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REVIEW PAPER

Health-oriented urban planning and design: A comprehensive review of global evidence on urban environmental exposures and health outcomes (1984–2025)

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ABSTRACT

Rapid urbanisation has transformed cities into both concentrations of health risks and key arenas for improving population health. Understanding how urban environmental conditions influence multiple dimensions of health has therefore become a central concern for health-oriented urban planning and design. This study synthesises global scientific evidence on the relationships between urban environmental exposures and health outcomes published between 1984 and 2025 and develops an analytical framework for integrating health considerations into urban planning and design practice.

A systematic review with narrative synthesis was conducted in accordance with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Relevant studies were identified through structured searches in major international and national academic databases. The records were screened using predefined inclusion and exclusion criteria, and eligible studies were systematically coded and analysed. The reviewed studies were classified according to key categories of urban environmental exposure, including green and blue spaces, public and recreational spaces, built form and urban morphology, transport systems and walkability, and environmental risks such as air pollution, noise, and urban heat exposure. Health outcomes were examined across four domains: physical, mental, social, and cognitive health. The findings reveal consistent evidence that access to green and blue spaces and high-quality public spaces is associated with improved mental health, increased physical activity, and higher overall quality of life. Urban form characteristics—particularly density, land-use configuration, and walkability—are systematically linked to patterns of physical activity, obesity, and non-communicable diseases. Conversely, exposure to environmental hazards such as air pollution, noise, and heat stress is strongly associated with mortality and the urban burden of disease. Recent research has also expanded to include cognitive health, child development, healthy ageing, and the mediating roles of perceptual and social factors. Despite these advances, important knowledge gaps remain regarding spatial health equity, the evaluation of urban design interventions, and empirical evidence from low- and middle-income countries. Based on this synthesis, the study proposes a multi-level analytical framework linking urban spatial structure and design, environmental exposures and behavioural pathways, perceptual and social mediators, and multidimensional health outcomes. The framework provides a conceptual basis for systematically integrating health considerations into urban policy, planning, and design.

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INTRODUCTION

Health is widely recognised as a fundamental indicator of societal development and a basic human right. Yet it is not produced solely within healthcare systems. Rather, it is continuously shaped through everyday life in urban settings and through people's interactions with the built environment (Mirgholami et al., 2017). Over recent decades, rapid urbanisation, changing patterns of daily activity, sedentary lifestyles, unhealthy diets and chronic exposure to stress have contributed to a substantial rise in non-communicable diseases. Conditions such as obesity, type 2 diabetes, cardiovascular diseases and mental disorders now account for the majority of global mortality and disability (Helia Sareminia et al., 2023). Within this context, urban planning, design and governance are increasingly recognised as strategic determinants of population health. Cities can be understood as complex socio-spatial systems in which environmental, social and behavioural factors interact across multiple scales. Urban areas simultaneously concentrate environmental risks while also providing opportunities for prevention and health promotion (Barton, 2005; Giles-Corti et al., 2016). This perspective has important historical roots in planning theory. Early models such as Howard's Garden City and Perry's neighbourhood unit were grounded in the assumption that spatial form, land-use organisation and access to green and public spaces can influence residents' wellbeing and health outcomes (Howard, 1902; Perry, 1929). During the past two decades, these ideas have gained substantial empirical support. A growing body of primary studies, systematic reviews and meta-analyses demonstrates consistent associations between urban morphology, walkability, transport systems, green and blue infrastructure, public space design and environmental stressors—including air pollution, noise and heat—and multiple dimensions of physical, mental, social and cognitive health (Twohig-Bennett and Jones, 2018; Yang et al., 2018; Mouratidis, 2021; Xian et al., 2024). Despite this expanding evidence base, the literature on cities and health remains partially fragmented. Several thematic clusters have emerged within the field. One major stream focuses on the relationship between built-form characteristics, physical activity and obesity (Ferdinand et al., 2012; Tcymbal et al., 2020). A second cluster examines the role of green and blue spaces in shaping mental health and subjective wellbeing (James et al., 2015; Gascon et al., 2015; Browning et al., 2022). A

