Expanding the 15-Minute City through e-micromobility services

Abstract

Urban planners are increasingly tasked with strengthening neighborhood economies and encouraging more connected communities. Central to this objective is ensuring equitable access to essential amenities such as grocery stores, parks, and hospitals. In recent years, shared e-micromobility services such as publicly available e-bikes and e-scooters have gained popularity as a means of local transport, offering potential to extend access. However, their contribution to the 15-Minute City framework across cities is not well understood. In this study, we assess if shared e-micromobility services expand access to essential amenities (i.e., supermarkets, schools, hospitals, parks, and entertainment venues), across five international cities. Observed e-micromobility trips are used to generate city-level travel time surfaces, which are compared with counterfactual walking times for the same trips. Results suggest access gains from e-micromobility are uneven, largely determined by urban form, distribution of amenities, and distance from city center. Cities and neighborhoods with less compact urban form and more dispersed land use tend to experience the largest gains in access with e-micromobility, increasing the proportion of the city reachable within 15 minutes by up to threefold in some cities. This work provides evidence to inform policies to better integrate new forms of local-scale transport (i.e., e-micromobility services), to improve access to essential services within the 15-Minute City framework.

Keywords: micromobility, 15-minute city, e-bike, e-scooter, active transport, connected communities

1 Introduction

The concept of the 15-Minute City has gained interest over the past decade as an idealized vision of urban living [1, 2]. Founded in early work on *New Urbanism* [3], the concept emphasizes that important resources and amenities, e.g., workplaces, schools, healthcare facilities, parks, etc., should be accessible within 15 minutes of travel from one's home. Following the COVID-19 pandemic, the 15-Minute City has garnered renewed attention as a potential approach to urban resilience [1]. The framework aims to reduce the need for long-distance travel, financial and environmental costs, and promote community cohesion and local economic growth [4, 5].

Much of the existing research on 15-Minute Cities has focused on walking and public transit, emphasizing neighborhood walkability and decreased reliance on private automobiles [6, 7]. An increasing body of work has argued that private automobiles, while effective at covering large distances, often isolate individuals from their communities instead of strengthening social connections [8]. Walking, in contrast, is frequently championed for enhancing community engagement and urban vitality [9]. Walking-based access is well-suited for compact urban regions, where essential amenities are densely distributed. In regions where essential amenities are sparsely distributed, the same walking threshold often corresponds to limited access. Less dense cities may be excluded from potential benefits of the 15-Minute city when access is defined by walking and fixed-route transit options.

Shared e-micromobility offers an alternative mobility option to further the extent of a 15-minute radius. Such services provide a more flexible alternative for short-distance travel, without constraints of fixed transit routes and schedules. Unlike private bicycle ownership, which typically imposes a round-trip obligation, shared micromobility systems easily allow uni-directional and multi-modal trips. This flexibility proved critical during the COVID-19 pandemic, when e-micromobility services provided a means to reach essential services while limiting close contact [10]. Venture capital-backed operators like *Lime* and *Tier* have rapidly scaled free-floating vehicle services to hundreds of cities worldwide, making short travel more accessible and relatively affordable for city residents [11].

Since the 15-Minute City framework is based on a fixed time budget, the range of accessible amenities expands or contracts based on travel speed. Shared e-micromobility services expand access beyond walkable or cyclable distances, without financial costs or commitments associated with driving or traditional transportation systems. In this study, we define e-micromobility as publicly available e-bikes and e-scooters equipped with electric assistance. These vehicles offer travel speeds that are more consistent regardless of a rider's fitness level, expanding the 15-minute catchment area beyond other active modes (e.g., cycling or walking). While personal e-micromobility vehicles offer comparable benefits regarding speed and range, they have higher upfront ownership and maintenance costs. Shared e-micromobility services lower logistical and financial barriers, making the benefits of e-micromobility accessible to a wider population.

In this study, we measure how e-micromobility redefines spatial reach within the 15-Minute City framework. We analyze millions of shared e-micromobility trips across five international cities – Berlin, Germany; London, UK; Paris, France; Wellington, New Zealand; and Washington DC, USA. These cities were selected because they have existing e-micromobility systems, and varying urban forms, ranging from compact to more car-centric regions. We focus on five core amenity types central to the 15-Minute City framework: supermarkets, schools, hospitals, parks, and entertainment venues. Observed e-micromobility travel times are compared with simulated (i.e., counterfactual) walking travel times for the same routed origin-destination pairs, providing a baseline for assessing modal differences in *access*, defined as the ability to reach amenities within a specified travel time threshold under existing service conditions.

Unlike distance-based accessibility measures that rely on assumed speeds [12], observed trip data capture real-world conditions (e.g., traffic congestion, construction detours, or regulatory speed limits) that often slow travel time. Discrete trip observations are extended to city-wide measures using Inverse Distance Weighting (IDW) spatial interpolation. This yields a continuous travel time surface for each amenity and mode, to estimate travel time at unobserved locations based on surrounding trip data. We then classify e-micromobility and walking travel time surfaces into three temporal thresholds (i.e., $\leq$ 15 Minutes, 15-30 Minutes, and 30+ Minutes). This classification allows us to quantify how shared e-micromobility expands the spatial extent of amenity access within each city, consistent with the objectives of the 15-Minute City framework. We address the following research questions (`RQ`).

`RQ1` *Do e-micromobility services increase access to essential services within a city, as compared to walking?*
To answer this question we compare city-wide travel time surfaces derived from e-micromobility trips against counterfactual walking times for the same trips, to quantify changes in access.

`RQ2` *Does access to amenities via e-micromobility vary based on the type of amenity?*
To answer this question, we compare travel time surfaces for five essential amenities (i.e. hospitals, parks, supermarkets, schools, and entertainment venues) within a city.

`RQ3` *Does access to amenities via e-micromobility, based on existing service conditions, vary by city*?
To answer this question, we compare the total proportion of each city accessible within the 15-Minute threshold. We explore variability in access between core and peripheral regions within these cities.

2 Related Work

At its core, the 15-Minute City envisions an environment where residents can access essential urban functions such as housing, employment, healthcare, education, entertainment, or key transportation hubs (e.g., bus stops, train stations, metro stations, or ferry terminals) within a 15-minute radius via active mobility modes like walking or cycling [13]. While the 15-minute threshold is widely used in accessibility metrics [14, 15], it has faced critique for oversimplifying and discontinuities [16, 17], for example, treating opportunities reachable in 16 minutes as *inaccessible*. Critics argue that a universal 15-minute cutoff is an arbitrary planning guideline that may not align with the complex *time-geography* of diverse urban residents [18]. Varying thresholds can lead to different spatial rankings and policy implications [19, 20], suggesting a need for continuous travel time metrics (e.g, within 15 Minutes or 15 to 30 Minutes) rather than a single cutoff.

A growing body of research has explored the feasibility of transforming various cities into x-Minute Cities in terms of their potential for walking or biking [21–23]. However, few studies have separately evaluated the accessibility of different urban functions [24, 25]. Additionally, these evaluations are frequently confined to single cities or regions, overlooking the disparities in planning and implementation challenges across diverse geographic and socioeconomic contexts [26, 27]. For instance, European cities, characterized by their smaller scale and compact design, may find it easier to achieve the goals of a 15-Minute City [28]. In contrast, low-density North American cities face significant challenges in a 15- or even 30-Minute City model [29]. This underscores a critical research gap in the pressing need for more nuanced, function-specific analyses of the 15-Minute City concept across a broader range of urban environments.

The original 15-Minute City concept states that all essential services should be accessible within a 15-minute walk or bike ride [30]. However, most current research centers on walking, while cycling-based x-Minute City frameworks remain underexplored [31]. The reality is that the rise of micromobility services has transformed human travel behavior [32–35]. There is little doubt that micromobility has had an impact on the first/last mile challenge in public transportation [36–38]. By integrating micromobility solutions with public transit systems, cities are attempting to create seamless multimodal transportation networks [39, 40], improving access and providing a competitive, sustainable alternative to private car usage [41, 42].

