate personal and caregiving trips into daily routines, and (3) conflicts arising from competing personal and care-related travel demands. Associations were estimated using regression models controlling for demographic and socio-economic characteristics, with both individual proximity dimensions and the composite index included. The following sections detail the study setting and survey, the construction of proximity measures, the operationalisation of variables, and the modelling strategy.

3.1. Study setting and survey

The study area includes the city of Barcelona and nine adjacent municipalities (see Fig. 1). These municipalities form the inner ring of the Barcelona metropolitan area and are characterised by continuous urban development, commuting flows, and shared transport and service infrastructures (Gil-Alonso et al., 2022).

The survey targeted adults residing in the study area who undertake caregiving trips (e.g., escorting children, older adults, and/or people with disabilities, running household errands, shopping for groceries), aiming to capture variation in service accessibility. A total of 823 responses were collected between September and October 2025, including 473 online responses and the remainder via telephone. Participants were recruited through Opinometre, a company specialising in mobility research. The telephone sample was randomly selected from a pre-coded database stratified by accessibility levels, while the online sample was recruited through panels (Netquest, Cint, Toluna). In both recruitment modes, eligibility was established using screening questions regarding caregiving responsibilities and trips taken in the previous week.

The questionnaire gathered detailed information on mobility practices, such as trip organisation, temporal and spatial constraints, and perceived trade-offs. It also collected socio-demographic and household characteristics, including age, gender, income, education, car availability, household size, and type of care provided (for children, older adults, people with disabilities, or multiple responsibilities). Descriptive statistics are provided in Table A in the Appendix.

Respondents were geolocated using home coordinates (see Fig. 1). Seven individuals residing outside the metropolitan area were excluded, resulting in a final sample of 816 respondents for the accessibility analysis. Due to missing outcome data, regression models include 809 observations for cognitive labour and ease of travel, and 798 for conflict. Sampling weights were not applied because reliable population benchmarks for caregivers in Barcelona are unavailable, which precludes the construction of valid weights.

3.2. Dimensions of proximity

Urban proximity was operationalised using three complementary dimensions. Proximity metrics were derived from a pedestrian network constructed with OpenStreetMap data¹ (OpenStreetMap Contributors, 2026). Respondents' home locations were geolocated and snapped to the nearest network node to ensure valid routing origins. Walking times were estimated using shortest-path algorithms, with an assumed average walking speed of 4.5 km/h. This standardised speed facilitated consistent measurement across all respondents and destination types, including personal, household, leisure, and care-related trips, although it is recognised that actual walking speeds may vary between individuals and travel situations.

Points of interest (POIs) were identified and classified into destination types following Fevry et al. (2026), with minor modifications for the local context and data availability (see Table 1). These destinations were selected to represent everyday needs across various life stages that

should be accessible within walking distance, in accordance with the 'X-minute city' framework (Ferrer-Ortiz et al., 2022). Misclassified entries were excluded using rule-based filters (see Table B in the Appendix). Spatial analyses were conducted using OSMnx (Boeing, 2017), NetworkX (Hagberg et al., 2008), and GeoPandas (Jordahl et al., 2020).

The three dimensions of urban proximity were computed as described below.

Dimension A, travel time to essential destinations, assesses basic access by calculating the minimum walking time required to reach key services (Miller, 2018). For each residence, the shortest-path walking times to the nearest POI in each destination category were determined using Dijkstra's algorithm (Dijkstra, 1959) and then reverse-normalised, so that higher values indicate greater accessibility.

Dimension B, density of destinations within walking distance, quantifies cumulative opportunities by measuring the number of destinations accessible within a 10-minute walk (Mouratidis, 2026). Counts were calculated along the pedestrian network for each service category, normalised to account for baseline differences, and then averaged across domains (see Table C in the Appendix). Whereas Dimension A reflects the nearest opportunity, Dimension B captures the overall breadth of accessible opportunities.

Dimension C, spatial clustering of destinations, characterises the spatial arrangement of amenities and their potential to facilitate efficient trip chaining (Poudyal et al., 2023). For each respondent, the nearest POI within each service sub-domain (e.g., dining, entertainment) was identified, and network travel times between these destinations were computed. The median travel time was then reverse-normalised, so that higher values indicate stronger clustering.

The composite proximity index was calculated as the unweighted mean of the three normalised dimensions. Equal weights were assigned because these dimensions are conceptualised as complementary aspects of proximity, avoiding assumptions about their relative importance. Higher index values indicate shorter travel times, greater destination density, and stronger clustering. Both the composite proximity index and its individual components were included in the regression models to estimate their associations with care-related mobility outcomes (see Fig. 2).

3.3. Defining the outcome variables

Three outcome variables were derived from survey responses, each representing a distinct dimension of organisational load associated with care mobility: cognitive labour, ease of travel, and the conflict involved in negotiating personal and care-related trips. Together, these variables reflect the mental effort and trade-offs involved in organising, coordinating, and managing care-related travel within daily routines.