third strand investigates the health impacts of environmental exposures such as air pollution and noise (Dockery et al., 1993; Katsouyanni et al., 1997; Muonde et al., 2024). Another body of research analyses the role of public spaces in fostering social interaction, social capital and social health (Mehta, 2014; Qi et al., 2024). In recent years, additional domains have gained prominence. Research on transport safety highlights the health burden associated with traffic injuries and emphasises the importance of pedestrian- and cycling-oriented urban design. Studies on urban heat islands document increasing health risks linked to extreme heat events and climate change. Parallel work on climate resilience and environmental justice emphasises how vulnerabilities to environmental exposures are unevenly distributed across urban populations. Consequently, the concept of health equity has become central to contemporary urban health research, drawing attention to spatial inequalities in environmental conditions and health outcomes. At a broader conceptual level, several frameworks have sought to organise the relationship between cities and health. These include the Healthy Cities movement, liveability frameworks and models based on the social determinants of health (Ashton et al., 1986; Kent and Thompson, 2012; Pineo, 2020; Yang et al., 2018). While these paradigms provide important conceptual foundations, their translation into operational indicators that can directly inform urban planning and design practice remains uneven. A further challenge concerns the measurement of both urban conditions and health outcomes. Earlier studies often relied on relatively simple indicators, such as green space per capita or distance to the nearest park. More recent research conceptualises cities as multi-level systems and employs integrated indicators capturing urban morphology, accessibility patterns, spatial configuration of green and blue spaces, perceived environmental quality, environmental exposures, behavioural mediators and a broad range of physical, mental, social and cognitive health outcomes (Giles-Corti et al., 2016; Markevych et al., 2017; Yang et al., 2018; Ruszanov et al., 2023). However, existing studies rarely synthesise these heterogeneous indicators within a coherent analytical structure. In particular, few reviews simultaneously reconstruct the historical evolution of the field, map the thematic architecture of environmental exposures and health outcomes, and systematise the indicators used to measure urban conditions and health within a uni-

fied causal framework linking urban design, environmental exposure, behavioural and perceptual mediators and multidimensional health outcomes. The geography of knowledge production further reflects significant imbalances. Most empirical evidence derives from cities in Europe, North America and Australia, while urban areas in low- and middle-income countries remain underrepresented. This gap is notable given that many of these cities face rapid urbanisation, pronounced spatial inequalities, limited access to public and green spaces and high vulnerability to environmental and social risks (Shen, 2024; Andalib *et al.*, 2024). Within the Persian-language literature, a growing number of studies have examined relationships between neighbourhood environmental quality, green and public spaces, urban form and indicators of physical, mental and social health (Abrun *et al.*, 2018; Hakimian, 2015, 2016; Enayati *et al.*, 2021; Mahdi, 2020; Hosseini Mand *et al.*, 2021; Sarvar *et al.*, 2025; Shahvaran and Asadpour, 2024). Nevertheless, systematic syntheses that situate this body of work within the broader international literature remain limited. Against this background, the present study addresses a specific analytical gap in the literature. Rather than proposing an entirely new normative framework, the study advances the field by integrating diverse strands of research into a structured, multi-level analytical synthesis. It combines three complementary perspectives: the historical evolution of the field, the thematic clustering of environmental exposures and health outcomes, and the systematic organisation of variables and indicators within a causal chain linking urban form, environmental exposure, behavioural and social mediators, and multidimensional health outcomes. Based on a systematic review covering the period from 1984 to 2025, this article pursues three interrelated objectives. First, it reconstructs the historical trajectory of research on cities and health by identifying analytically meaningful phases in the development of the field. Second, it classifies the evidence into coherent thematic clusters defined by types of urban environmental exposure and categories of health outcome. Third, it extracts and organises the indicators used to measure urban conditions and health within a structured multi-level framework. The resulting framework provides an evidence-informed basis for integrating health considerations into urban policy, planning and design. It also contributes to bridging the gap between research and practice by offering a clearer analytical

structure for understanding causal pathways between urban environments and health outcomes. Finally, by incorporating evidence from both international and Persian-language studies, the framework supports the development of context-sensitive approaches to health-oriented urban planning in Iranian cities and other urban contexts in the Global South.

METHODOLOGY

Review design

This study employs a systematic review methodology to synthesize the expanding body of knowledge on the relationship between urban environments and health outcomes. The review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and MetaAnalyses) guidelines to ensure transparency, replicability, and procedural clarity. The review process followed four sequential stages consistent with PRISMA: Identification, Screening, Eligibility, and Inclusion.

