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An assessment of proximity in the 15-Minute City: A systematic literature review

John Omwamba [a,b,*], Lucia Rotaris [b], Giovanni Longo [b]

[a] Doctoral School, IUSS Pavia, Broletto Palace Piazza della Vittoria, n.15, 27100, Pavia, Italy
[b] Department of Economic, Business Mathematical and Statistical Sciences (DEAMS), University of Trieste, Via Valerio, 4/1-Ed. D, 34127, Trieste, Italy

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ABSTRACT

The 15-Minute City concept (FMC), proposed by Carlos Moreno, offers a chrono-urbanist approach to fostering sustainable, inclusive, and low-carbon urban living by promoting proximity-based access to daily services. This paper systematically reviews 113 peer-reviewed publications from 2021 to early 2025, sourced from Scopus and Web of Science using the PRISMA protocol, to evaluate how proximity is empirically measured, its impacts on mobility, urban form, and spatial equity.

Network-based accessibility models dominate proximity measurement, though slope-sensitive modelling remains rare despite its importance for hilly cities. Evidence from Paris, Barcelona, and Lisbon shows that FMC strategies reduce car dependency, promote walking and cycling, and lower emissions. However, socio-spatial inequalities could persist, particularly for children, elderly, and low-income residents. Research remains heavily concentrated in Europe, North America, and East Asia, with minimal empirical evidence from the Global South.

Key research gaps identified include the limited integration of urban freight and last-mile logistics into FMC frameworks, the lack of slope-adjusted accessibility models, insufficient investigation of traveller behaviour and perception of local services, limited attention to service quality and affordability, and the need for strategies to mitigate gentrification and displacement risks.

Future research must address these areas to operationalise equitable, context-sensitive FMC strategies across diverse urban environments. This review offers an evidence base for planners, policymakers, and researchers seeking to advance sustainable urban development through the FMC model.

1. Introduction

The world today is more concerned about the adverse impacts of climate change, which are getting more pronounced around the world [1]. The latest IPCC report attributes approximately 70 % of global carbon emissions to urban areas as per energy consumption, which face additional challenges such as air pollution, urban sprawl and high energy consumption [2]. Additionally, 25 % of energy CO_2 emissions are attributed to the transport sector, while 78 % of urban transport emissions are attributed to vehicular emission [3]. In this context, the 15-Minute City (FMC) has emerged as a planning response that directly addresses these intertwined challenges by reducing car dependency, localising access to daily services, and supporting compact, low-carbon urban forms.

The FMC is a chrono-urbanist planning model proposed by Carlos Moreno in 2016, which proposed an urban development model that is compact and connected, and where all necessary amenities and services can be accessed within a 15-minute walk or a bike ride from home [4]. He listed the six essential services as living, working, commerce, healthcare education and entertainment; all being adapted to reflect proximity, diversity, density and ubiquity [5]. It aims to achieve more liveable and sustainable urban areas that are not dependent on vehicles, ultimately reducing travel related emissions, alleviating traffic congestion and improving the overall quality of life in urban areas [6]. This time-based model is different from earlier planning concepts, which were majorly based on land use zoning [7] as shown in Fig. 1. The figure illustrates the historical evolution of urban planning paradigms from Garden Cities focused on self-sufficiency and greenbelts, through Neighbourhood Units and Post-Urbanism centred on functional zoning and superblocks, to Eco-Urbanism and Smart Cities integrating

* Corresponding author.
E-mail address: john.omwamba@iusspavia.it (J. Omwamba).

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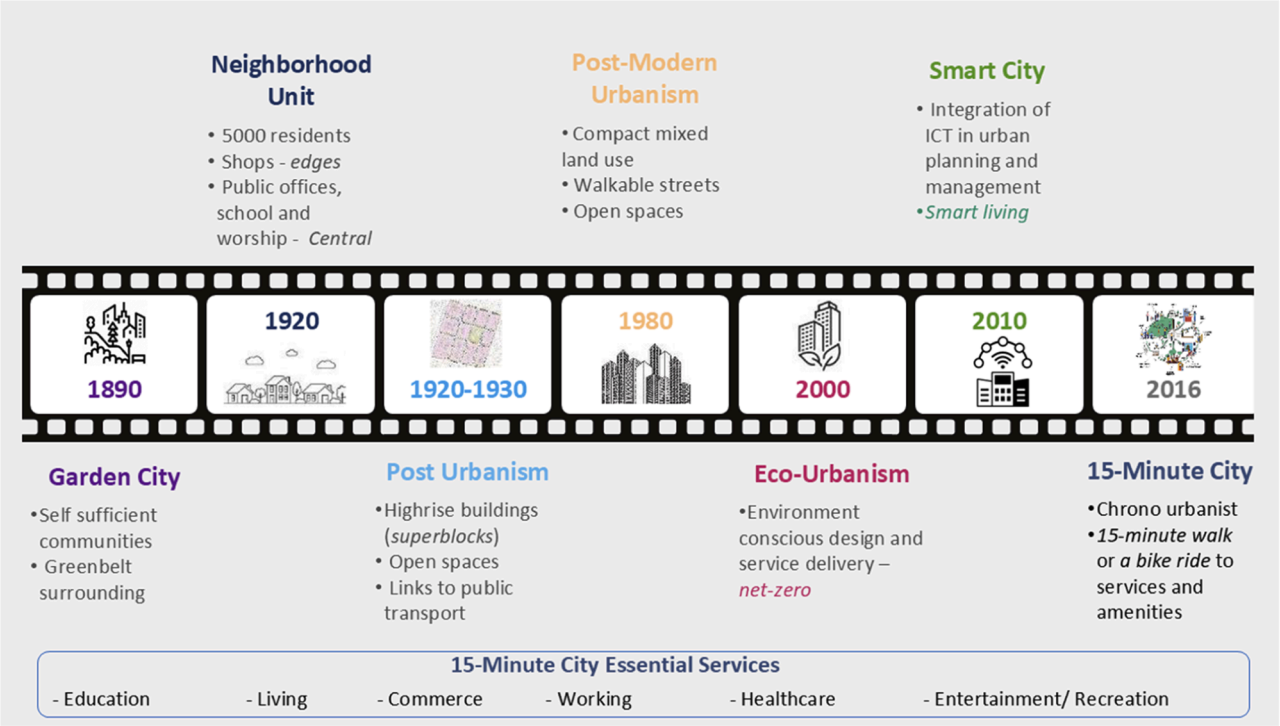


Fig. 1. Evolution of planning concepts.
Source: Adapted from Khavarian-Garmsir et al. [7].

environmental consciousness and digital technologies, with the FMC being the most recent planning concept.

In addition, the FMC also resonates with related contemporary planning practices such as New Urbanism, Transit-Oriented Development, and Compact City strategies, which similarly promote mixed-use, walkable neighbourhoods and reduced car dependency. What distinguishes the FMC is its chrono-urbanist emphasis on time-based accessibility benchmarks and the explicit operationalisation of "proximity" as a measurable planning principle. This review clarifies how the FMC builds on these earlier approaches by combining participation, compactness, diversity, and technological integration with a time-based framework of proximity and accessibility, rather than abstract spatial units.

The model emphasises proximity and local living as keys to sustainable, liveable neighbourhoods. By minimising the need for long commutes and vehicular travel, the FMC aims to reduce car dependency, cut greenhouse gas emissions, and foster healthier, more inclusive communities [8]. Proximity is thus positioned as a transformative spatial principle, whereby bringing people and everyday destinations closer together, cities can become more environmentally sustainable, socially cohesive, and economically vibrant [3]. Compact urban forms where housing, jobs, and services are located close together lead to lower car use and higher rates of active mobility [9].

The FMC model applies this idea by setting a clear target: people should be able to reach essential services within a 15-minute walk or bike ride. This approach can help reduce emissions, improve air quality, and support public health through increased physical activity [10,11]. It also fits into wider sustainability goals, including complete communities, compact city strategies, and the Sustainable Development Goals for greener and more inclusive cities [12–14]. The FMC makes the idea of liveability concrete by providing a measurable framework. Researchers have developed methods to assess how many amenities can be reached within 15 min on foot or by bicycle. These methods allow cities to measure service accessibility at the neighbourhood scale [15]. By setting proximity benchmarks, planners and policymakers can identify areas that meet the 15 min goal, find service gaps, and track the results of efforts to improve local access. Proximity therefore moves beyond being just a planning goal and becomes a practical tool for guiding sustainable urban development. However, the rapid rise of the FMC from a visionary concept to a mainstream planning paradigm (especially in the wake of COVID-19) has outpaced the accumulation of empirical evidence, where city leaders have embraced proximity-based planning rhetorically, yet questions remain about how it needs to be implemented and assessed in practice [16,17]].