Cognitive labour and ease of travel were operationalised as multi-item constructs, measured using three and five Likert-scale items, respectively (1 = strongly disagree, 5 = strongly agree). These items were aggregated through exploratory factor analysis (EFA), with factor loadings and reliability statistics reported in Table 2. Conflict was measured using a single-item Likert scale (1 = strongly disagree, 5 = strongly agree): "Care-related trips (e.g., picking up children, accompanying elderly people) prevent me from fitting personal activities into my weekly schedule (e.g., going to the gym, going out with friends)".

3.4. Statistical modelling

The relationship between urban proximity and care-related mobility outcomes was analysed using two sets of regression models. The composite proximity index and its individual dimensions served as the primary explanatory variables (see Table 3). All models controlled for socio-demographic and household characteristics relevant to mobility and caregiving.

Control variables comprised gender (0 = female [reference], 1 = male), age (standardised), education (1 = university [reference], 0 = no

¹ Map data copyrighted OpenStreetMap contributors and available from <https://www.openstreetmap.org>.

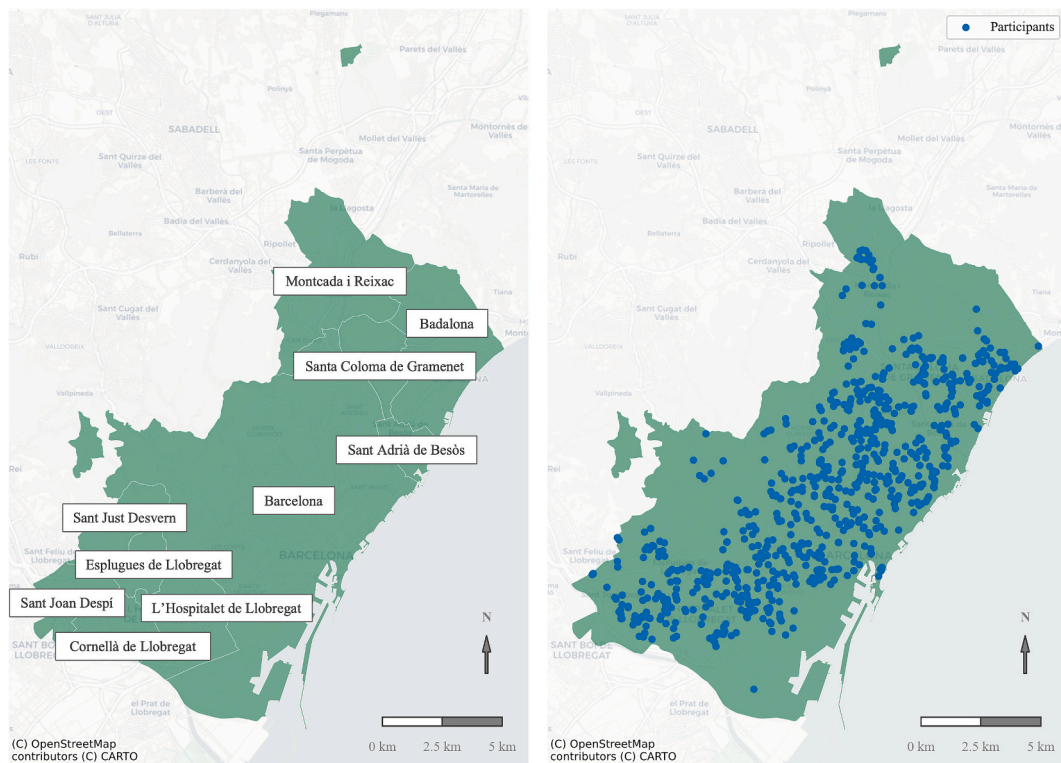


Fig. 1. Study area overview: The left panel shows Barcelona and surrounding municipalities, and the right panel shows the merged metropolitan area with the residential locations of the 816 participants. Source: own elaboration.

university), and household income (low, medium [reference], high; dummy-coded). Care responsibilities were assessed using binary indicators for caring for children, older adults, or persons with disabilities, as well as a count of care roles to capture caregiving intensity. Additional controls included household size (standardised) and car availability (full access [reference], limited, none, unknown; dummy-coded). Respondents identifying as non-binary had to be excluded due to insufficient sample.

Two model specifications were estimated for each outcome variable. The first specification used baseline ordinary least squares models (OLS), defined as follows:

$$Y_i = \beta_0 + \beta_1 \text{Proximity}_i + \beta_2 X_i + \epsilon_i$$

where Y_i denotes the outcome for respondent i , Proximity_i represents either the composite index or its individual dimensions, X_i is the vector of control variables, and ϵ_i is the error term.