Micromobility plays a crucial role in sustainable urban planning [43, 44]. Beyond reducing reliance on cars [45], it may help to minimize air pollution and greenhouse gas emissions [46], making it an important form of transport in combating climate change. Similarly, increased availability of micromobility services is contributing to individual well-being and public health while fostering social connections [10, 47].

A large amount of literature on the 15-Minute City focused on access through walking [48–52]. Very few studies examine cycling, let alone compare walking and cycling within a unified framework. One case study in Vancouver, Canada, found that less than 1% of residents lack a grocery store within a 15-minute bike ride, whereas about one-fifth are without one within a 15-minute walk at an older pedestrian's pace [53]. An analysis of 12 major U.S. cities revealed that, on average, only 10% of essential activities are within a 15-minute walk, 41.5% by bike, and over 65% by car [6]. They found that the 15-Minute City model works in megacities like New York, San Francisco, Boston, and Chicago, but not in cities such as Atlanta, Dallas, Houston, and Phoenix. However, a Chicago study reveals that, despite biking generally improving access, many areas struggle to connect with essential destinations within a 15-minute journey [54]. It is evident that previous studies have yet to reach a consensus on the 15-Minute City framework for multiple travel modes, with a number of challenges remaining.

Traditional accessibility metrics often use home-based locations as the primary reference point [55]. For example, a study found that people who live and work in the city center appear to have the smallest average movement radius compared with those who have at least one location outside the city center [56]. However, this approach risks oversimplifying the complexity of modern urban movement. In particular, women are significantly more likely than men to engage in complex trip chains (e.g., stopping for groceries or childcare on the way to/from work) [57, 58]. E-micromobility trips could be a way to shift the focus from potential accessibility to measure realized or actual access [59, 60]. E-micromobility data offers a unique lens on this transition because these trips are often spontaneous [61] or used for both home-based and non-home activities [62, 63]. Therefore, analyzing e-scooter traces enables a more inclusive understanding of access that accounts for actual travel behavior.

There are still several research gaps in further development and evaluation of the 15-Minute City concept, particularly cross-city comparisons with respect to shared e-micromobility [64]. To our knowledge, this study is the first to examine access to essential amenities, comparing observed e-micromobility travel times to counterfactual walking durations for the same trip at three different time intervals. Furthermore, while most cross-city comparisons have been confined to a single country or continent, our study, for the first time, compares major cities across five different nations.

3 Methodology

3.1 Data

E-micromobility trip data were accessed between August 2020 and May 2024. Trip data include the geographic coordinates and timestamps of the origin and destination along with the duration of the trip. These data were collected by accessing the *Available Vehicles* public application programming interfaces (API) for the three e-micromobility operators every 60 seconds.[1] Following the approach outlined in [35], a trip origin was identified when a vehicle identifier disappeared from the set of available vehicles, and trip conclusions were identified when vehicles reappeared as available. We removed trips that are unlikely to represent valid user trips, such as those resulting from rebalancing, maintenance, or noise. Data were cleaned to remove trips less than 5 minutes in duration or less than 100 meters (Euclidean) distance. Additionally, trips over a max speed of 30 km/hr or longer than 2 hours were removed from analysis.

Trip data were accessed for five cities: Washington, D.C., USA; Wellington, New Zealand; London, United Kingdom; Paris, France; and Berlin, Germany. The total number of trips as well as operators are listed in Table 1.

We gathered data on places of interest (POIs) by selecting five essential amenity categories, including supermarkets, parks, hospitals, schools, and entertainment venues, which influence residents' daily lives. These categories were identified based on their roles in supporting everyday needs, promoting social interactions, and contributing to overall community well-being. These have also been the focus of previous studies [65–67] on 15-Minute Cities. We obtained OpenStreetMap (OSM) data from

[1] Tier: https://platform.tier-services.io/v2/vehicle?zoneId=cityname
Lime: https://data.lime.bike/api/partners/v1/gbfs/washington _dc/free_bike_status
Flamingo: https://api.flamingoscooters.com/gbfs/wellington/free_bike_ status.json

Table 1: Counts of e-micromobility trips, e-micromobility operator, and places of interest grouped into five categories across each of our five focal cities.

	Berlin	London	Paris	Washington DC	Wellington
Total trip count	11,761,219	1,192,227	4,848,310	5,951,082	1,052,900
E-micromobility operator	Tier	Tier	Tier	Lime	Flamingo
Supermarkets	869	352	710	63	16
Parks	2,705	1,865	702	766	238
Hospitals	56	88	59	12	5
Schools	111	84	601	216	82
Entertainment venues	11,149	15,304	15,247	2,185	723

Trip data span Aug 28 2020–May 9 2024 (Berlin), Aug 6 2021–Apr 28 2024 (London), Aug 28 2020–Apr 29 2024 (Paris), Sep 22 2022–May 6 2024 (Washington DC), and Nov 29 2021–May 9 2024 (Wellington).

the Geofabrik[2] server, selecting the corresponding cities and downloading the latest .osm.pbf files. We then derived the amenities layer by extracting point features with relevant tags (e.g., amenity, shop, tourism, leisure, etc). The resulting amenities dataset was exported to a GIS-ready format (e.g., shapefile) for analysis. We acknowledge that there is ongoing discussion in the academic community regarding the validity of using OSM POI data for urban mobility research [68, 69] but given the multi-city nature of our analysis, OSM is a reasonable source of POI data.

3.2 Analysis

An overview of the analytical workflow used to estimate and compare e-micromobility and walking access across cities and amenity types is shown in Figure 1. We identify e-micromobility trips associated with each amenity type by selecting trips whose origin or destination lie within a 1-km radius of an amenity. A 1-km threshold was used to represent the furthest distance an individual is generally willing to walk to access amenities [70–72]. This roughly corresponds to a 10 to 15-minute walking time, consistent with how access is operationalized in existing 15-Minute City literature [25]. The use of such a distance threshold for amenity catchment areas has precedent in mobility and accessibility studies [73, 74].

E-micromobility trips are associated with a given amenity if either the trip origin or destination is within a 1-km catchment area surrounding that amenity. When only a trip origin falls within this catchment (i.e., the trip ends outside the 1-km radius), trip destination coordinates are used as origins in trips. This approach assumes that travel duration is comparable in either direction, including both inbound and outbound trips in the analysis. Directional differences in e-micromobility travel times are assumed to be limited, as trips generally traverse the same street network under similar speeds and operating conditions [75]. Observed durations of these trips are used to represent e-micromobility travel times, categorized for each amenity type across cities. If a trip falls within the catchment areas of multiple amenities of the same type (e.g., multiple grocery stores or hospitals), the trip is assigned to the closest amenity of that type. This one-to-one assignment ensures each trip is linked to a single amenity,

[2] https://download.geofabrik.de/. Accessed on 20 August 2024.