In FMC implementation, knowledge gaps have been noted. First, there is no consensus on the *methods* for measuring a "15-minute city", as different studies use different distance thresholds, modes (walking vs. cycling), and sets of services, raising comparability issues [18,19]. Second, while the FMC is assumed to encourage shifts toward active travel and transit, the empirical evidence of mobility outcomes is still emerging [9,20]. It is unclear to what extent proximity alone leads to reduced car use or increased walking/cycling in different urban contexts [10]. Third, the influence of FMC-inspired proximity planning on *urban form* (density, land-use mix, street network) needs evaluation on whether pursuing the FMC alters the spatial structure of cities, or if it is achievable under pre-existing urban forms. Finally, there are *equity and spatial justice* concerns. A city may be "15-minute" for some while others, especially in peripheral or underserved areas, lack equivalent access [21]. The FMC's promise of inclusion needs to be scrutinised by examining differential accessibility for marginalised groups such as low-income households, the elderly, disabled and children.

Despite a growing number of publications on the FMC since 2020, no comprehensive review has focused specifically on how proximity is empirically operationalised and evaluated, and with what results. Existing reviews have primarily addressed conceptual framings, policy discourse, or broad sustainability implications of the FMC, but have not systematically analysed the empirical measurement of proximity itself. Lima and Costa [22] survey computational and design toolchains for FMC, while Sedini and Colleoni [23] qualitatively assess the inclusiveness of proximity ambitions in city plans. Related discussions consider

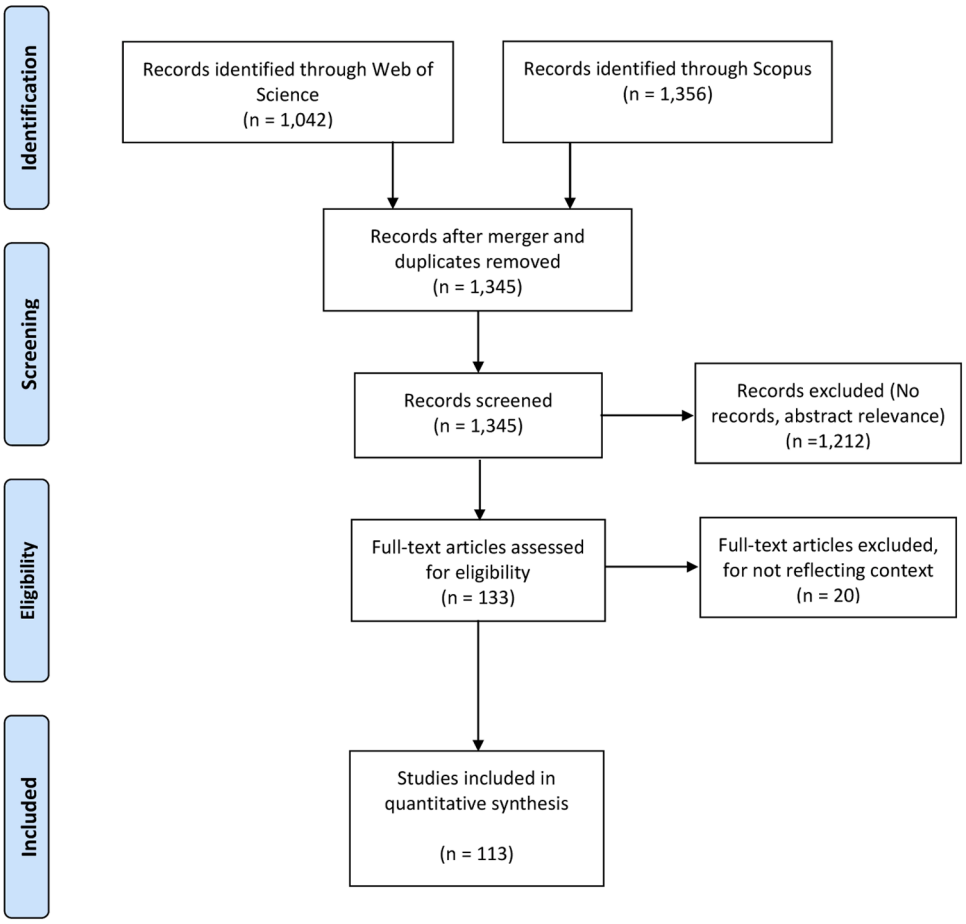


Fig. 2. Article selection flowchart.

micromobility as an enabler of short trips and co-benefits [24], socio--spatial dynamics and community cohesion in post-crisis narratives [28], and the integration of health impact assessment with FMC ideas [29]. Broader historical and theoretical framings trace the evolution of urban sustainability and transport paradigms [7,30], and conceptual pieces position FMC in post-pandemic urbanism and net-zero trajectories [5,6]. Collectively, these works fail to systematically examine how proximity is empirically operationalised across studies and how those measurements relate to mobility outcomes, urban form, and equity.

To address this gap, this paper conducts a systematic literature review of recent studies that have empirically examined the FMC or closely related proximity-based planning approaches, and the consequent outcomes on mobility, urban form and spatial equity. This paper therefore goes beyond previous reviews and is novel by foregrounding proximity as both a methodological and evaluative construct. It does this by synthesising evidence on proximity's outcomes for mobility, urban form, and spatial equity, while also extending analysis to its outcomes for mobility, urban form, and spatial equity. The primary objective of this systematic literature review examines how proximity is empirically operationalised and evaluated in FMC research, its outcomes and gaps. It specifically addresses the following research questions:

RQ1: What methods are used to empirically measure proximity to essential services in FMC studies, and what are their strengths and limitations?

RQ2: What empirical evidence demonstrates that proximity-based FMC planning results in measurable shifts toward active mobility or public transport, and how are these outcomes assessed?

RQ3: How do empirical studies assess the influence of proximity-based planning on urban form and land-use structure, particularly in terms of compactness, density, and mixed-use zoning?

RQ4: How is spatial equity empirically assessed in proximity-based FMC studies, and what evidence demonstrates differential access for vulnerable or marginalised groups?

This review will be useful for urban planners, policymakers, researchers, and environmentalists interested in sustainable urban development. It provides insights into the practical implementation of the FMC model, offering evidence-based strategies and policy recommendations that can be adapted to various urban contexts to operationalise FMC. Additionally, it will benefit those studying the socio-economic impacts of urban planning initiatives and the role of transportation policies in achieving sustainable urbanisation.

The paper is structured into five sections. The *Introduction* section introduces the concept of the FMC, its significance in contemporary urban planning, and outlines the objectives and scope of the review. The *Methodology* section describes the systematic literature review process, including the research paper search strategy, selection criteria, and data extraction methods. The *Bibliometric Overview* section gives a bibliometric analysis of papers analysed in this research. The *Results and Discussion* section presents and discusses the findings of the review across the thematic research areas, including environmental impacts, social inclusion, transportation and policy implications and implementation of the concept in diverse urban contexts. Finally, the *Conclusion* section summarises the key findings, highlights the gaps in the existing literature, and suggests directions for future research to enhance the applicability and effectiveness of the FMC model in diverse urban settings.

2. Methodology

This study followed a *systematic review* methodology guided by the

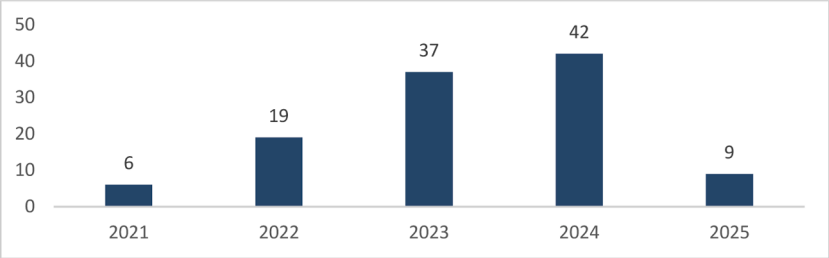


Fig. 3. Annual scientific production.

Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) protocol to ensure a transparent and reproducible literature search and screening process. A detailed search protocol was developed a priori, including defined inclusion/exclusion criteria, target databases, and keywords reflecting the FMC concept and its variants. Given the interdisciplinary nature of the topic, two bibliographic databases were queried: Scopus and Web of Science (WoS). These databases were selected because they offer the most comprehensive coverage of peer-reviewed journal articles across the fields of urban studies, planning, and sustainability, and thus capture the breadth of FMC-related scholarship. The searches covered publications from 2016 when the term "15-minute city" was conceptualised, up to April 2025. Only English-language publications were considered, and the review focused on peer-reviewed journal articles, as translation capacity was limited and English represents the dominant language of global academic publishing in urban studies, thereby ensuring comparability across studies and geographies. The search was done on 4th April 2025.

To identify the publications, a search on the Scopus and the WoS database was used, with search strings as reported in Appendix A. The search strings combined terms related to the FMC and proximity-centred planning. The following query was used: ("15-minute city" OR "15 minute city" OR "x-minute city" OR "10-minute city" OR "20-minute city" OR "chrono-urbanism") AND (sustain* OR accessibility OR mobility OR plan* OR social) with year limits. To improve precision, unrelated subject areas such as medical research using "15 min" in a different context) were excluded. The initial Scopus search returned 1356 records, and the WoS 1042 records. After removing duplicates across databases, a total of 1345 unique records were identified. Fig. 2 provides a PRISMA flow diagram of the screening process, visually documenting the stepwise exclusion of records and final inclusion of 113 studies, thereby reinforcing the transparency and reproducibility of the review.