The second specification used interaction models (OLS + interactions), which extended the baseline model to assess whether the effects of proximity varied by age, income, caregiving responsibilities, and car availability:

$$Y_i = \beta_0 + \beta_1 \text{Proximity}_i + \beta_2 X_i + \beta_3 (\text{Proximity}_i \times Z_i) + \epsilon_i$$

where Z_i denotes interaction variables. Higher-order socio-demographic interactions were not estimated to preserve model parsimony and minimise instability in smaller subgroup combinations.

Sensitivity analyses were conducted to assess the robustness of the findings. Multilevel models, with individuals nested within municipalities, were estimated. Very low intraclass correlation coefficients indicated that most of the variation occurred at the individual level; therefore, multilevel specifications were excluded from the primary analysis. Standard errors were calculated using HC3 heteroskedasticity-robust corrections. Models with municipality-clustered standard errors produced substantively similar coefficients. However, given the small number of clusters ($n = 10$), these estimates are likely downward-biased.

Consequently, HC3 corrections were selected. Sensitivity checks, including alternative 5-minute isochrones and various service aggregation procedures, confirmed the stability of the results.

4. Results

Results are presented for ordinary least squares models with interaction terms (Model 2). These models assess whether relationships between proximity and its dimensions (travel time, destination density within a 10-minute walk, and spatial clustering) and three aspects of the organisational load involved in care-related mobility (cognitive labour, ease of travel, and conflict between personal and caregiving activities) differ by age, income, caregiving responsibilities, and car availability. This approach allows the analysis of variation across population groups. For comparison, figures display baseline coefficient estimates from models without interaction terms (Model 1). Table 4 provides descriptive statistics for the three proximity dimensions.

Table 5 presents descriptive statistics for the three outcome variables—cognitive labour, ease of travel, and conflict between personal and caregiving activities. Responses generally clustered around the midpoint or slightly above it (Means (M) = 3.03–3.77), with substantial variation across participants (Standard deviations (SDs) = 1.17–1.40). Ease of fitting essential personal trips into the weekly schedule received the highest rating ($M = 3.77$, $SD = 1.19$), while coordinating weekly schedules and planning multi-stop trips received the lowest ratings ($M = 3.03$ and 3.04 , respectively).

4.1. Relationship between proximity and cognitive labour

The results indicate that greater urban proximity is associated with reduced cognitive labour, as evidenced by the negative effect of the composite index ($\beta = -0.11$, $p = 0.015$; Model 2). This means that caregivers residing in more proximate environments report fewer cognitive demands related to scheduling and coordinating everyday

Table 1

Destinations grouped by service domain and their contribution to the proximity dimensions.

Domain	Sub-domain	Destination categories	Aggregation
Education	n/a	Nurseries Schools Clinics	Absolute number in dimension Average between primary healthcare > Dimension
Healthcare	Primary healthcare	Social services	Average between secondary healthcare > Dimension
	Secondary healthcare	Dentists Pharmacies	Average between fresh food > Average between food provision > Dimension
Food provision	Fresh food	Bakeries Butchers Fishmongers Greengrocers Markets	Absolute number > Average between food provision > Dimension
	n/a	Supermarkets	Average between entertainment > Average retail > Dimension
Retail	Entertainment	Bookshops Electronics Kiosks & Newsagents Sport stores Stationery Toys Chemists & Perfumeries	Average between apparel and personal care > Average retail > Dimension
	Apparel and Personal care	Clothes Hairdressers Opticians Shoes	Average between household maintenance > Average retail > Dimension
Dining	Household maintenance	Furniture stores Hardware stores Houseware stores & Interior decoration shops Department stores & Malls Variety stores	Average between variety > Average retail > Dimension
	Variety	Bars Cafes Fast food places Ice cream places Pubs Restaurants Arts centres Cinemas Community centres Libraries Museums Theatres	Average between dining > Dimension
Culture and Sport	n/a	Fitness centres Fitness stations Pitches Sport centres Gardens	Average between culture > Average culture and sport > Dimension
	Culture	Parks Playgrounds Bicycle rentals	Average between sport > Average culture and sport > Dimension
Green spaces	n/a	Bus stops Subway entrances Tram stops	Average between green spaces > Dimension
Public and Active transport	n/a	ATMs Banks Post offices	Average between public and active transport > Dimension
Financial and public services	n/a	Places of worship	Average between financial and public services > Dimension
Places of worship	n/a		Absolute number in dimension

Note: when two destinations are listed together with '&', the calculation uses the nearest destination for each participant.

mobility. While modest, the effect remains consistent across model specifications.

This association varies across different proximity dimensions (see Fig. 3). Both travel time to essential destinations (Dimension A) and the density of nearby destinations (Dimension B) show significant negative relationships of similar effect sizes ($\beta = -0.11$, $p = 0.012$; $\beta = -0.10$, $p = 0.023$; Model 2). In contrast, spatial clustering (Dimension C) is not statistically significant ($\beta = -0.06$, $p = 0.138$; Model 2). These findings suggest that minimising travel time from home and ensuring access to a sufficient concentration of nearby services and activities are more influential in reducing cognitive labour than the spatial arrangement of amenities.