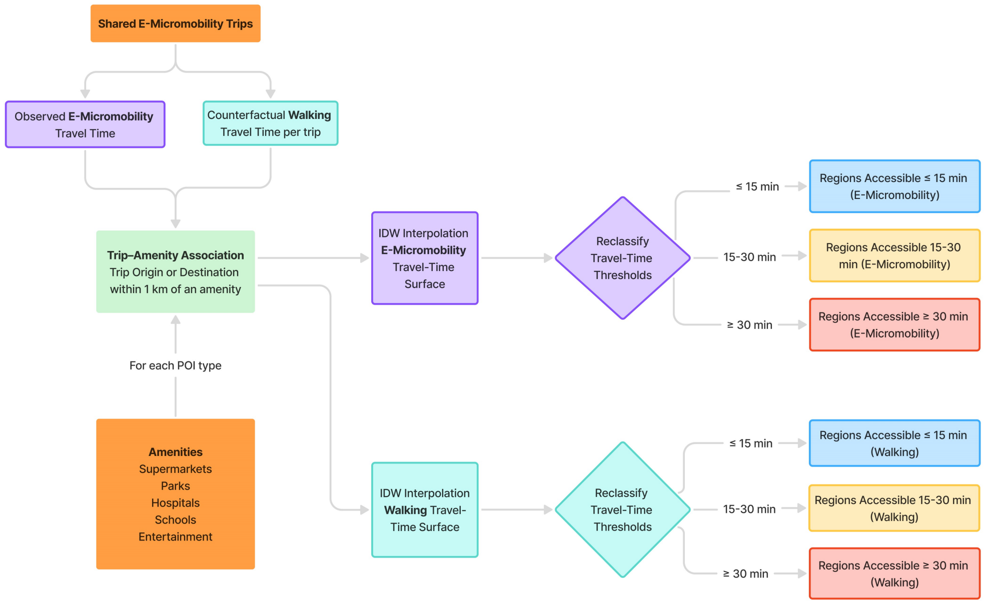

Fig. 1: Workflow used to associate shared e-micromobility trips with amenities, generate e-micromobility and counterfactual travel time surfaces with IDW, and classify regions into three travel time thresholds: $\leq$ 15 minutes (blue), 15–30 minutes (yellow), and $\geq$ 30 minutes (red), for each city and amenity type. Orange indicates input datasets; purple and teal indicate e-micromobility and walking workflows, respectively.

preventing duplicate trip associations in our final dataset, which can bias interpolation results. Resulting amenity-specific trip durations are used as inputs for Inverse Distance Weighting (IDW) interpolation.

We generate amenity-specific travel time surfaces for each city. After testing multiple grid resolutions, we selected a 200-meter cell size across cities. A 200-meter resolution provided the best utility trade-off between over-fitting at very high resolution and an overly smoothed surface that presented no spatial nuances. At this resolution, travel time values at each grid cell are estimated using Inverse Distance Weighting (IDW) based on distance-weighted averages of nearby e-micromobility trips. IDW is chosen over other interpolation methods, such as kriging, due to its lower computational demands while yielding comparable results [76].

IDW is a widely used spatial interpolation technique used to estimate values in regions that lack measurements, based on known surrounding observations [77]. It produces a continuous spatial surface representing estimated travel times across the study area [78]. For an unobserved grid cell, estimated travel duration is computed as a distance-weighted average of known e-micromobility travel duration, with weights inversely proportional to distance (Equation 1).

Here, Z(x) represents estimated travel time at a target grid cell, where e-micromobility travel time is unknown. Z_i represents observed e-micromobility travel time at grid cell i, and w_i is the distance-based weight assigned to observation i

[77]. Weight (w_i) is determined by the distance between grid cell i (with a known e-micromobility travel time) and the target grid cell, calculated using Equation 2.

$$Z(x) = \frac{\sum_{i=1}^{n} w_i Z_i}{\sum_{i=1}^{n} w_i} \tag{1}$$

$$w_i = \frac{1}{d_i^p} \tag{2}$$

At each location, d_i represents the Euclidean distance between the target grid cell (x) and a grid cell with a known observation (i). Parameter p controls the distance-decay weighting, which determines the relative influence of each known observation at x. As p increases, observations closer to the target cell have greater influence, while the contribution of more distant observations decreases. We use a power value of 2, which is commonly applied in spatial interpolation tasks, allowing closest points to strongly influence the estimated value at x [76].

Potential for access offered by e-micromobility, relative to walking, is assessed for each amenity type across cities. Counterfactual walking times for the same trips for baseline comparison are estimated using the Open Source Routing Machine (OSRM)[3]. OSRM calculates the shortest duration walking paths between the trip origin and destination of each e-micromobility trip. Walking travel time is estimated based on routed network distance and a base walking speed of 5km/hour, with variations in speed based on physical factors (e.g., terrain, elevation) [4]. Walking travel time surfaces are generated using the same IDW approach as e-micromobility surfaces, at a 200-meter resolution, for each city and amenity type.

We use walking, and not cycling, as the baseline for access comparison for several reasons grounded in data availability, methodological consistency, and equity considerations. First, cycling-based travel time estimates would represent potential rather than realized access, as they rely on assumed speeds and network routing rather than observed behavior. This introduces another systematic asymmetry with our e-micromobility estimates, which are observed. Second, private bicycle ownership varies substantially across cities and socioeconomic groups [79], meaning cycling-based access reflects a mode unavailable to many residents. Third, shared cycling services, where available, introduce the same availability constraints as shared e-micromobility (vehicle location, docking station proximity, fleet rebalancing), making them equally contingent on service conditions rather than a stable baseline. Walking, by contrast, is universally available, requires no ownership or infrastructure assumptions, and is the mode most commonly used as a benchmark in 15-Minute City research.

IDW travel time surfaces representing trip durations by e-micromobility and walking are reclassified into three time intervals: *Less than 15 minutes*, *15-30 minutes*, and *Over 30 minutes*. Reclassified surfaces show how access is distributed spatially for each amenity. For each city and amenity type, we calculated the proportion of grid cells in each time interval, relative to the total city area. Computed proportions

[3] https://project-osrm.org/
[4] Walking speed calculation: https://github.com/Project-OSRM/osrm-backend/blob/master/profiles/foot.lua

quantify how much of the city is reachable within a given travel time interval, allowing e-micromobility and walking access to be compared across cities and amenity types.

4 Results

Table 2 categorizes the percentage of each city accessible within the three time intervals (i.e., *Less than 15 minutes*, *15-30 minutes*, and *Over 30 minutes*). We present plots showing cumulative gains in access at a higher temporal resolution (i.e., five-minute intervals) in (Figure 2-6). In these figures, the red curve represents access provided by e-micromobility, while the blue curve shows a walking baseline. The vertical distance between the e-micromobility curve (red) and the walking baseline (blue) curves represents the proportion of the city that is accessible via e-micromobility, but beyond reach on foot within the same time frame.

Table 2: City-wide comparison of e-micromobility trip durations for a specific amenity type and their corresponding walk durations. Percentage of cells are classified into three groups: Less than 15 minutes, 15-30 minutes, and Over 30 minutes.

City	POI Type	E-micromobility (%)			Walking (%)		
		≤15 Mins	15-30 Mins	30+ Mins	≤15 Mins	15-30 Mins	30+ Mins
Wellington	Entertainment	44	53	3	6	42	52
	Parks	32	66	2	4	35	60
	Schools	52	46	1	8	48	44
	Hospitals	33	45	22	11	23	66
	Supermarkets	23	53	24	5	22	73
Washington DC	Entertainment	54	39	7	37	47	16
	Parks	34	53	13	16	51	33
	Schools	35	48	17	16	46	38
	Hospitals	15	33	51	9	16	74
	Supermarkets	27	42	30	13	38	49
Berlin	Entertainment	31	40	30	37	39	24
	Parks	23	34	42	24	33	43
	Schools	15	33	53	13	22	66
	Hospitals	26	50	24	24	55	21
	Supermarkets	22	33	45	21	31	48
Paris	Entertainment	46	43	11	45	43	12
	Parks	37	46	17	30	51	18
	Schools	34	46	20	28	48	24
	Hospitals	30	45	25	24	41	36
	Supermarkets	33	46	21	26	49	25
London	Entertainment	13	37	50	9	39	52
	Parks	17	37	47	11	42	48
	Schools	12	26	66	8	22	71
	Hospitals	10	28	62	9	23	69
	Supermarkets	12	35	53	8	35	57