Titles and abstracts of the 1345 records were screened to filter out works that were clearly irrelevant. To be included, a study had to explicitly address the FMC concept *and* closely relate to the study objectives. Conceptual papers and unrelated technical studies were excluded, to ensure the review focused on empirical evidence rather than theoretical framings. Grey literature and non-peer-reviewed publications were also excluded to maintain methodological rigour, comparability, and replicability. This initial screening yielded 133 papers that met the screening criteria, which were retrieved in full text for a review. At this stage, each paper was examined to confirm it indeed contained empirical research (quantitative or qualitative) about measuring or evaluating proximity to services or assessing outcomes of proximity-based planning. A few articles ($n = 20$) did not address FMC implementation were excluded. After full-text review, 113 papers were deemed relevant and of sufficient quality to be included in the final synthesis as the core literature base for this review. The screening and coding process was conducted using Excel spreadsheets, where duplicates were removed, inclusion/exclusion decisions recorded, and coding applied systematically. To ensure reliability, ambiguous cases were re-checked against the inclusion criteria. Screening was carried out by two researchers, following the predefined protocol, and the final studies were collectively agreed upon.

Each included study was systematically coded along several dimensions: bibliographic details (title, author, year), study context (city/region and scale of analysis), research aim, *methods* used to operationalise or measure proximity, services assessed, and key *outcomes* examined relating to the study objectives. This coding scheme was designed to align with the study objectives, allowing grouping of studies by the primary question they inform. Many studies addressed multiple research areas, so cross-tagging was employed. Thematic synthesis was then conducted for each research category. Summary tables for each research theme were prepared to catalogue the studies, their methods, and a summary of main findings.

In addition to the qualitative synthesis, a bibliometric analysis was conducted on the 113 papers to contextualise the state of this research field. Using the R Package, *and VOS Viewer*, publication trends by year were charted, co-occurrence of author keywords was analysed to reveal major themes, and collaboration networks by country explored. This helps identify which journals and researchers are leading in FMC studies, and how research topics cluster, to understand emerging research frontiers within the broader sustainability and urban planning literature. The bibliometric results complement the qualitative review by illustrating the *trend* of research on 15-minute cities.

Empirical evidence was interpreted broadly from quantitative analyses, statistical modelling and qualitative case studies or text analyses, as long as they offered data-based insights on proximity in urban contexts. Given the interdisciplinary mix, no single critical appraisal tool was uniformly applied; however, for consistency, each paper was assessed for basic quality to support conclusions using the following appraisal criteria: (i) clarity and relevance of research objectives, (ii) clear and appropriate methodological design to address stated objectives, (iii) transparent analytical procedures, and (iv) coherence between evidence and conclusions. Studies that failed to meet these basic thresholds were excluded at the screening stage.

3. Bibliometric overview

The final list of 113 publications comprising 112 journal articles and 1 early access journal paper was uploaded to *Bibliometrix* for bibliometric analysis (https://www.bibliometrix.org/) and visualised through VOS Viewer software. This section provides an overview of, the evolution, disciplinary scope geographical focus, and thematic clustering of literature on proximity in the FMC. The summary statistics of the papers reviewed are in Appendix B.

3.1. Publication trends and citation dynamics

Academic interest in proximity-based urbanism has increased sharply since 2020. As shown in Fig. 3, there were only 6 publications in 2021, but this number rose to 19 in 2022, 37 in 2023, and reached a peak of 42 in 2024. By Q1 of 2025, 9 studies were recorded, which is likely to rise as the publication backlogs clear. All reviewed articles were published post-2021, highlighting the FMC as a concept of contemporary relevance, particularly after the COVID-19 pandemic heightened awareness of the need for localised urban living.

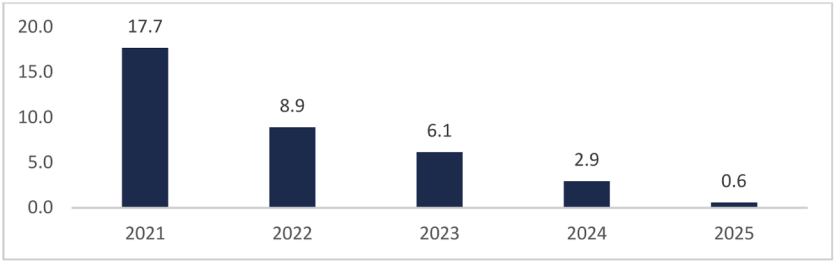


Fig. 4. Mean total citations per year.

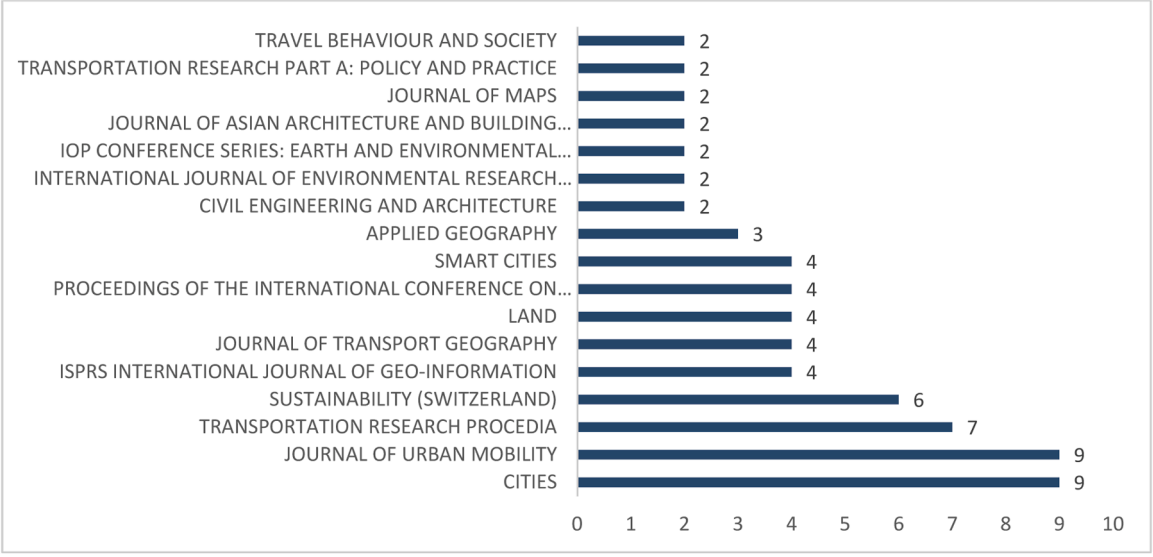


Fig. 5. Top journals publishing FMC-related literature.

The mean total citation metrics reflect this publication surge. The average citations per article peaked in 2021 at 17.7, before tapering to 8.9 in 2022 and 2.9 in 2024 (Fig. 4). This decline is consistent with the increasing volume of publications. Together, these patterns show that FMC is a very recent field, still dominated by cross-sectional and exploratory studies, with methodological fragmentation.

3.2. Leading journals and disciplinary anchors

The reviewed articles span 62 unique journals, underscoring the concept's interdisciplinary reach. Five journals dominate the publication landscape with the most relevant sources (Fig. 5). The *Journal of Urban Mobility and Cities* have the most papers *(n = 9), Transportation Research Procedia (n = 7), Sustainability (n = 6),* the *Journal of Transport Geography, Journal of Geo-Information, Land, International Conference on Computer-Aided Architectural Design Research in Asia* and *Smart Cities* have the fourth position *(n = 4),* while the *Journal of Applied Geography* has 3 papers. The remaining journals account for 2 or 1paper each. These imply that the key domains where FMC is being studies are on urban planning, transport geography, environmental science, and spatial analysis. It also implies that FMC research is situated at the confluence of mobility, equity, climate resilience, and planning, where it addresses the structuring and functioning of cities across time and demographic groups. This disciplinary breadth reinforces the relevance of analysing FMC not only as a mobility intervention, but also as a planning paradigm with implications for urban form and equity.

3.3. Most influential authors and collaboration networks

Among the most cited contributors to the FMC literature is Ferrer-

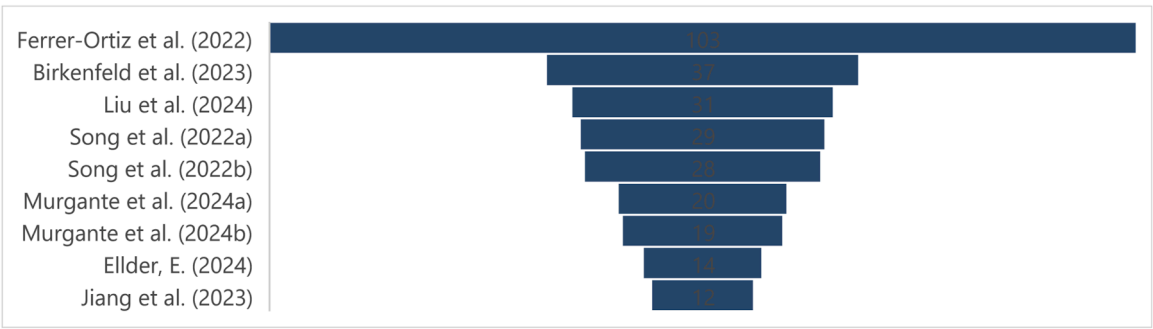


Fig. 6. Top citations per author.