Analysis of control variables reveals that older respondents report lower cognitive labour ($\beta = -0.15$, $p = 0.001$; Model 2, Composite index), as do higher-income individuals compared to the medium-income group ($\beta = -0.18$, $p = 0.031$; Model 2, Composite index). Men also report significantly lower levels of cognitive labour than women, with a notable effect size ($\beta = -0.19$, $p = 0.001$; Model 2, Composite index). None of the interaction terms is statistically significant, indicating that the effect of proximity on cognitive labour is consistent across socio-demographic groups (see Table D in the Appendix).

Item-level analyses show a consistent association between proximity and reduced cognitive burden, particularly for routine tasks such as coordinating weekly schedules and organising multi-stop trips. The observed effects are weaker for disruptions caused by unexpected delays, suggesting that proximity primarily alleviates routine planning demands rather than reactive adjustments. Results for item-level analyses are presented in Fig. A in the Appendix.

4.2. Relationship between proximity and ease of travel

Greater urban proximity is associated with increased ease of travel, defined as the capacity to integrate personal, household, leisure, and caregiving trips—both routine and spontaneous—into weekly schedules (see Fig. 4). The composite proximity index shows a significant positive association ($\beta = 0.12$, $p = 0.006$; Model 2, Composite index), indicating that caregivers residing in more proximate environments are therefore better able to integrate multiple activities without significantly increasing organisational effort.

This relationship is driven by shorter travel time to destinations (Dimension A) and higher density of nearby services (Dimension B), both of which are statistically significant ($\beta = 0.12$, $p = 0.003$; $\beta = 0.09$, $p = 0.016$; Model 2). In contrast, spatial clustering (Dimension C) is not statistically significant ($\beta = 0.08$, $p = 0.06$; Model 2).

Several socio-demographic variables are associated with ease of travel. Older individuals report greater ease ($\beta = 0.11$, $p = 0.001$; Model 2, Composite index), as do those in the high-income group compared to the middle-income group ($\beta = 0.18$, $p = 0.006$; Model 2, Composite index). The type of caregiving is also significant: caring for older adults is associated with higher ease than caring for children ($\beta = 0.18$, $p = 0.023$; Model 2, Composite index), while caring for persons with disabilities is associated with lower ease ($\beta = -0.22$, $p = 0.045$; Model 2, Composite index). The effect size associated with disability-related caregiving suggests that mobility constraints linked to disability may limit the extent to which neighbourhood proximity translates into perceived flexibility. Limited car access corresponds to lower reported ease of travel ($\beta = -0.17$, $p = 0.003$; Model 2, Composite index). Interaction results indicate that the positive association between proximity and ease of travel is weaker for this group ($\beta = -0.19$, $p = 0.011$). These findings suggest that constrained or inconsistent access to a car reduces the perceived ability to access nearby opportunities for flexible trip organisation (see Table E in the Appendix).

Item-level analyses demonstrate that proximity most strongly facilitates spontaneous trips and the coordination of household tasks, which in turn enables increased leisure time. The effects are less pronounced for personal trips and multi-purpose trip combinations, suggesting that

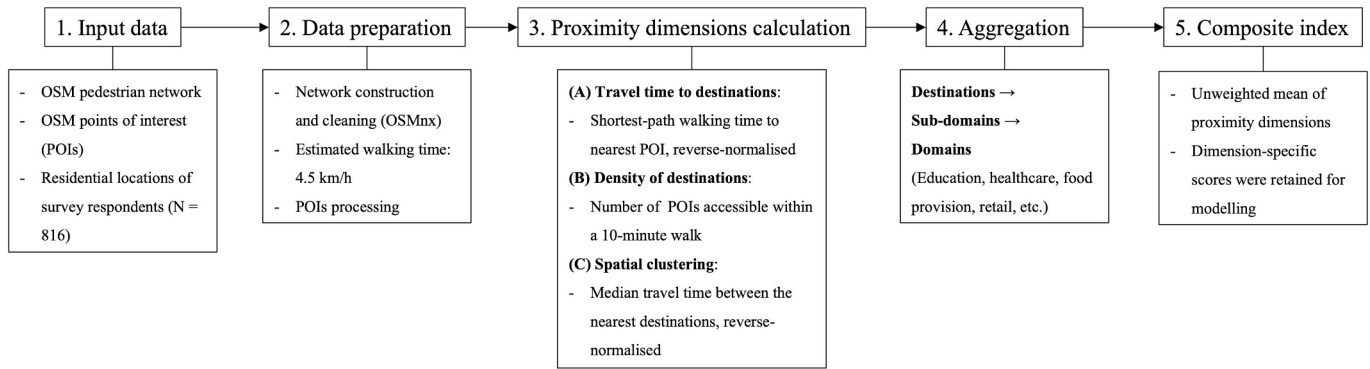


Fig. 2. Methodological framework for constructing the proximity index. Source: own elaboration.

Table 2

Factor loadings and reliability statistics for the outcome constructs.