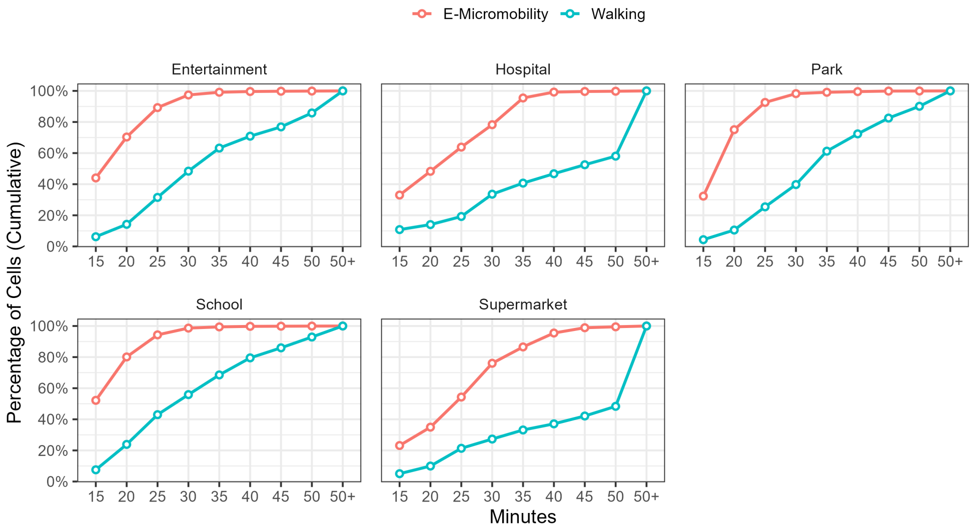

Fig. 2: E-micromobility travel times in Wellington for trips within 1 km of a given amenity type. The x-axis represents trip duration (in minutes), while the y-axis shows the cumulative percentage of cells derived from IDW interpolation. Walking travel times for the same set of trips are also shown.

E-micromobility generally expands the 15-minute radius compared to walking (RQ1). However, the degree of this expansion depends on amenity type (`RQ2`) and urban form of a city (`RQ3`). In non-European cities (i.e., Wellington and Washington DC), the cumulative plots show divergence between e-micromobility and walking curves, suggesting differences in access between the two modes. In these cities, e-micromobility reduces travel time, making large parts of the city accessible within a 15-minute radius. In compact European cities like Berlin and Paris, the curves often track closely or even overlap, suggesting diminishing returns with e-micromobility. In these cities, comparison to walking suggests that e-micromobility offers limited gains within the 15-minute threshold, as walking satisfies access to most amenities.

In Wellington, the cumulative plots (Figure 2) show an immediate separation between the two modes. The introduction of e-micromobility triples the proportion of the city accessible within 15-minutes, improving from an average of 7% (walking) to 37% (e-micromobility) across all amenity types. Similarly, in Washington DC (Figure 3), e-micromobility nearly doubles the proportion of the city accessible within the 15-minute threshold (18% walking vs 33% e-micromobility).

In contrast, compact European cities (i.e., Berlin and Paris) show more modest improvements in the 15-minute threshold with e-micromobility (Figure 4-6). The percentage of short duration (i.e., less than 15 minutes) e-micromobility trips in these cities is comparable to walking. This means that short-distance trips are already well served by walking.

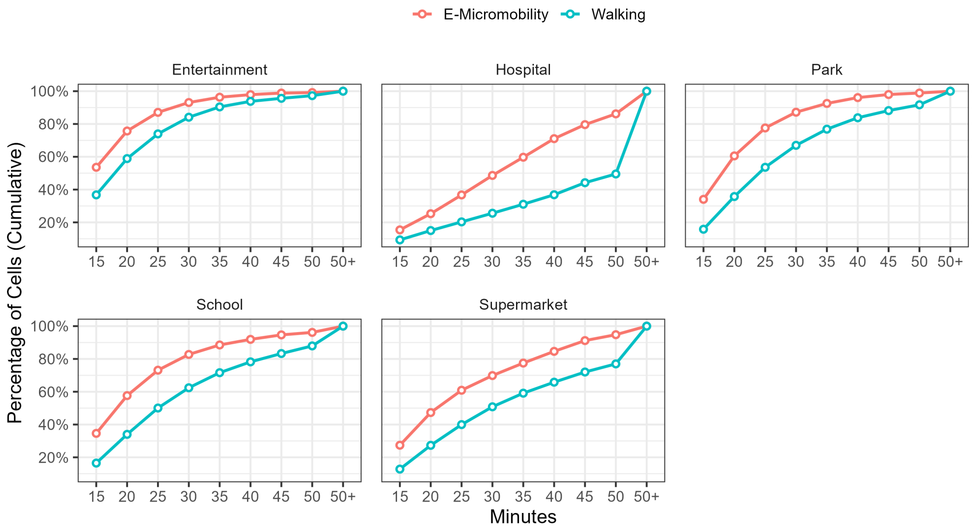

Fig. 3: E-micromobility travel times in Washington DC for trips within 1 km of a given amenity type. The x-axis represents trip duration (in minutes), while the y-axis shows the cumulative percentage of cells derived from IDW interpolation. Walking travel times for the same set of trips are also shown.

4.1 Access Gains by Amenity Type

Amenity gains from e-micromobility vary depending on the spatial distribution and prevalence of amenity types across cities. European cities generally have higher overall density of amenities, particularly for daily amenities compared to those in non-European cities. As a result, improvements within the 15-minute threshold are smaller than those observed in non-European cities, where amenities are fewer and further apart.

4.1.1 Entertainment

Entertainment access shows larger gains in lower-density cities. In Wellington, access within 15-minutes increases from 6% (walking) to 44% (e-micromobility). Washington DC also sees improvements with e-micromobility expanding access from 37% (walking) to 54% (e-micromobility). In Paris, e-micromobility offers negligible improvement over walking to entertainment amenities. As shown in the cumulative plots, the curves for entertainment track closely in parallel, which can be attributed to the high density of cafes and restaurants in the city center.

4.1.2 Parks

Access to parks improves in most cities, suggesting that e-micromobility is particularly effective at connecting residents to green spaces that lie beyond a comfortable walking radius. In London, the greatest relative improvement among all amenities is

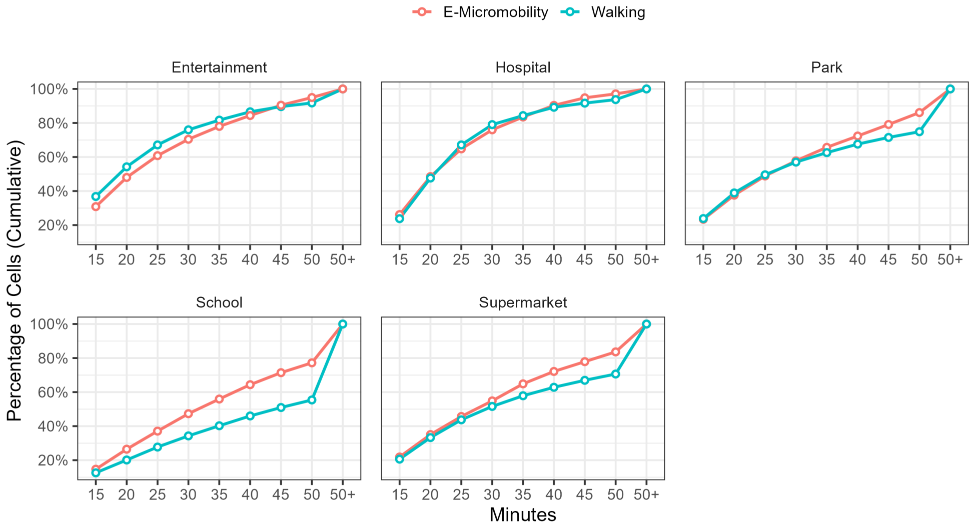

Fig. 4: E-micromobility travel times in Berlin for trips within 1 km of a given amenity type. The x-axis represents trip duration (in minutes), while the y-axis shows the cumulative percentage of cells derived from IDW interpolation. Walking travel times for the same set of trips are also shown.

observed for parks, where access within 15-minutes rises from 11% (walking) to 17% (e-micromobility). Similarly, Washington DC sees park access double from 16% to 34% overall. In Berlin, we observe negligible change to park access within the 15-minute threshold with e-micromobility.