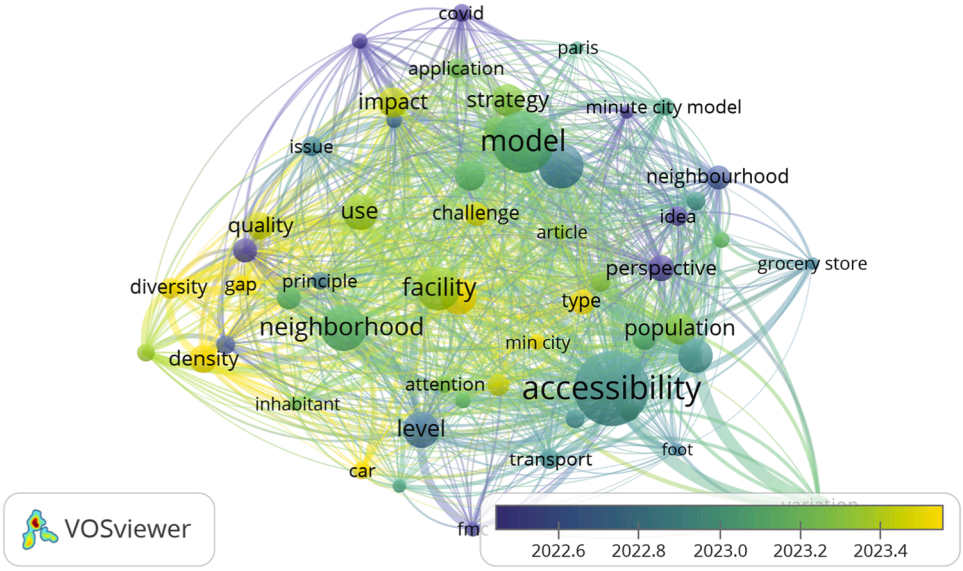


Fig. 7. Keyword co-occurrence network analysis.

Fig. 8. Keyword word cloud.

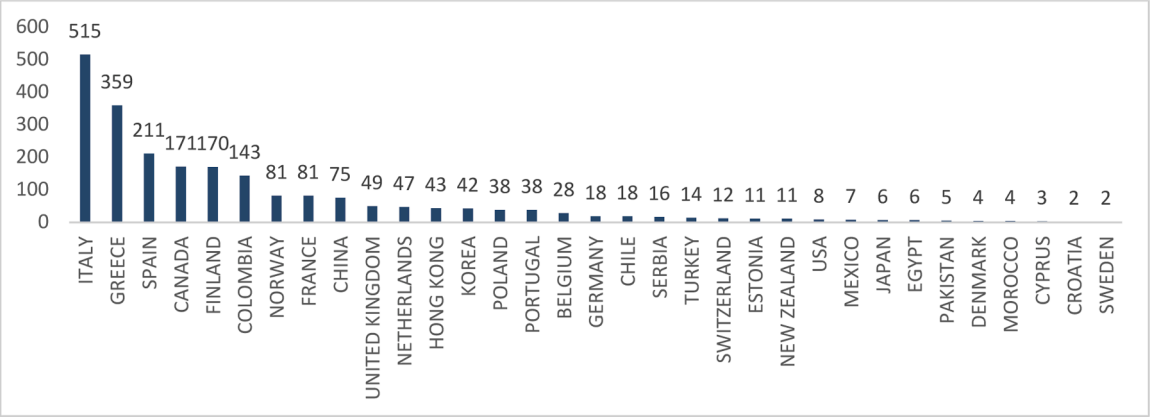
Ortiz et al. [25], whose empirical study on pedestrian accessibility in Barcelona under the FMC framework has garnered 103 citations. Birkenfeld et al. [21] follow with 37 citations for their Montréal-based study on local lifestyle behaviours and FMC/30-minute city overlaps. Liu et al. [26] ranks third with 31 citations for a comprehensive assessment of FMC status in Hong Kong, complemented by an additional 11 citations for her development of a chrono-urbanism index using social media data Liu et al. [27]. Luo et al. [31,32] also features prominently with two China-based studies focused on healthcare accessibility and green space equity, together cited 57 times. In the Italian context, Murgante et al., [33] has produced two influential articles; one evaluating urban quality using configurational analysis (20 citations) [33], and another comparing four Italian cities (19 citations) [34]. Collectively, these scholars represent the most cited empirical research on proximity and the FMC research (Fig. 6).

3.4. Thematic structure and keyword co-occurrence

Thematic keyword co-occurrence analysis (Fig. 7) reveals three dominant conceptual groupings that structure the FMC literature. The first cluster, *Proximity Infrastructure and Service Design,* aggregates terms related to the material organisation of urban space, including "transport," "neighbourhood," "public transport," "walking," "travel time," "density," "diversity," "facility," "gap," and "quality." These keywords reflect efforts to quantify and model proximity through spatial metrics, street networks, and service accessibility. The second cluster, *Policy, Governance, and Planning Narratives*, captures the discursive and institutional framing of FMCs, combining terms such as "model," "strategy," "urban policy," "COVID-19," "public space," and "citizen." This grouping reflects the normative and political dimensions of implementation, often linked to FMC branding and planning. The third cluster, *Human-Centric Access and Experience*, grounds the behavioural and lived aspects of proximity in FMC, with keywords like "accessibility," "home," "cycling," "population," "foot," "grocery store," and "neighbourhood" pointing to how individuals experience service access, local mobility, and spatial equity.

The word cloud in Fig. 8 further reinforces these patterns by visualising the relative prominence of terms, making evident the centrality of "urban planning," "accessibility," and "15-minute city," while also highlighting emerging dimensions such as "climate change," "sustainability," and "policy making."

High-frequency terms such as "urban planning" ($n = 25$), "accessibility" ($n = 18$), "15-minute city" ($n = 12$), "walking" ($n = 11$), and "mobility" ($n = 8$) confirm that the literature remains anchored in the interlinked domains of proximity, urban form, and everyday accessibility, while keywords such as "climate change," "GIS," and "policy



Map 1. Article production per country.

making" imply a methodological and applied orientation of recent FMC research. Research thematic evolution shows that earlier studies (around 2022) focused on basic accessibility and service facility distribution at the neighbourhood scale, whereas more recent literature (2023–2025) increasingly emphasises proximity modelling, strategic applications of localised living, and the integration of diversity, density, and equity considerations into proximity planning metrics. These keyword clusters align directly with the structure of this review: methods for measuring proximity, mobility outcomes, implications for urban form, and spatial equity.

3.5. Geographical and contextual coverage

Analysis of the geographical coverage of the reviewed literature reveals that out of the 41 countries covered, there is a skew toward developed countries in Europe, North America, and East Asia, and a limited representation from the Global South (Map 1 and Fig. 8). Italy leads and ranks highest in scholarly impact, (17 papers; 14.8 % of the total papers, 508 citations) followed by Greece (8 papers, 359 citations), China (7 papers, 75 citations), Canada (7 papers, 134 citations), Germany (6 papers, 18 citations), Spain (6 papers, 209 citations) and UK and Poland have 5 papers each (49 and 38 citations respectively). The other countries have less than 4 papers and citations on their publications.

Developing country representation remains disproportionately low compared with their rapid urbanisation and growing interest in sustainable urban form. Africa is represented in only two countries: Egypt (3 articles, 6 citations) and Morocco (1 article, 4 citations). Latin America appears through Colombia (3 articles, 143 citations) and Chile (1 article, 18 citations), and Southeast Asia includes Indonesia, Malaysia, and the Philippines, each with one paper and no recorded citations.

This is corroborated by sum of articles per institutional affiliation. Top contributions come from the Chinese University of Hong Kong (21) articles, while Europe is represented by Politecnico di Milano (16 papers), Aristotle University of Thessaloniki (12 papers) and the Universität Autonoma de Barcelona (12 papers). Mc Gill University represents America among the top research producers on the topic (11 papers).

Overall, this geographical skew suggests that the current FMC evidence disproportionately reflects developed country-centred discourse, raising concerns about its contextual fit in informal, rapidly expanding urban environments of developing countries. This geographical skew could also partly reflect the methodological scope of this review, which was limited to English-language publications indexed in Scopus and WoS, and therefore may underrepresent research published in other languages or indexed in regional databases. It also reflects regional policy implications where Europe has been an early adopter of the FMC discourse, supported by the European Green Deal and post-COVID recovery strategies that promoted localised living.

The bibliometric patterns also confirm that FMC research is highly recent, interdisciplinary, and geographically skewed. These patterns align with and frame the four research questions guiding this review: on methods of measuring proximity, given the methodological fragmentation evident in recent papers; on mobility outcomes, reflected in the clustering of keywords around walking, cycling, and accessibility; on urban form, as seen in the prominence of journals in planning and transport geography; and on equity, underscored by the weak representation from the Global South and the policy-driven concentration of studies in Europe.

4. Results and discussion

4.1. Measuring proximity in the 15-Minute City

The reviewed literature reveals significant methodological diversity on how FMC is assessed empirically, with studies adopting different models, service typologies, and spatial scales to define and measure proximity. From the 113 papers, five broad methodological categories emerge, summarised in Appendix C.