Outcomes	Survey items	Item total correlation	Factor loading
Cognitive labour	Coordinating the weekly schedule for myself and my family is mentally taxing.	0.58	0.69
	Planning trips with multiple stops (e.g., running errands, picking up children) requires significant mental effort.	0.65	0.84
	Unexpected changes or delays while travelling often disrupt my planned schedule and increase stress.	0.55	0.63
Cronbach's α was 0.76 with a 95% confidence interval of [0.73, 0.79]. Sampling adequacy was acceptable (KMO = 0.68), and Bartlett's test of sphericity was significant ($p < 0.001$), indicating the items' suitability for factor analysis.			
Ease of travel	I can easily fit essential personal trips (e.g., doctor's appointment) into my weekly schedule.	0.43	0.51
	I can regularly take part in new leisure activities (e.g., cultural activities, workshops) or visit new destinations (e.g., parks).	0.50	0.60
	It is easy for me to make spontaneous trips (e.g., last-minute errands, non-planned activities) because I have everything I need nearby.	0.47	0.57
	I am able to manage household-related trips and still find time for activities the family enjoys together.	0.53	0.66
	I can often combine multiple tasks (e.g., run errands, pick up children) during trips to save time for personal activities.	0.46	0.57
Cronbach's α was 0.72 with a 95% confidence interval of [0.69, 0.75]. Sampling adequacy was acceptable (KMO = 0.77), and Bartlett's test of sphericity was significant ($p < 0.001$), confirming the suitability of the items for factor analysis.			

flexibility gains differ across mobility purposes. Overall, urban proximity enhances discretionary flexibility in daily travel. Results for item-level analyses are presented in Fig. B in the Appendix.

4.3. Relationship between proximity and conflicts between personal and care-related trips

The analysis indicates that greater urban proximity is associated with fewer conflicts between care responsibilities and personal travel, as measured by the composite index ($\beta = -0.11$, $p = 0.045$, Model 2). This supports the balancing of care-related trips with personal activities, such as leisure and social participation, within limited weekly schedules. The relationship is primarily attributable to travel time to destinations (Dimension A), which is significantly and negatively associated with the

Table 3

Model specifications.

Model	Model name	Individual level	Interactions with proximity	Sample size
1	OLS: Individual characteristics	Age, gender, education, income, type of care, household size, car availability		Cognitive labour, N = 809; Ease of travel, N = 809; Tension, N = 798
2	OLS + interactions: Interactions with proximity	Same as model 1	Proximity x age, proximity x income, proximity x type of care, proximity x car availability	Cognitive labour, N = 809; Ease of travel, N = 809; Tension, N = 798

Table 4

Descriptive statistics of proximity dimensions.

Dimensions	Mean	SD	Min	25%	50%	75%	Max
Dimension A – Travel time to essential destinations (minutes by walking)	9.61	6.45	3.68	5.95	7.85	10.05	50
Dimension B – Density of destinations within a 10-minute walk (count)	5.09	3.22	0.08	2.80	4.36	6.96	15.62
Dimension C – Spatial clustering of destinations (minutes by walking)	6.88	3.87	2.19	4.58	5.80	7.76	42.15

Note: values are presented in their original scale to facilitate interpretation. Normalisation was applied to compute the composite measure and conduct the regression analyses. SD stands for standard deviation.

outcome ($\beta = -0.09$, $p = 0.026$, Model 2). In contrast, neither density (Dimension B) nor spatial clustering (Dimension C) demonstrates a statistically significant effect (see Fig. 5). These results suggest that having essential destinations close to home exerts a greater influence on reducing conflicts than either the density or spatial arrangement of these destinations. Among the covariates, gender remains a significant predictor; men report fewer conflicts than women ($\beta = -0.21$, $p = 0.008$, Model 2, Composite index). None of the interaction terms is statistically significant. The OLS results are presented in Table F in the Appendix.

Table 5
Descriptive statistics for the outcome variables.

Outcomes	Survey items	Mean	SD	1, n (%)	2, n (%)	3, n (%)	4, n (%)	5, n (%)
Cognitive labour	Coordinating the weekly schedule for myself and my family is mentally taxing.	3.03	1.36	17.7%	18.9%	25.7%	18.4%	19.4%
	Planning trips with multiple stops (e.g., running errands, picking up children) requires significant mental effort.	3.04	1.35	17.6%	18.2%	25.8%	19.7%	18.8%
	Unexpected changes or delays while travelling often disrupt my planned schedule and increase stress.	3.48	1.36	11%	15.6%	19.3%	22.7%	31.5%
	I can easily fit essential personal trips (e.g., doctor's appointment) into my weekly schedule.	3.77	1.19	5.3%	10%	23.5%	25.3%	35.9%
Ease of travel	I can regularly take part in new leisure activities (e.g., cultural activities, workshops) or visit new destinations (e.g., parks).	3.12	1.35	14.9%	18.9%	27.8%	15.7%	22.7%
	It is easy for me to make spontaneous trips (e.g., last-minute errands, non-planned activities) because I have everything I need nearby.	3.65	1.40	16%	0.9%	23.2%	22.1%	37.9%
	I am able to manage household-related trips and still find time for activities the family enjoys together.	3.47	1.17	7.7%	10%	33.5%	25.2%	23.6%
	I can often combine multiple tasks (e.g., run errands, pick up children) during trips to save time for personal activities.	3.58	1.18	7.5%	8.7%	30.3%	25.6%	23.6%
Conflict	Care-related trips (e.g., picking up children, accompanying elderly people) prevent me from fitting personal activities into my weekly schedule (e.g., going to the gym, going out with friends).	3.28	1.40	16.5%	12.1%	25.6%	18.4%	27.4%