4.1.3 Schools

Schools show improvement across all cities. Wellington observes the largest change, with access increasing from 8% to 52%, while Washington DC improves from 16% to 25% with e-micromobility. More modest increases are seen in Paris (28% to 34%), London (8% to 12%), and Berlin (13% to 15%).

4.1.4 Hospitals

Hospitals have lower walking access across all cities. E-micromobility increases the share of regions with access to hospital within 15-minutes in Wellington (11% to 33%) and Washington DC (9% to 15%). Smaller improvements are seen in Berlin (24% to 26%), Paris (24% to 30%), and London (9% to 10%).

4.1.5 Supermarkets

Supermarkets show some improvements in all cities. Non-European cities observe the largest improvements with increases in Wellington (5% to 23%) and Washington DC

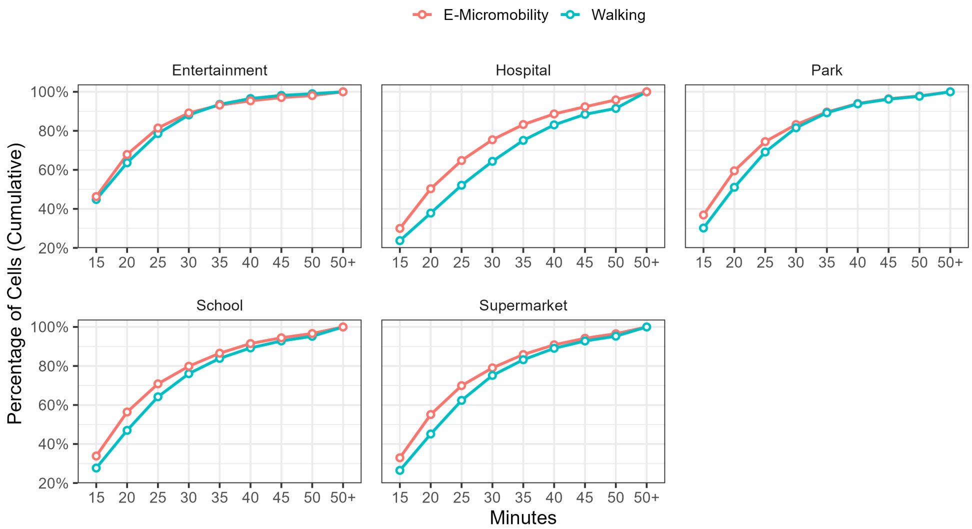

Fig. 5: E-micromobility travel times in Paris for trips within 1 km of a given amenity type. The x-axis represents trip duration (in minutes), while the y-axis shows the cumulative percentage of cells derived from IDW interpolation. Walking travel times for the same set of trips are also shown.

(13% to 27%). Some improvements are seen in Paris (26% to 33%), London (8% to 12%), and Berlin (21% to 22%).

4.2 Spatial Patterns in Access

The greatest improvements within the 15-minute threshold occur in cities with lower walking access. In these cities, amenities may be fewer in number or more spatially dispersed. In compact European cities, gains are smaller, and for some amenity types, walking performs similarly or slightly better than e-micromobility for shorter travel times. Although the largest gains are observed in non-European cities, e-micromobility may extend reach beyond immediate areas located further away. Across amenity types, e-micromobility is consistently associated with a larger share of the city becoming accessible at longer travel times, even when differences within the 15-minute threshold are small. For example, in Berlin, access to schools within the 15-30 minute interval improves from 22% (walking) to 33% (e-micromobility), even though the 15-minute radius is comparable.

Spatial distribution of e-micromobility and walking surfaces show neighborhood-level differences in access, not captured by city-wide aggregations. Maps for select amenities and cities are presented in the Supplementary Materials (Figure S1-S5). In non-European cities, walking-travel time surfaces within the 15-minute threshold highly concentrated in core areas, reflecting denser distribution of amenities in these areas. Although city-wide aggregations show only modest improvements in park access in London, spatial patterns suggest a more pronounced neighborhood-level difference.

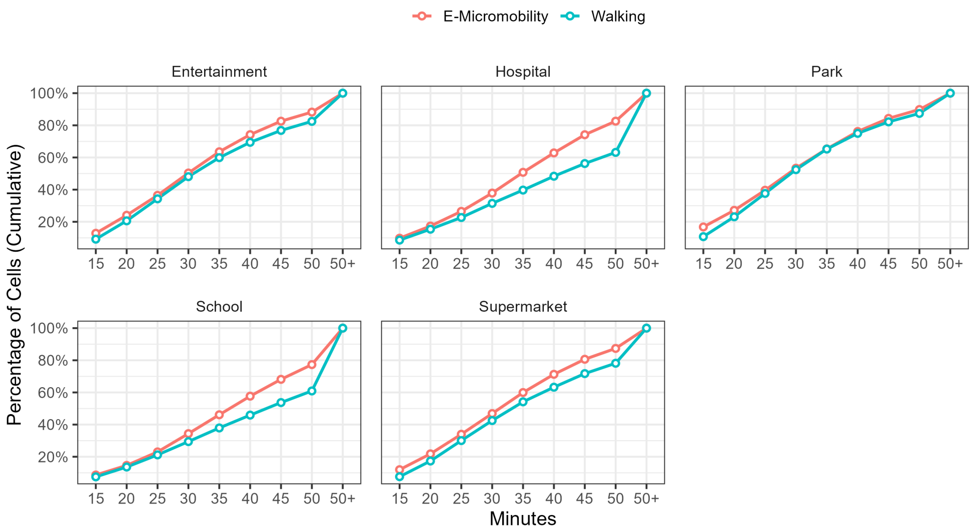

Fig. 6: E-micromobility travel times in London for trips within 1 km of a given amenity type. The x-axis represents trip duration (in minutes), while the y-axis shows the cumulative percentage of cells derived from IDW interpolation. Walking travel times for the same set of trips are also shown.

In several peripheral neighborhoods, parks that require more than a 30-minute walk to reach on foot become more accessible (i.e., categorized under within 15 minutes or 15-30 minutes). A similar pattern is seen in Berlin for hospital access. While city-level changes are limited, e-micromobility expands access to hospitals within 15 minutes in neighborhoods outside the city center, including *Steglitz*, *Friedenau*, and *Wilmersdorf* (Figure S5). These spatial patterns suggest the benefits of e-micromobility are unevenly distributed, with the most noticeable gains occurring in peripheral regions.

5 Discussion

In this work, we explored the potential of shared e-micromobility to expand access to daily amenities within the 15-Minute City framework. Our results show that despite offering faster travel speeds than walking, e-micromobility does not uniformly improve access within or across cities. Access outcomes vary with urban form, distribution of amenities, and a neighborhood's location relative to city center (e.g., core vs. periphery).

The potential for shared e-micromobility to improve access to essential amenities within the 15-Minute City framework is closely tied to urban form and land-use patterns. Cross-city differences in urban form are readily observable by calculating the average block length with OSMnx [80], as a proxy for compactness. Among cities in our analysis, Paris and Berlin are the most compact, with an average block length of 30m and 34m, respectively, reflecting denser street networks. These cities are also characterized by land-use patterns that commonly allow mixed-use zoning, where residential and commercial activities can co-exist within the same city block [81]. As a result, a large share of essential amenities are already accessible within short walking distances, allowing walking to fulfill the 15-minute access threshold. This leaves limited scope for e-micromobility to further improve access. In these cities, e-micromobility provides limited, and in some cases negative, travel time benefits compared to walking. Short trip lengths constrain potential speed advantages, as time spent locating or unlocking a vehicle, navigating dense street networks, and complying with infrastructure regulations can increase total travel times [82].