Network-based accessibility models dominate the empirical landscape, applied in 48 % of the studies. These models simulate realistic travel paths over pedestrian, cycling, or multimodal networks to estimate the reachable area within time thresholds such as 5, 10, or 15 min. Notable examples include Hosford et al. [11] in Vancouver, Caselli et al. [35] in Turin, and Jeong et al. [36] in Seoul. Some studies integrate multimodal access, combining walking with cycling or transit [15,19,37], while others adopt topological frameworks such as Space Syntax [38–40]. However, slope sensitivity remains underexplored. Only a few studies adjust walking speeds to reflect gradient effects, even though topography substantially influences actual travel behaviour, particularly for older or mobility-impaired populations. In Helsinki, Willberg et al. [37] accounted for individual walking-speed variation and terrain effects, showing that measured walking accessibility changes once slope and user heterogeneity are considered. In Seoul, Jeong et al. [36] included slope in a walkability assessment index and reported lower effective walkability in hilly districts despite high service densities. Similarly, in Hong Kong Liu et al. [26] demonstrates that steep gradients constrain independent access in districts such as Sham Shui Po relative to flatter areas like Tin Shui Wai. Further, evidence from Chongqing quantifies the bias introduced by ignoring terrain, where observed walking paths reduced nominal 5/10/15-minute network isochrones by 32.12 %, 46.49 %, and 46.30 %, respectively, with some facilities experiencing attenuation up to 87.71 % [41]. These confirm that relying

Table 1
Service categories considered in FMC proximity studies.

Service Category	% of Studies
Grocery/Food Stores - [10],[11]	92 %
Primary Healthcare - [9,19]	78 %
Schools/Education Facilities - [37,47]	75 %
Green/Recreational Spaces - [25],[45]	68 %
Public Transport Access - [19],[48]	54 %
Employment Centres/Jobs - [10]	41 %
Leisure Facilities (Cinemas, Cafes) - [35,49]	29 %

on flat-speed network models or simple buffers can materially overstate "15-minute" access in steep settings. In effect, differences across cities can reflect modelling choices as much as spatial realities unless terrain, surface condition, and user-specific speeds are explicitly represented and their influence reported.

POI-based catchment analyses are the second most common method, used in 20 % of studies. This approach defines fixed-distance or fixed-time buffers around services [9,25], offering simple and intuitive metrics. However, it risks overstating accessibility by assuming uniform, barrier-free access within catchments, ignoring slope, pedestrian infrastructure gaps, or real network structure. In practice, this could ease interpretability at the expense of realism, particularly in topographically complex settings where underreporting access is most likely.

Composite proximity indices account for 12 % of the studies. These indices aggregate access to multiple types of essential services into a synthetic accessibility score, often weighting services based on perceived importance or frequency of use [26,42–44]. While offering valuable benchmarking capabilities across cities and countries, they depend on normative choices about which services to include and how to weight them. Without routine sensitivity checks to alternative weights and thresholds, cross-city comparisons may mirror modelling priors more than contextual lived accessibility.

Cumulative opportunity and gravity-based models, also at 12 %, measure either the number of reachable destinations or weight accessibility based on travel impedance. Studies such as Monteiro et al. [45] and Colaço & de Abreu e Silva [10] exemplify this approach, which captures service density and user behaviour more realistically than simple catchments. Others, such as Pinto and Akhavan [46], extend this to location-allocation modelling to identify facility placement that would maximise 15 min coverage. Literature review papers comprised of 8 % of the body of literature.

Analysis of services covered across studies shows a clear focus on daily essential needs. Table 1 summarises the types of services commonly included in reviewed studies.

Grocery or food stores are the most consistently included category, appearing in 92 % of studies. Primary healthcare services are covered in 78 % of cases, and schools in 75 %. Green and recreational spaces are considered in 68 % of the studies, reflecting the strong public health dimension of FMC objectives. Public transport access points, crucial for multimodal connectivity, are included in 54 % of studies. Employment centres and leisure facilities, such as cafes and cinemas, are included less consistently, at 41 % and 29 % respectively [22,49]. The spatial scale of analysis is concentrated at the local or metropolitan level. Of the 107 empirical studies reviewed, 103 (97.2 %) focus on individual cities or metropolitan areas, such as Barcelona [25,50], Lisbon [10,51], and Hangzhou [26]. Only 7 studies (6.6 %) adopt a regional or inter-municipal perspective, analysing proximity across multiple cities or districts [46,52]. National-scale analyses are even rarer, with only four studies fitting this category: Olivari et al. [44] for Italy, Sdoukopoulos et al. [48] for Greece, Lima and Costa [22] for Portugal and Poorthuis and Zook [53], who analyse FMC lifestyle patterns across the Netherlands based on 16 years of national travel survey data.

The methods adopted have various strengths and limitations. Network-based accessibility models realistically represent urban form and street connectivity, but their accuracy is sensitive to network data quality and, as noted, they rarely model slope effects except in isolated cases. POI-based catchments are simple and scalable but risk overestimating accessibility by ignoring real-world travel barriers such as missing links and physical mobility barriers. Composite indices depend heavily on subjective weighting decisions, which might not be consistent. Cumulative opportunity and gravity models better capture service density and accessibility potential, although they too assume standardised travel behaviour across diverse populations. Across methods, two cross-cutting needs occur: routine uncertainty and sensitivity analysis, such as DEM resolution, walking-speed distributions, and weighting schemes, and clearer reporting standards to enable comparability and replication are needed.

While proximity metrics in chrono-urbanism are evolving, there is a limit on standardising distance and time thresholds, integrating perceived accessibility, service quality, affordability, or temporal dynamics in service points [54]. Furthermore, despite the critical impact of topography in cities with significant elevation variation, slope-sensitive modelling remains rare in the FMC literature, representing an important gap for future research. A practical next step is to align context-specific thresholds with DEM-adjusted networks and equity-aware metrics, rather than rely on universal distances or flat-speed assumptions.

4.2. *Proximity and mobility outcomes*

This section interrogates if proximity-based planning can measurably shift mode choices and trip patterns, and how are these outcomes assessed based on existing literature. Across the reviewed literature, there is evidence that higher local accessibility leads to reductions in private car use, increase in walking and cycling rates, and decrease in transport-related CO_2 emissions. However, the magnitude of these impacts varies by context, methodology, and baseline urban conditions.

Studies operationalise "mobility outcomes" through diverse metrics: changes in walking, cycling, or car mode shares; trip frequencies; distance travelled; and estimated reductions in CO_2 emissions. Common methodologies employed in such assessments include GIS-based proximity modelling cross-referenced with travel surveys [10,21,55], mode share and accessibility mapping [31,56,57], and scenario simulations [45,58]. In other cases, integrated travel behaviour and land-use datasets have used elasticity to analyse between proximity and mobility behaviours [59,60].

4.2.1. *Proximity and mobility implications*

Across the reviewed literature, proximity-based planning consistently shifts travel behaviour by increasing active mobility and reducing car use. In Portland, Pozoukidou and Chatziyiannaki [61] found that achieving a 90 % proximity target led to a 16 % increase in walking and a 10 % drop in car use. Jeong et al. [36] reported that service- and transit-dense districts in Seoul had walking and cycling shares 22.8 % higher than other areas. In Barcelona, Ferrer-Ortiz et al. [25] observed that FMC-compliant parcels which were only 22.1 % of the total, registered 17.3 % more walking trips. Pandemic-era bike lanes also triggered sharp behaviour shifts: Guzman et al. [62] found cycling rose by 85 % in Bogotá, 65 % in Mexico City, and 52 % in Lima, showing how quick tactical upgrades can boost active travel where proximity is strengthened.

Proximity also reduces car reliance and ownership. In Barcelona, Fernández Núñez et al. [9] showed that service proximity reduced the probability of car use by 10.6 % ($r = 0.106$, $p < 0.001$), though habitual drivers did not shorten their trip distances. In Hong Kong, Wang et al. [63] reported that improved service accessibility reduced reliance on private motorized travel by 17 %, confirming spatial compactness as a key mechanism in lowering car dependence. Reductions in CO_2 emissions further reinforce the environmental benefit of proximity. In Lisbon, Colaço and de Abreu e Silva [10] found that residents in FMC-compliant areas made 8.7 % more non-motorized trips, used public transport 6.5 % more, and had statistically lower CO_2 emissions (β

= −0.060). Vale and Lopes [64], across 585 European cities, linked a 10 % increase in accessibility to a 2.5 % drop in per capita transport emissions. Jin et al. [19] estimated that FMC adoption could reduce urban CO_2 emissions by up to 80 % in cycling-led and 88 % in transit-led systems, alongside a projected 70 % decrease in car use.

Health, wellbeing, and spatial quality gains also emerge. Gallarday et al. [65] found walkability upgrades raised Urban Diversity Index scores by 12.3 % and Quality of Life indicators by 9.8 %. In Barcelona, Rojas-Rueda et al. [66] projected that Superblocks and green corridors could reduce emissions by 23 %, prevent 667 premature deaths annually, and save 1.7 % of GDP in health costs. These outcomes reinforce the systemic benefits of reconfiguring urban form around proximity.