Note: SD stands for standard deviation.

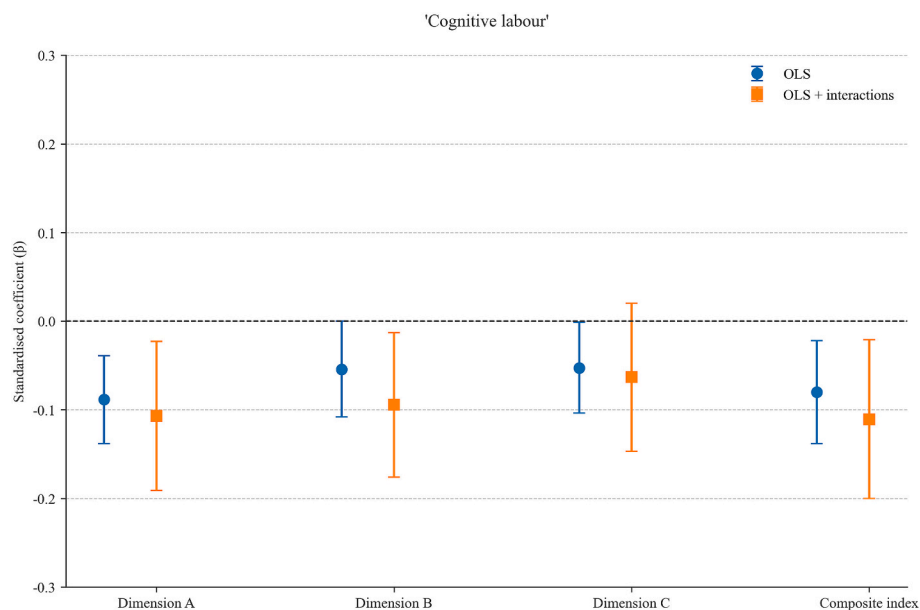


Fig. 3. Estimated effects of proximity dimensions and the composite index on cognitive labour, based on the OLS and OLS with interaction models. Source: own elaboration.

5. Discussion

This study contributes to the mobilities of care literature by investigating how urban proximity influences not only access to care destinations but also the practices through which caregiving mobility is organised, experienced, and negotiated. Specifically, the research addresses three research questions: whether proximity reduces the cognitive burden of organising care travel, facilitates the integration of personal, household, and caregiving trips, and mitigates conflicts between personal activities and care responsibilities. This analysis builds upon existing quantitative approaches, which have primarily focused on trip patterns and spatial accessibility (Gómez-Varo et al., 2024; Murillo-Munar et al., 2023; Ravensbergen et al., 2023; Soukhov et al., 2025a, 2025b), by foregrounding the relational and processual nature of care (Daminger, 2019; Gilow, 2020; Jirón et al., 2020) and incorporating subjective dimensions of care, such as the organisational work that underpins everyday mobility.

A key contribution of this study is showing that proximity functions

not only as a spatial condition related to destination accessibility but also as an organisational resource associated with reduced cognitive effort in the organisation of care mobility. In lower-density or less proximate environments, coordination tasks such as schedule synchronisation, trip sequencing, and contingency management impose greater organisational demands on households, thereby increasing cognitive load. In contrast, proximate and dense urban environments can internalise some of these demands by offering shorter travel times and a broader array of local options. As a result, the built environment may absorb part of the organisational burden otherwise borne by caregivers. This relationship is most evident in routine coordination tasks such as weekly scheduling, suggesting that proximity is more closely linked to structural rather than situational aspects of cognitive effort. This interpretation is consistent with evidence highlighting the continuous and iterative nature of planning work (e.g., Gilow, 2020; Breitzkreuz et al., 2021) and shows that the intensity of cognitive labour varies across spatial contexts. More broadly, these results advance understanding of how the built environment shapes well-being, not only through access