E-micromobility shows greater potential in non-European cities, where less compact urban forms create greater separation between residential areas and amenities. Cities such as Wellington and Washington DC exhibit greater average block lengths at 51m and 36m, respectively. More dispersed land-use patterns constrain walking-based access and have historically increased dependence on private automobiles [83, 84]. In these cities, where distances to essential amenities frequently exceed comfortable walking thresholds, e-micromobility meaningfully expands access within 15-minutes.

Compactness of urban form alone is insufficient in explaining differences in realized access. For example, London and Washington DC have comparable average block lengths (36m), yet access outcomes with e-micromobility vary between these cities. London has a higher volume of amenities, which means shorter distances for residents, despite similar levels of compactness. Like many US cities, Washington DC exhibits more dispersed land-use patterns, which increase distances to essential amenities [85]. These findings suggest that the benefits of e-micromobility are marginal in amenity-rich areas, where density is high enough to support walking, regardless of urban form.

Within cities, access gains also exhibit spatial patterns consistent with cross-city differences in compactness. Core urban areas, particularly in Wellington and Washington DC, are characterized by shorter block lengths and a higher density of amenities, resulting in shorter travel times to access amenities [86]. The largest improvements with e-micromobility occur in outlying areas, where sprawl increases and walking becomes less favorable. In these cities, many peripheral regions shift from being more than 30 minutes on foot from key amenities, to being accessible within a shorter travel time with e-micromobility. Similar patterns are observed in suburban areas of London, where access to parks improves most outside the city core. These results suggest that even within the same city, access gains are not uniform, and determined by local urban form.

Differences in access gains from e-micromobility also vary by amenity type. Amenities that are widely distributed, such as entertainment venues (i.e., cafés, bars, museums, restaurants, stadiums, and zoos), show limited improvements from e-micromobility, as walking often remains a convenient option for these short trips. In contrast, amenities that are fewer in number and more spatially dispersed, such as hospitals and schools, exhibit greater potential for access improvements, especially in lower-density regions. Expanded access to these services can reduce burdens for students and caregivers, particularly in areas where walking-based access is limited.

These findings show that e-micromobility can improve access to vital services that are not comfortably accessible on foot.

E-micromobility generally extends access to essential amenities within the 15-Minute City framework, particularly in sprawling cities and in outlying urban areas. Despite this potential, these regions are often underserved by e-micromobility service providers, and remain more dependent on private vehicles [87, 88]. Our results emphasize that bridging 15-minute access gaps through e-micromobility requires policies that consider urban form and land-use patterns. Without targeted policies to expand e-micromobility services in these regions, benefits of e-micromobility may remain unevenly distributed.

Along with its role in improving access, e-micromobility contributes to urban sustainability and resilience [10, 88]. Compared to private vehicles, shared e-micromobility offers a more space-efficient and lower-carbon option for short trips [43]. Prior studies suggest that e-micromobility commonly substitute trips made on foot [89], by bicycle [90], or via public transit [90] while substitutions away from private vehicle varies across cities [89–91]. As a result, public health and safety outcomes are mixed as e-micromobility may reduce physical activity when it replaces walking or cycling. In lower density neighborhoods, where walking-based access is limited, e-micromobility has greater potential to expand access to daily amenities that may otherwise require other means of travel. E-micromobility may offer positive health benefits in these areas as it can support modal shift from other motorized modes. Therefore, the contribution of e-micromobility services in expanding access within the 15-Minute City framework depends on where these systems are deployed.

5.1 Limitations

There are a few limitations in this study that should be acknowledged and potentially addressed in future work. First, observed e-micromobility trips capture realized travel times under existing service availability and operating conditions (e.g., fleet distribution, station locations, available vehicles), and therefore are contingent on the availability of vehicles at the time of travel. For trips of shorter durations (e.g., 5-minute, 10-minute), access costs associated with e-micromobility, including locating, unlocking, and parking a vehicle, may constitute a proportionally larger component of total trip time. This study focuses on shared e-micromobility and walking as the two modes of comparison. Cycling, while related, represents a distinct mode of transportation with different infrastructure requirements, ownership models, and user demographics, and was therefore outside the scope of this work. Inclusion of cycling in future analyses would provide an additional mobility baseline against which e-micromobility access gains could be compared. Future work can extend this analysis to incorporate shared cycling trips for comparison with e-micromobility.

Second, our results represent observed trip patterns under existing service conditions of an e-micromobility service provider. We focus on shared e-micromobility service providers (e.g., Tier, Lime, and Flamingo), that have operated in these cities for multiple years and hold considerable market share, allowing for reliable cross-city comparisons. Future work could incorporate trips from multiple operators, where data is available.

IDW interpolation does not produce uncertainty estimates. As the interpolation surface captures generalizable spatial patterns, we focus on city-wide realized access. Since interpolation surfaces were generated from observed trips, they represent access where vehicles were deployed and services were actively used during the study period, rather than the travel capabilities of e-micromobility modes themselves. Areas with lower vehicle availability or fewer recorded trips may contain sparser data and greater uncertainty in interpolation surfaces, which should be considered when interpreting the results.

In addition, amenity data were collected in August of 2024, while e-micromobility data span August 2020 to May 2024. We acknowledge that this temporal mismatch may influence observed access, particularly in areas where amenities opened or closed during this period. Although amenity locations represent a single snapshot in time, use of multi-year trip data for spatial interpolation allows us to characterize long-term access patterns within each study area. Additionally, some data collection periods overlapped with the COVID-19 pandemic, which may have affected travel times due to changes in travel behavior, service demand, and availability during the study period.

Finally, observed access benefits primarily reflect improvements for demographics currently using these services, who tend to be younger, able-bodied, and economically advantaged [79]. Barriers such as smartphone reliance, rental costs, and a lack of adaptive vehicles make these services inaccessible to many population groups. Without targeted regulations, access benefits of the 15-Minute City through e-micromobility may be limited to populations that use these services. In addition, the study is limited to cities in the Global North. Future work should expand this analysis to cities in the Global South for a comprehensive understanding of e-micromobility's potential to expand access across regions. Transport planners should prioritize equitable access when developing e-micromobility policies.

6 Conclusion

In this work, we explored if shared e-micromobility services can improve access to essential amenities (i.e., supermarkets, schools, hospitals, parks, and entertainment venues) within the 15-Minute City framework. We analyzed observed e-micromobility trips in Berlin, Germany; London, UK; Paris, France; Wellington, New Zealand; and Washington DC, USA, comparing travel times against walking durations for the same trips. Results suggest that despite faster speeds than walking, e-micromobility services do not improve access uniformly. Instead, access benefits are dependent on factors such as urban form, distribution of amenities, and distance from the city center.

Differences in urban form and land-use planning lead to differences in access outcomes across cities. In more car-centric sprawling cities like Wellington and Washington DC, e-micromobility improves areas reachable within 15 minutes, particularly improving access to amenities such as schools and hospitals. In these cities, e-micromobility helps bridge larger separations between land uses resulting from dispersed development and a lower density of amenities. In contrast, in dense European cities with more mixed land-use patterns, such as Paris and Berlin, these benefits are limited. Since essential amenities are widely available and already reachable within short distances, walking often satisfies 15-minute access thresholds in these cities.

Shared e-micromobility services offer greatest value in outlying areas, where walking alone is insufficient to fulfill 15-minute access thresholds to essential amenities. In these areas, e-micromobility services can expand access by bringing areas located more than 30-minutes by foot into 15-minute access zones. However, existing e-micromobility services remain disproportionately concentrated in city centers, where access gains are comparatively limited. To improve access to essential amenities in outlying areas with e-micromobility, policymakers must prioritize expansion of these services into underserved peripheral neighborhoods. Prioritizing these regions is important to make benefits of the 15-Minute City accessible to all.