Lastly, evidence shows proximity significantly improves access to jobs and services. In Lisbon, Monteiro et al. [45] demonstrated that combining walk and cycle catchments increased job access sixfold, from 5000 to 30,000 jobs within 15 min. In Hamilton, New Zealand, Wang et al. [63] showed that extending proximity thresholds from 10 to 15 min expanded liveable urban area by 237 % and raised active travel potential by 18 %. These findings confirm how marginal gains in spatial reach translate into measurable inclusion and equity benefits. Therefore, the literature confirms that proximity-based planning supports modal shift, could help cut emissions, expands access to local areas, and improve wellbeing, making it a practical framework for sustainable urban mobility transformation.

These studies demonstrate that proximity is a reliable directional lever but not a self-standing solution, with the impactful shifts appearing where local access is paired with continuous, safe infrastructure. Proximity works best as a complement to, not a substitute for, networked mobility. Experience from the pandemic reveals significant latent demand that is realised quickly when active mobility infrastructure realignment reduces friction with motorised travel, but its sustenance hinges on institutional follow-through permanent space reallocation, pricing and on land use changes, which helps explain why car use falls more readily than commute distance. Emissions results show conditional potentials under supportive FMC policy bundles. Finally, proximity can be improved through micro-connectivity fixes such as safe crossings, active mobility infrastructure and slope mitigation to deliver inclusion gains especially for marginalised groups, underscoring that design quality and network continuity can lead to the achievement of the FMC.

4.2.2. Challenges and limitations

Despite the implied positivity on the impact of proximity and sustainable travel, some limitations are worth noting. Guzmán et al. [62] observed that although Bogotá residents localised activities during pandemic restrictions, car dependence rebounded sharply once mobility controls were lifted, suggesting policy, cultural and infrastructural, barriers to permanent modal shifts. Additionally, Birkenfeld et al. [67] and Elldér [68] highlighted that commuting trips are less elastic than errands or leisure trips. For instance, without job decentralisation or telecommuting policies, proximity alone has limited influence on work-related car trips. Finally, studies such as Olivari et al. [44] caution against "proximity overloading", where adding more amenities beyond basic needs yields diminishing returns on mobility outcomes. Therefore, a sufficiency-based threshold which ensures basic services are within reach, is more efficient than aiming for abundance in local service accessibility.

These constraints reframe proximity in the FMC as a conditional for behavioural change. Proximity lowers generalized travel costs, yet durable travel shifts require concurrent reforms in land use, pricing, and service supply that harmonise the interventions with everyday habits. Where employment remains spatially concentrated, proximity reshapes nonwork trips and induces partial car shedding rather than full substitution of commute travel. Excess provisioning of amenities without attention to quality, affordability, and network continuity can deter further realisation of proximity benefits and can even redistribute demand without reducing vehicle kilometres travelled (VKT). Effectively, FMC has potential to realise mode shift in local access and realise local emissions reduction.

4.3. Proximity, urban form, and land use

The capacity of the FMC to be realised in practice is linked to underlying urban form and built environment characteristics. Across scoped literature, four main built environment enabling factors emerge: density, land use mix, street connectivity, and polycentricity. These elements interact synergistically to create neighbourhoods where daily needs are reachable within short local trips.

4.3.1. Density

Studies confirm that moderate to high population density correlates with greater proximity to services. Vale and Lopes [64] found that across 585 European cities, service variety within 15 min increased significantly once residential densities reached about 75 residents per hectare (7500 per square kilometre), with diminishing returns beyond this point. Colaço and de Abreu e Silva [10] reported that in Portugal, areas with an average density of 3790 residents per square kilometre had significantly lower car use compared to less dense areas. In Sweden, Elldér [68] showed that while 51 % of the population could access basic services within one kilometre, achieving access to a full range of functions required both higher density and land use mix, outweighing the effect of city size. Guzmán et al. [62] found that 92 % of inner-city residents in Bogotá had walking access to daily services within 15 min, while only 29 % of suburban residents achieved the same, highlighting the role of higher residential density. In Hong Kong, Wu [69] reported that over 90 % of children in the dense Sham Shui Po district could access daily services within ten minutes, compared to about 80 % in the lower density Tin Shui Wai area. This suggests that while a minimum density is crucial for sustaining local commerce and public transit, land use diversity is a co-requisite.

4.3.2. Land use mix

The diversity of land uses through co-location of residential, commercial, institutional, and recreational functions, emerges as a predictor of proximity success. Jeong et al. [36] built a Walkability Assessment Index for Seoul, finding that districts with higher land use mix achieved the highest scores, exerting a stronger influence on walkability than density or sidewalk coverage. In Montreal, Birkenfeld et al. [67] observed that neighbourhoods with greater land use diversity were more likely to support a 15 min active travel lifestyle compared to predominantly residential zones, although no precise odds uplift was specified. Monteiro et al. [45] demonstrated through simulations that inserting just three essential amenities (grocery store, pharmacy, and park) into residential suburbs could raise FMC compliance by 17 to 22 %. Thus, FMC realisation hinges not merely on the density of an area, but also on a mix of destination types embedded within neighbourhoods, making density and land use mix complementary. The policy challenge then shifts to redistributing essential functions to low-demand areas while preserving affordability, to avoid car-oriented spillovers.

4.3.3. Street connectivity and walkability

Even where density and land use mix are present, poor street network connectivity can limit effective proximity. Studies highlight that intersection density, block size, and pedestrian infrastructure can influence the usability of “15 min” distances. Helsinki, Willberg et al. [37] found that neighbourhoods with intersection densities above 110/km^2 achieved 30–40 % higher walking rates compared to fragmented grids. In Seoul, Jeong et al. [36] showed that sidewalk continuity and gentle slopes were equally important as proximity itself in encouraging active trips. In Bogotá, Guzmán et al. [62] reported that barriers such as highways and rivers reduced effective 15 min walking catchments by 27 %, highlighting that short distances are meaningless

without a connected network. In Lisbon, Vale and Lopes [64] found that accessibility gaps were often driven by railway lines and expressways disrupting pedestrian routes, even in dense, service-rich areas. Monteiro et al. [45] simulated suburban retrofitting and showed that low street permeability sharply limited walking catchments despite new amenities. Similarly, Baig et al. [70] reported that densely populated but fragmented districts had lower FMC compliance, demonstrating that impermeable street layouts can cancel out the advantages of compact development. This is consistent with the Chongqing evidence, steep segments and multi-level barriers can shrink nominal 15 min areas by roughly one-third to nearly one-half at common thresholds, underscoring the need for DEM-adjusted speeds and empirically traced paths in proximity assessments [41]. Good proximity therefore depends on network quality for pedestrian or cyclist permeability, and eliminating the missing links can unlock larger gains compared to the cost of adding new siloed facilities.

4.3.4. Polycentricity

Evidence shows that proximity outcomes are significantly shaped by how well services are distributed across the urban space. In Sweden, Elldér [68] found that decentralised urban regions enabled 32–48 % of residents to reach basic services within 15 min, while larger monocentric cities achieved only 10–17 %. In Lisbon, Vale and Lopes [64] reported that accessibility sharply declined beyond consolidated cores, revealing the limits of monocentric development. Similarly, in Morocco, Harroucha and Chaouni [71] found that 71.7 % of mosques in Rabat-Salé were accessible within 15 min, with clustered spatial patterns around sub-centres supporting equitable access. In Pisa and Perugia, Murgante et al. [34] observed that integrated accessibility values (0.620–0.839) were concentrated in historical centres, while outer zones saw a steep drop, reinforcing the role of sub-centres in ensuring reach. These findings affirm that realising the FMC at scale depends on a polycentric structure where well-connected local hubs host essential services, rather than relying solely on dense central districts. Thus, maximising the reach of the FMC model depends on supporting multiple well-connected, mixed-use centres rather than relying solely on a dominant downtown core. To support polycentrism in the FMC, governance and transit coordination must keep pace, or new sub-centres risk reproducing central-city inequities at smaller scales, eroding the intentions of proximity.

4.3.5. Urban reconfiguration

Real-world interventions provide evidence on how urban reconfiguration can strengthen proximity and reshape mobility patterns. In Barcelona, the Superblocks program restricted through-traffic inside 3 × 3 block areas and reclaimed streets for walking and cycling. In for instance, Poblenou, this led to a 30 % rise in walking trips and a 33 % reduction in motorised traffic [66]. In Paris, retrofitting local amenities such as Maison de Santé clinics and redesigning streets under the "*ville du quart d'heure*" strategy contributed to a 25 % increase in cycling, a 5 % decline in car use, and shorter trip distances in central arrondissements between 2019 [72]. In Ferrara, traffic calming and pedestrianisation raised proximity scores above 85/100 in the historic core compared to 20–40 in peripheral villages [44]. These cases affirm that retrofitting urban space and public infrastructure is critical for advancing FMC outcomes, and their impact will be sustained through complementary mobility demand management and institutional policy support for local level interventions.