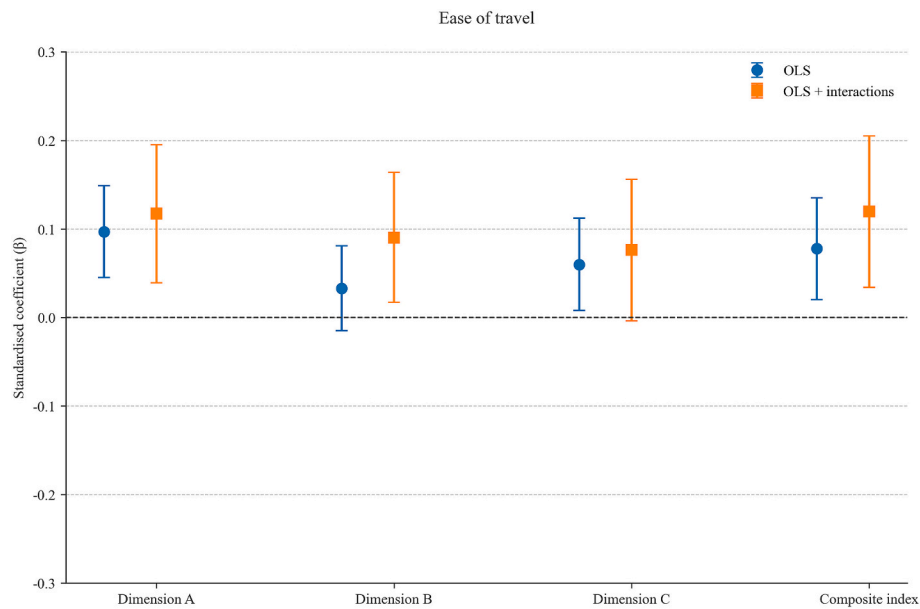


Fig. 4. Estimated effects of proximity dimensions and the composite index on ease of travel, based on the OLS and OLS with interaction models. Source: own elaboration.

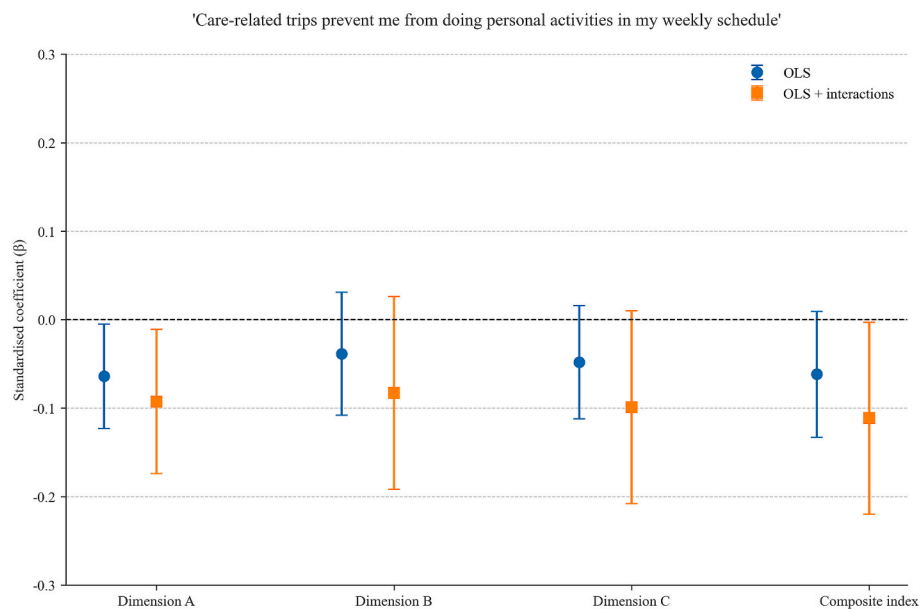


Fig. 5. Estimated effects of proximity dimensions and the composite index on conflicts between personal and care-related trips, based on the OLS and OLS with interaction models. Source: own elaboration.

and travel conditions but also through the effort required to organise daily life.

These findings further inform debates regarding social participation among caregivers. While caregiving is frequently linked to restricted personal travel and reduced participation in activities (McKeown, 2021; Shaw, 2008), living in proximal environments may facilitate the integration of multiple activities within limited time and space constraints, as well as reduce the trade-offs between care obligations and personal pursuits. Shorter travel times and greater local options for destinations and activities improve opportunities for leisure and social participation. Although proximity does not eliminate these caregiving-related constraints, it may render them more manageable and mitigate the risk of social exclusion for caregivers (Greenwood et al., 2018).

Methodologically, this study underscores the value of adopting a

multidimensional approach to operationalising proximity. Defining proximity as a combination of walking time to essential destinations, destination density, and spatial arrangement of amenities yields a more nuanced understanding of care-related mobility than traditional single-destination metrics, particularly for routines involving short distances and trip chaining (Gilow, 2020; Jirón et al., 2020; Porath and Galilea, 2025; Ravensbergen et al., 2023; Uteng, 2021). The observed significance of travel time from home likely reflects the structure of care-related mobility, which centres on fixed anchor points such as home, schools, or care appointments, with additional activities organised around these locations (Isaksen and Näre, 2022). Similarly, the relevance of destination density suggests that, when several suitable options are available locally, daily needs can be met without relying on efficient routing across the nearest destinations. This interpretation is consistent

with evidence that destination choice is influenced not only by proximity but also by service quality, familiarity, and personal relationships (Maciejewska et al., 2025). In contrast, the weaker association observed for clustering may be attributable to measurement limitations, as the indicator captures network efficiency between nearest destinations rather than the full complexity of trip chaining in practice.