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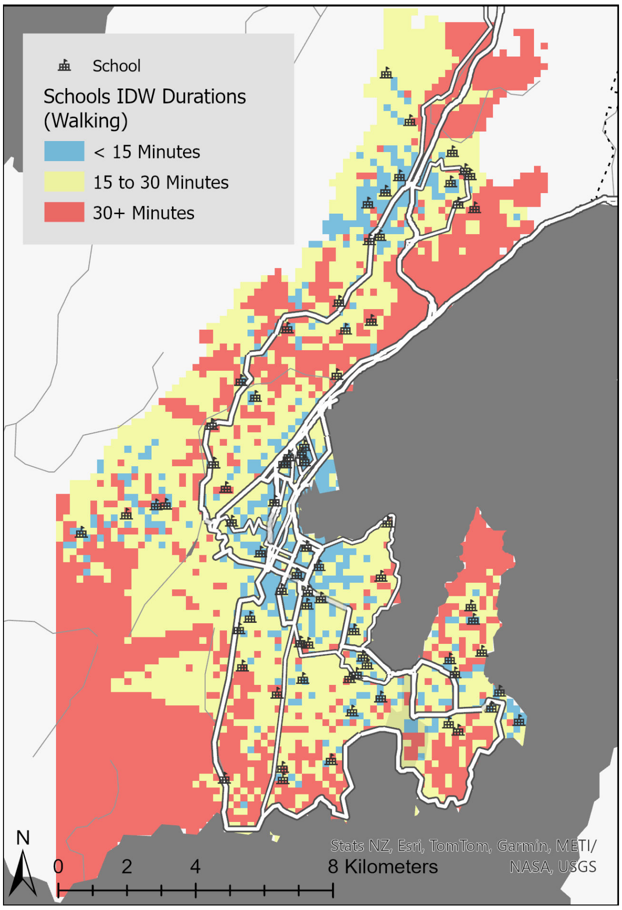
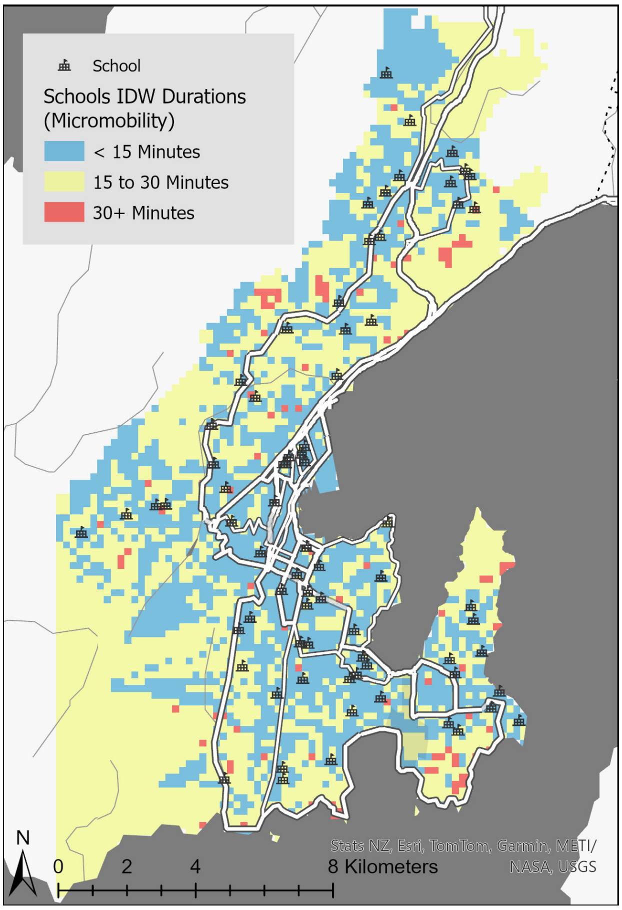
Supplementary Material