4.3.6. Conclusion

Realising FMC benefits through planning and land use should be context specific. Historic mixed-use fabrics can adapt more easily, while postwar suburban grids often require substantial infill and mobility redesign [44,45]. In contrast, new city developments, especially in emerging economies, offer opportunities to embed proximity principles from the outset [73,74]. Cultural attitudes and institutional frameworks also shape outcomes; without demand management policies like parking reform or congestion pricing, car reliance often persists even where physical proximity improves [19,75]. Finally, evidence shows that after a service sufficiency threshold is reached, adding more amenities yields limited additional benefits, reinforcing that optimum sufficiency rather than numeric maximisation of services should guide FMC transformations.

4.4. Proximity, equity and spatial justice

While the FMC concept aspires for equitable access, empirical evidence suggests that proximity outcomes remain highly uneven. Much of the literature reports distributional access metrics rather than demonstrated equity outcomes, and causal or longitudinal evaluations of who benefits or who does not remain sparse. Across the studies reviewed, spatial equity was assessed by measuring variations in service accessibility across income groups, age cohorts, geographic zones, subjective perceptions of equity, or disability inclusion. Most findings indicate that physical proximity alone does not guarantee equitable urban living without deliberate design for inclusion.

4.4.1. Income-Based inequities

Income disparities are the most persistent observed form of inequality. Elldér [76] found that in Sweden, high-income households had significantly greater proximity to essential services than low-income ones, even within the same urban environments. In Bogotá, Guzmán et al. [62] reported that although 80 % of the city's population had walking access to at least one basic service, low-income neighbourhoods remained systematically underserved. Gritton et al. [77] similarly highlighted that in Orange County, California, mean bicycle accessibility was 1.2 times greater in affluent tracts compared to low-income ones, underlining spatial inequities in active travel opportunities. In Hong Kong, Liu et al. [26] found that healthcare and education accessibility were significantly lower among lower-income residents, despite overall advances in proximity planning. These patterns of unequal access were also confirmed in European settings, with Giuffrida et al. [78] demonstrating service access inequities in Italian cities, and Núñez et al. [9] highlighting that the affluent districts in Spanish metropolitan areas consistently achieved higher compliance with FMC thresholds.

These patterns imply that proximity gains are path dependent, with market-driven amenity clustering and historic underinvestment concentrating services where purchasing power is highest, systematically producing a proximity premium that market forces alone cannot offset. Service distribution reporting must move beyond mean access to reveal details of deprivation, with equity weights applied to proximity indicators. In the FMC context, the supply-side correction and demand-side protection deployed together should be integrated. On the supply side, a minimum service bundle should be mandated for low-income districts and backed by location-allocation, public leasing, and targeted operating subsidies. On the demand side, anti-displacement measures, income-indexed fares, and rent stabilisation are required so that new access does not capitalise into higher costs.

4.4.2. Age-Based inequities

Elderly populations often face compounded barriers to accessibility. In Chinese cities, Wang et al. [63] and Liu et al. [26] both found that elderly residents had 10 to 22 % lower access to public services compared to the general population, with the widest disparities outside city centres and in suburban areas. Although Ulloa-León et al. [79] showed that elderly individuals living in FMC-compliant districts made 35 % more walking trips than those in car-dependent areas, effective access remained constrained by infrastructure quality. Willberg et al. [37] further demonstrated in Helsinki that poor sidewalk conditions and topographic barriers reduced elderly 10-minute accessibility by 9 %, with winter conditions worsening mobility loss. More broadly, Ramirez et al. [80] pointed out that while many city plans aim for proximity, only

39 % systematically address the mobility needs of elderly or disabled residents, risking the exclusion of vulnerable groups from FMC benefits. Ageing amplifies the gap between nominal and actual proximity because speed, stamina, and risk perception vary systematically across cohorts. The FMC context therefore needs calibration to the physiological reality of the elderly, where slower walking speeds, shorter continuous segments, frequent resting points, and step-free access are prerequisites, to ensure thresholds are realistically age-compliant. Without these corrections, cities can meet headline "15-minute" goals while still failing older adults in actual access.

4.4.3. Children and child-friendly access

Children's proximity needs are increasingly recognised in FMC literature measures. In Milan, Gorrini et al. [81] found that while most districts met FMC distance thresholds for schools, fewer than half offered continuous, safe pedestrian routes suitable for independent child travel. Similarly, Wang et al. [82] reported that in Chinese cities, despite the formal presence of services, 60.39 % of neighbourhoods exhibited very poor walkability for children due to missing child-friendly and safe street design features. Giuffrida et al. [78] found that nearly 20 % of students in Italian cities had no school access within 15 min, while Shoina et al. [83] showed that only 30 % of residential areas in Greek cities achieved school access within a five-minute walk. In FMC implementation, safe systems design for children should be mainstreamed to ensure continuous sidewalks, intersection calming, protected crossings, filtered permeability near schools, and supervised "walking bus" networks. Proximity metrics should incorporate route quality and guardians' perceived safety, recognising that parents' risk thresholds govern mode choice.

4.4.4. Intra-Urban geographic disparities and displacement risks

Studies demonstrate inequalities between central and peripheral areas. In Barcelona, Ferrer-Ortiz et al. [25] found that only 22 % of residential parcels achieved full FMC compliance, with fragmented service coverage and weak walking connectivity particularly affecting peripheral zones. In the Lisbon Metropolitan Area, Lima and Costa [22] highlighted that higher accessibility levels were concentrated in central neighbourhoods, while outer districts showed significant gaps. Similar patterns were observed in Bogotá, where Guzmán et al. [62] reported that 92 % of inner-city residents had walking access to essential services compared to just 76 % in outer areas. In Rome, Barbieri et al. [84] demonstrated that peripheral districts such as Tor Bella Monaca experienced a sharp decline in 15 min accessibility, contrasting strongly with the continuous coverage observed in the city centre. Other studies emphasise that without protections, proximity improvements may trigger gentrification and displacement. Casarin et al. [85] found that in Mexico City, newly walkable neighbourhoods experienced rising housing costs, pricing out lower-income groups.

Centre-periphery patterns reflect both structural monocentricity and uneven network permeability, while rising accessibility can trigger value capture that pushes out the intended beneficiaries. In the FMC scenario, there should be spatial investment in peripheral sub-centres with missing links and co-location of essential services, and reliable public transit to reduce core dependency. Institutionally, the decentralisation should be paired with affordability protections to guard against gentrification, community land vehicles, and inclusionary requirements so proximity dividends are retained locally.

4.4.5. Disability inclusion and design-for-all

Ramirez et al. [80] found that although 87 % of city plans referenced spatial proximity goals, only 39 % addressed the accessibility needs of elderly or disabled users, and just 4 of 23 cities evaluated differentiated walking speeds. Barratt and Swetnam [86] evaluated 10 pedestrian and cyclist routes in Staffordshire, revealing gaps in safety, signage, and infrastructure continuity that hinder inclusive access. Despite mapped 15-minute catchment zones, key services like retail and healthcare remained unevenly reachable for mobility-impaired users. A universal-design FMC requires step-free networks, tactile guidance, kerb-level continuity, legible wayfinding, and graded slopes as baseline infrastructure rather than optional amenities. Assessment methods and interventions should embed differentiated speeds, surface friction, vertical barriers, and intersection delay penalties in network models, and participation of disability advocates to improve both accuracy and legitimacy.

4.4.6. Conclusion

While enhancing proximity remains central to the FMC model, achieving spatial equity demands more than simply shortening distances. Without explicit measures to prioritise vulnerable groups, prevent gentrification and displacement, address qualitative and infrastructural accessibility barriers, and embed universal design principles, proximity-based strategies risk reinforcing or even exacerbating existing inequalities. Evidence shows that proximity gains often favour already-advantaged populations unless spatial planning deliberately accounts for diverse mobility abilities, socio-economic disparities, and potential exclusion risks. Future FMC interventions must therefore integrate physical, procedural, temporal, and socio-economic dimensions of accessibility, ensuring that proximity improvements contribute meaningfully to spatial justice rather than becoming another agent of urban inequality.

5. Conclusion

The systematic review of the FMC literature confirms its potential to enhance urban sustainability and human scale mobility by promoting proximity-based access to daily services and supporting inclusivity by localising access to essential services. However, evidence of risks of gentrification, spatial inequality, affordability gaps, and uneven equity outcomes are limited and uneven in the empirical record. Across cities that have implemented FMC aligned strategies, including Paris, Portland, Ottawa, and Melbourne [38], there is evidence of reduced car dependency, increased active travel, improved urban health, and more compact spatial development. Further, risks such as gentrification and spatial inequality are noted as significant. Full FMC adoption is still rare. While many cities align with aspects of the model, few treat it as a core planning principle, and even fewer have in-depth evaluation frameworks to track long term outcomes.

Considering the research questions, four key insights emerge. For RQ1 on methods of measuring proximity, the literature reveals substantial diversity, with network-based models dominating but limited integration of slope sensitivity and real-time dynamics. For RQ2 on mobility outcomes, there is consistent evidence that improved proximity reduces car dependence and increases walking and cycling, though effects vary by context and are often short-term or cross-sectional. For RQ3 on urban form, findings confirm that density, land-use mix, connectivity, and polycentricity are critical enablers of FMC compliance, yet evidence remains fragmented on how FMC reshapes spatial structure over time. For RQ4 on equity, accessibility gaps persist across income, age, ability, and geography, indicating that proximity alone does not guarantee inclusion without deliberate policy safeguards.