The results also reveal substantial variation in the organisational demands of care mobility across socio-demographic and household characteristics. Gender disparities are particularly pronounced: women experience higher levels of cognitive labour and greater conflict between personal and care-related mobility, consistent with established evidence on the gendered division of care work (Hanson, 2010; Jirón et al., 2020). Differences by care type (e.g., caring for older adults or for people with disabilities) reinforce this pattern by underscoring the influence of care intensity, schedule rigidity, and different support needs.

In summary, our findings indicate that spatial conditions confer significant benefits through proximity. Well-served environments reduce organisational burdens and facilitate the integration of care and personal activities, thereby improving mental well-being and lowering the practical costs of daily mobility for caregivers. However, spatial conditions do not override existing social and household structures of care. Urban proximity should be regarded as a supportive spatial factor that may alleviate certain constraints, but it is not a standalone solution to care-related inequalities. It does not address the underlying structural inequalities that shape care responsibilities and mobility burdens for specific caregiver groups, such as women and individuals with higher care loads.

6. Conclusion

This study contributes to the mobilities of care literature by conceptualising urban proximity as an organisational resource for caregivers—one that can reduce the cognitive burden and effort required to coordinate care-related mobility while facilitating the integration of non-care trips. In doing so, this study advances the understanding of the social implications of proximity-based planning and extends research on care-related mobility beyond observed travel behaviour. Methodologically, this study contributes to transport scholarship by introducing a multidimensional operationalisation of proximity that surpasses single- and nearest-destination metrics, thereby more accurately capturing the spatial complexity of care-related routines.

The findings have direct implications for transport and planning practice, particularly for proximity-based models such as the X-minute city. Proximity should be considered not only as a strategy to improve access or reduce trip lengths but also as a means of simplifying the organisation of activity and travel patterns of caregivers. This perspective supports prioritising dense, mixed-use environments structured around everyday anchor destinations, where multiple care needs can be met within limited spatial and temporal constraints. In practice, proximity-based planning should incorporate multidimensional indicators that capture cumulative opportunities and spatial clustering, especially when assessing everyday mobility.

However, the observed associations across caregiver groups indicate that proximity alone is insufficient to address inequalities in care-related mobility. Although increased proximity may reduce organisational demands, it does not directly address the structural inequities underlying care responsibilities. Therefore, this finding highlights the need to complement land-use strategies with transport and social interventions that directly support groups with greater caregiving responsibilities, particularly women and caregivers of people with disabilities. Incorporating measures of organisational labour into accessibility and equity assessments may help identify where proximity is effective and where additional policy intervention is required.

Several limitations qualify these findings. First, the analysis is based

on a relatively high-density context; even areas with lower proximity within the Barcelona metropolitan area may offer greater accessibility than comparable areas in other cities. The generalisability of these associations to lower-density environments remains uncertain, and spatial clustering may play a more significant role when destinations are more dispersed. Second, the cross-sectional design precludes causal inference. The reported relationships should therefore be interpreted as associations, potentially influenced by residential self-selection, whereby caregivers with more complex routines or stronger preferences for convenience reside in areas of higher proximity. Unobserved factors, such as local social networks, may also contribute to the observed patterns. Third, the proximity measures reflect objective proximity based on the pedestrian network; however, they do not account for factors that may affect the practical accessibility of geographically proximate destinations, including road safety, traffic conditions, street quality, or other environmental barriers. Finally, data limitations, particularly the absence of workplace locations and the use of simplified clustering measures, limit the ability to analyse activity spaces and trip sequencing.

Future research should test the proposed framework across diverse urban contexts, employ longitudinal designs, and incorporate more detailed activity and travel data to capture the interaction between spatial configuration and temporal constraints. Further investigation is also needed into the relationship between objective and perceived proximity, for example by combining network-based measures with qualitative methods to gain deeper insight into how caregivers experience and navigate their local environments. Overall, these findings suggest that urban proximity is not only a spatial property but also a socially embedded condition that structures the effort required to organise everyday mobility.

CRedit authorship contribution statement

Serena Mombelli: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ersilia Verlinghieri:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Conceptualization. **Jamie Furlong:** Writing – review & editing, Validation, Supervision, Software, Project administration, Methodology, Conceptualization. **Monika Maciejewska:** Writing – review & editing, Supervision, Resources, Project administration, Investigation, Data curation, Conceptualization. **Oriol Marquet:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Funding acquisition, Conceptualization.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

Ethical considerations

Ethical approval was not required.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jtrangeo.2026.104857>.

Data availability

Data and models will be made available on request.

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