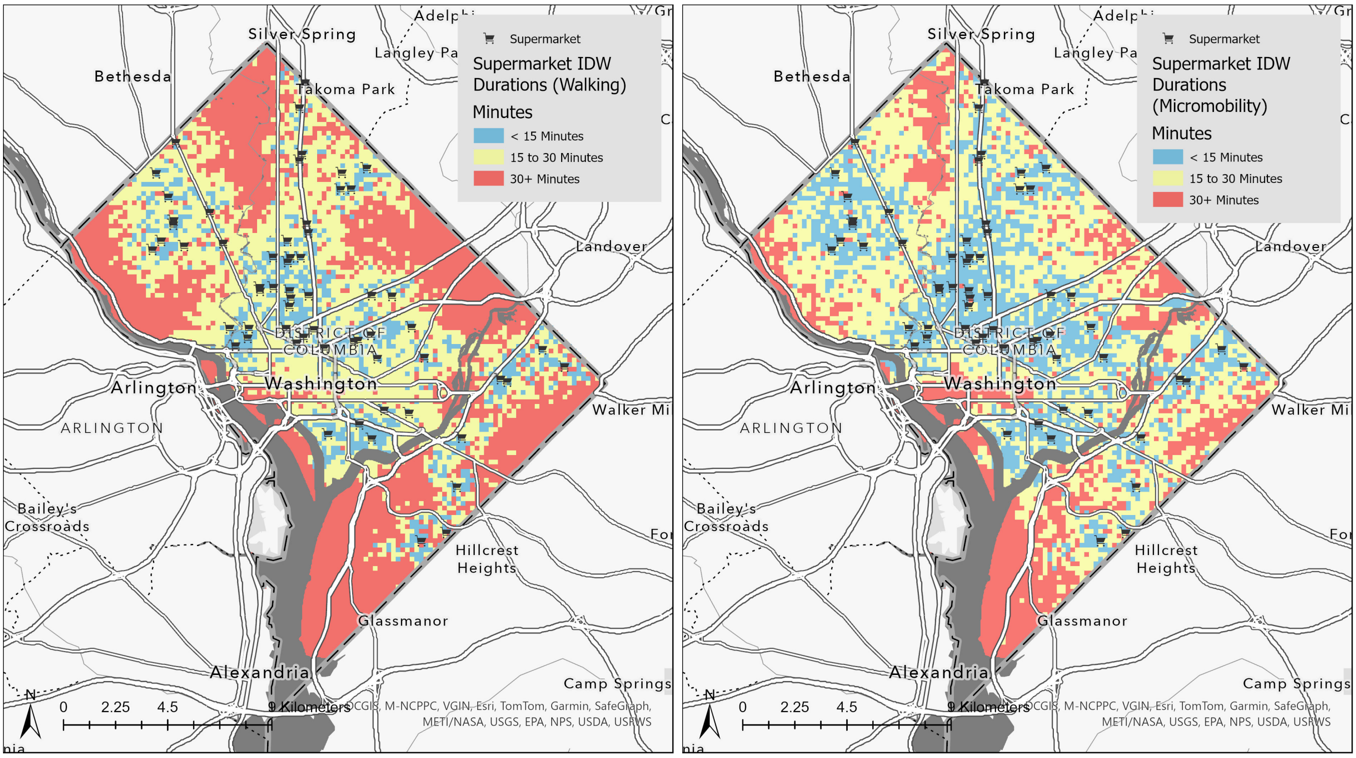


(a) Walking



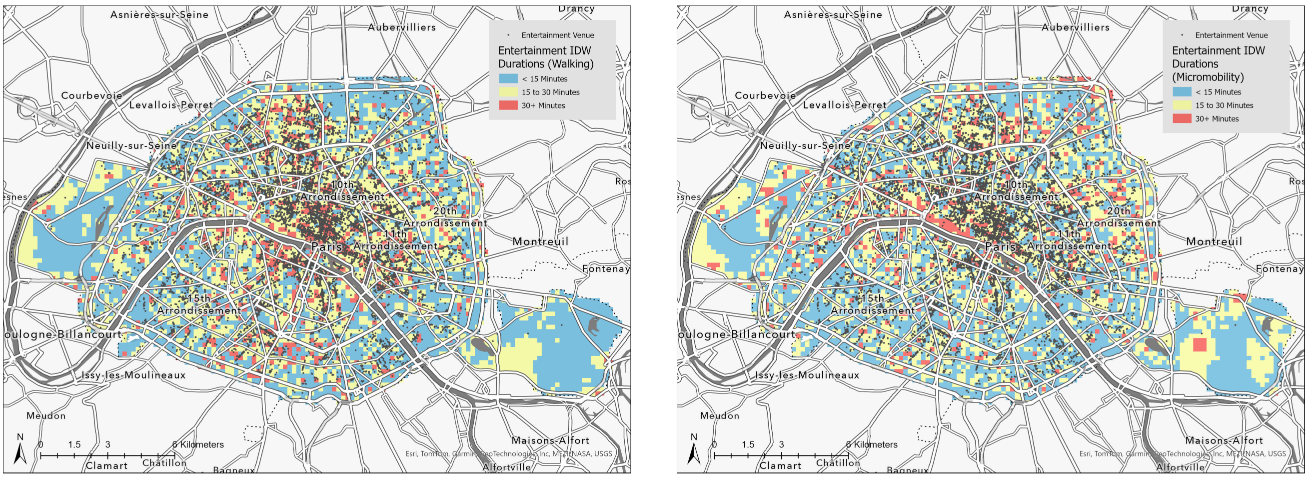
(b) E-micromobility

Fig. S1: Differences in travel times between walking and e-micromobility trips to or from *Schools* in Wellington, New Zealand.



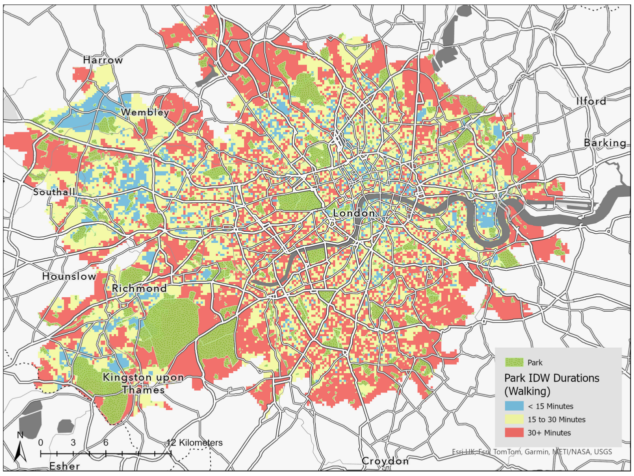
(a) Walking (b) E-micromobility

Fig. S2: Differences in travel times between walking and e-micromobility trips surrounding *Supermarkets* in Washington DC, USA.

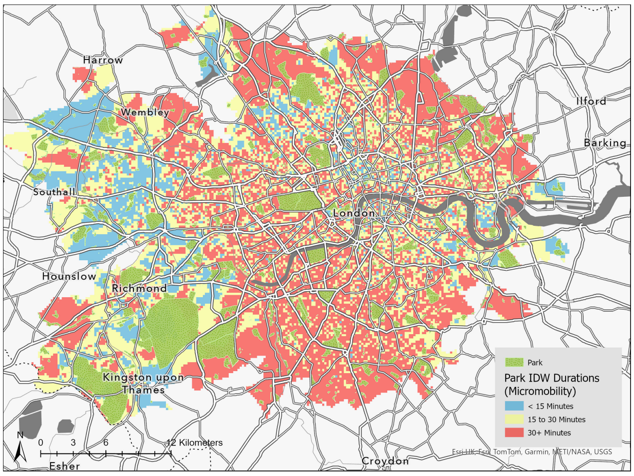


(a) Walking (b) E-micromobility

Fig. S3: Differences in travel times between walking and e-micromobility trips surrounding *Entertainment* venues in Paris, France.

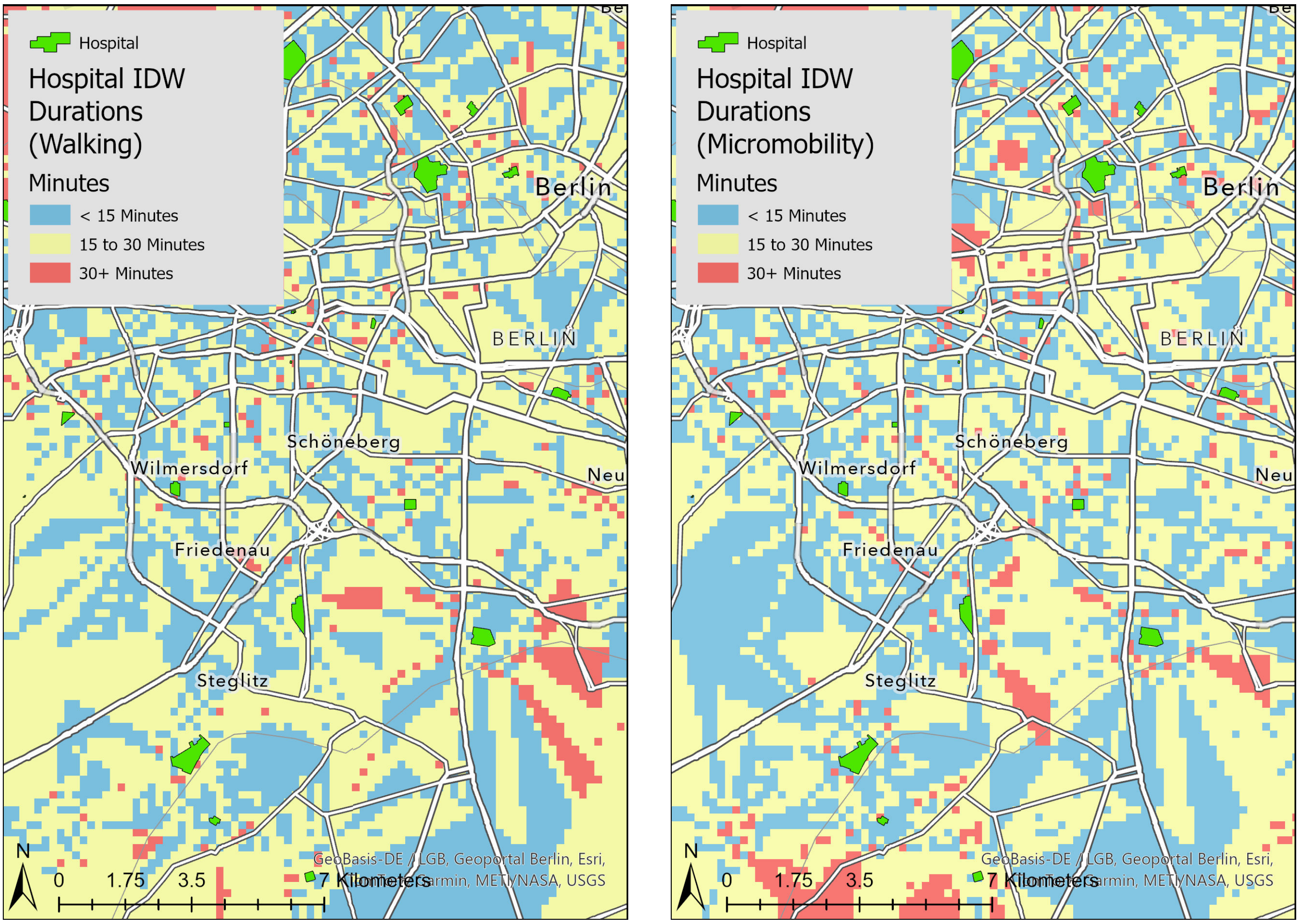


(a) Walking



(b) E-micromobility

Fig. S4: Differences in travel times between walking and e-micromobility trips surrounding *Parks* in London, United Kingdom.



(a) Walking (b) E-micromobility

Fig. S5: Differences in travel times between walking and e-micromobility trips surrounding Hospitals in Berlin, Germany.