Emerging gaps cluster around four thematic issues. First, the evidence base is uneven: empirical support is growing but remains partial, tilted toward cross-sectional or modelled studies and with limited representation from the Global South. Second, methods and measurement lag practice, with minimal treatment of terrain, freight and logistics, and a continued reliance on static proximity metrics that overlook time, quality, and user perception. Few studies probe how residents experience or value accessibility beyond distance, or how affordability, safety, and service quality shape real-world use. Effort should concentrate on slope-aware and real-time approaches on network data that incorporate DEM-adjusted travel speeds, smartphone and GPS traces, crowdsourced vertical barriers, and live transit feeds; on systematic sensitivity analysis

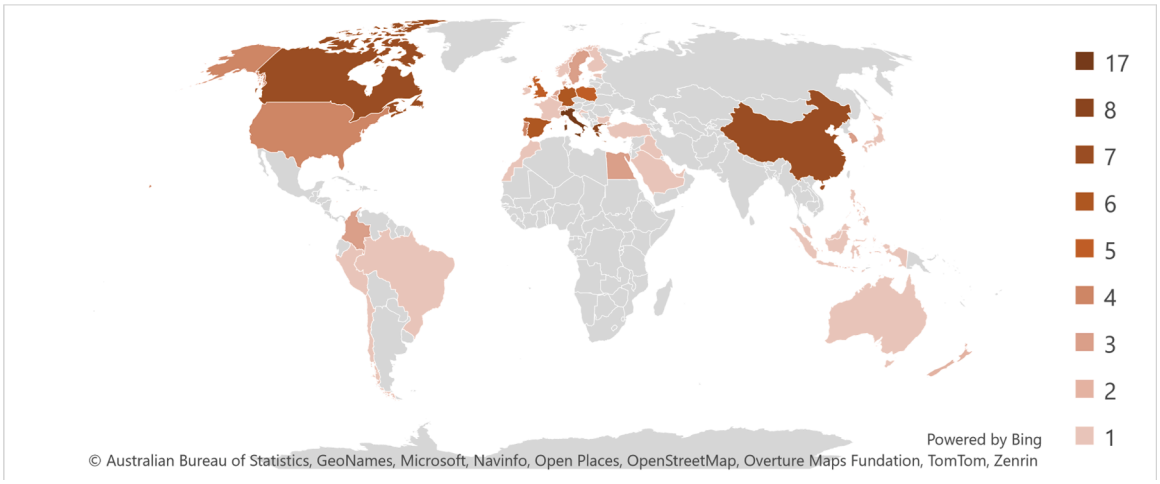


Fig. 9. Total citations per country.

to thresholds and weights; and on clearer reporting standards that enable comparability and replication.

Third, equity and implementation are weakly evidenced, with uneven outcomes across groups and places and modest affordability safeguards, signalling the need for stronger protections and evaluation frameworks. Priority should be to pair proximity upgrades with protections against displacement, equity-weighted monitoring, and evaluation frameworks that track distributional effects rather than mean access alone. Finally, systems integration is underdeveloped, with evidence on links to public transport, shared mobility, and urban freight being insufficient, constraining proximity assessment within active mobility catchments. Advancing this agenda means coupling neighbourhood-scale access improvements with dependable, frequent transit and last-mile freight strategies so that proximity functions as a complement to networked mobility rather than a substitute. Finally, cities in Africa, South Asia, and Latin America should receive greater focus, because most urban growth is currently taking place there. Applying FMC in these contexts will need innovation, flexible standards, low-cost data solutions, and participatory methods to address informal urbanism, weak institutional capacity, resource constraints and context-sensitive proximity standards.

Policy implications follow directly from these gaps and are framed here for city governments, transport agencies, and planning ministries. Stronger policy integration with efficient urban resource allocation strategies, and economic revitalisation policies can enhance its implementation and impact. Linking FMC with such systems ensures that proximity is not just a spatial principle but also a lever for healthier, fairer, and more economically vibrant cities. The model's promise rests on closing critical knowledge gaps and delivering a measurable, inclusive, and low carbon urban future.

While this review relied on Scopus and WoS for its bibliographic corpus, future reviews should also include specialised databases such as the Transport Research International Documentation, to capture a broader range of transport and urban planning studies and ensure a more comprehensive coverage of FMC-related research. In addition, the reliance on English-language, peer-reviewed journal articles may underrepresent perspectives from non-English-speaking contexts where FMC debates are active such as Francophone and Latin American literature. Future reviews should expand the linguistic coverage to capture a fuller range of proximity planning practices Fig. 9.

Ethical approval

Not applicable.

CRediT authorship contribution statement

John Omwamba: Writing – review & editing, Visualization, Project administration, Investigation, Formal analysis, Data curation, Conceptualization. **Lucia Rotaris:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Data curation, Conceptualization. **Giovanni Longo:** Writing – review & editing, Supervision, Funding acquisition.

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.

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Appendix A: Search strings

1. Scopus

15-minute AND cit* OR 15 min AND cit* OR x-minute AND city OR chrono-urbanism OR 10-minute AND city OR 20-minute AND city OR 30-minute AND city AND sustain* AND PUBYEAR > 2015 AND PUBYEAR < 2026 AND (LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "ENVI") OR LIMIT-TO (SUBJAREA, "BUSI") OR LIMIT-TO (SUBJAREA, "ARTS") OR LIMIT-TO (SUBJAREA, "ECON") OR LIMIT-TO (SUBJAREA, "MULT") OR LIMIT-TO (SUBJAREA, "EART") OR LIMIT-TO (SUBJAREA, "ENGI")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp")) AND (LIMIT-

TO (LANGUAGE, "English")) AND (LIMIT-TO (OA, "all"))

2. Web of Science

Refine results for (ALL=(15 min cit*)) OR ALL=(15-minute cit*) AND ALL=(Sustain*) and 15 min City and 15-minute Cities and 15-minute City and Chrono-urbanism and X-minute City and Review Article or Early Access or Book Chapters or Book Review or Article (Document Types) and Open Access and English (Languages) and 2016 or 2017 or 2018 or 2019 or 2020 or 2021 or 2022 or 2023 or 2024 or 2025 (Publication Years) and Pathology or Spectroscopy or Toxicology or Tropical Medicine or Biophysics or Zoology or Audiology Speech Language Pathology or Entomology or Dermatology or Anatomy Morphology or Reproductive Biology or Polymer Science or Fisheries or Microscopy or Parasitology or Virology or Optics or Rheumatology or Genetics Heredity or Allergy or Substance Abuse or Plant Sciences or Otorhinolaryngology or Dentistry Oral Surgery Medicine or Veterinary Sciences or Nursing or Cell Biology or Life Sciences Biomedicine Other Topics or Geriatrics Gerontology or Microbiology or Social Sciences Other Topics or Biochemistry Molecular Biology or Anesthesiology or Urology Nephrology or Physiology or Neurosciences Neurology or Surgery or Chemistry or Emergency Medicine or Obstetrics Gynecology or Oncology or Medical Informatics or Psychiatry or Endocrinology Metabolism or Gastroenterology Hepatology or Infectious Diseases or Ophthalmology (Exclude - Research Areas)

Appendix B. Reviewed papers summary statistics

Timespan	2021:2025
Sources (No. of Journals)	62
Documents	113
Annual growth rate %	10.67
Document average age	1.74
Average citations per document	18.93
Authors	344
Authors of single-authored documents	7
Single-authored documents	9
Co-Authors per document	3.57
Article	112
Early access paper	1

Appendix C. Classification of FMC Reviewed Papers

Measurement Approach and keywords	Description	% of Studies	Sampled Studies
Network-Based Accessibility Models - *"GIS-based network analysis," "Network analysis," "Pedestrian/cycling network analysis," "Travel time isochrones"*	Estimate reachable areas along pedestrian, cycling, or multimodal networks within specified time thresholds/ isochrones.	48.2 %	[11,19,21,25,31,34–36, 53,71,84,87–91,93,112]
POI-Based Catchment Analyses - "Catchment area," "Service buffers," "Fixed-distance catchments"	Create fixed-distance or time buffers around services or Points of Interest (POIs)	19.8 %	[25,26,50,52,61,82,83, 92,94–98,113]
Composite Proximity Indices - *"Composite Index," "Aggregated Accessibility Score," "Multiservice Accessibility Index"*	Aggregate access to multiple services into a unified accessibility score.	16.0 %	[22,26,36,42–44,48, 99–101]
Cumulative Opportunity and Gravity Models - *"Gravity Model," "Cumulative Opportunity Model," "Distance Decay Weighting," "Optimisation Modelling"*	Quantify reachable services, often using distance decay weighting; to include optimisation modelling.	16.0 %	[10,11,26,32,43,45,46, 63,82,102–106]
Literature Reviews	Review of various literature on FMC	9 %	[22,24,50,85,87,107–111, 114]

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