Search strategy

A structured and comprehensive literature search was conducted primarily in Scopus and Web of Science as the principal indexed databases. To broaden the scope and capture regionally published research, Google Scholar and national databases (SID, Magiran, Civilica, and ISC) were used as supplementary sources. This multi-database strategy was designed to ensure both international coverage and contextual relevance. The review included studies published between 1984 and 2025, allowing the analysis to encompass early conceptual discussions as well as contemporary empirical developments in health-oriented urban planning and design. Search queries were developed using bilingual keyword combinations (English and Persian) combined with Boolean operators. Searches were performed within titles, abstracts, and keywords. A representative search string was structured as follows: ("Healthy City" OR "Urban Health") AND ("Built Environment" OR "Urban Design" OR "Walkability") AND ("Physical Health" OR "Mental Health" OR "Well-being"). Database-specific syntax adjustments were applied where necessary. Only publications in English and Persian were considered.

Inclusion and exclusion criteria

Explicit inclusion and exclusion criteria were defined to ensure analytical coherence and relevance.

Studies were included if they:

- *Were peer-reviewed journal articles, selected policy reports, or reputable conference papers;*
- *Examined the relationship between urban spatial characteristics and health outcomes;*
- *Reported measurable or clearly defined health indicators;*
- *Addressed planning, design, or built environment dimensions;*
- *Were published between 1984 and 2025.*

Studies were excluded if they:

- *Focused solely on clinical or biomedical health topics without spatial or environmental context;*
- *Did not include identifiable environmental exposure variables;*
- *Lacked explicit linkage between urban factors and health outcomes;*
- *Were editorials, commentaries, or non-academic publications;*
- *Were duplicate records.*

Study selection process

The identification stage yielded 640 records across all selected databases. After removing 110 duplicate records, 530 titles and abstracts were screened for relevance to the research objectives. Following the initial screening, 320 full-text articles were retrieved and assessed for eligibility. During this stage, 59 studies were excluded due to insufficient methodological clarity, weak linkage between environmental exposure and health indicators, or lack of relevance to urban planning and design dimensions. Ultimately, 261 studies met the inclusion criteria and were included in the final analysis. The complete study selection procedure, including numerical transitions across the four PRISMA stages (Identification, Screening, Eligibility, and Inclusion), is presented in [Fig. 1](#).

Data extraction

For each included study, structured data extraction was conducted. The following information was systematically recorded: publication year, geographical context, type of urban environmental exposure, research design and methodological approach, health outcome indicators, and key findings. This extraction framework enabled comparative synthesis across temporal, thematic, and methodologi-

cal dimensions, forming the basis for the analytical categorization of the literature.

Data synthesis and analytical framework

The selected studies were coded and categorized along three principal analytical dimensions: temporal evolution of research trends, type of urban environmental exposure, and category of health outcome. Urban environmental exposures were grouped into major domains, including green and blue infrastructure, urban morphology and density patterns, transportation systems and mobility structures, and environmental risks such as heat stress and air pollution. Health outcomes were classified into physical health, mental health, social well-being, and cognitive dimensions. A qualitative thematic synthesis approach was employed to identify recurring patterns and interpret the pathways linking spatial conditions to health outcomes. Particular attention was given to mediating mechanisms such as physical activity, social interaction, and perceptual experience that translate spatial characteristics into measurable health effects. Additionally, existing systematic and umbrella reviews were examined to identify converging findings and remaining research gaps within the field. This integrative analytical process resulted in the development of a multi-level framework illustrating the relationships between urban design, environmental exposure, behavioral responses, and multidimensional health outcomes, as presented in [Fig. 2](#).

RESULTS AND DISCUSSION

Temporal evolution of research on urban environments and health

The temporal framework was developed to examine changes in research output over time. Publications were grouped into five consecutive periods based on the chronological distribution of studies in the dataset and observable shifts in publication frequency across the study period. This classification enables a consistent comparison of research activity across different phases of development in the field. As summarized in [Table 1](#), the temporal evolution of the literature reveals a clear acceleration in research activity over time. Between 1984 and 1999, 30 studies were identified, representing 11.5% of the total sample, and primarily explored general relationships between urban environments and health, particularly environmental pollution and access to natural

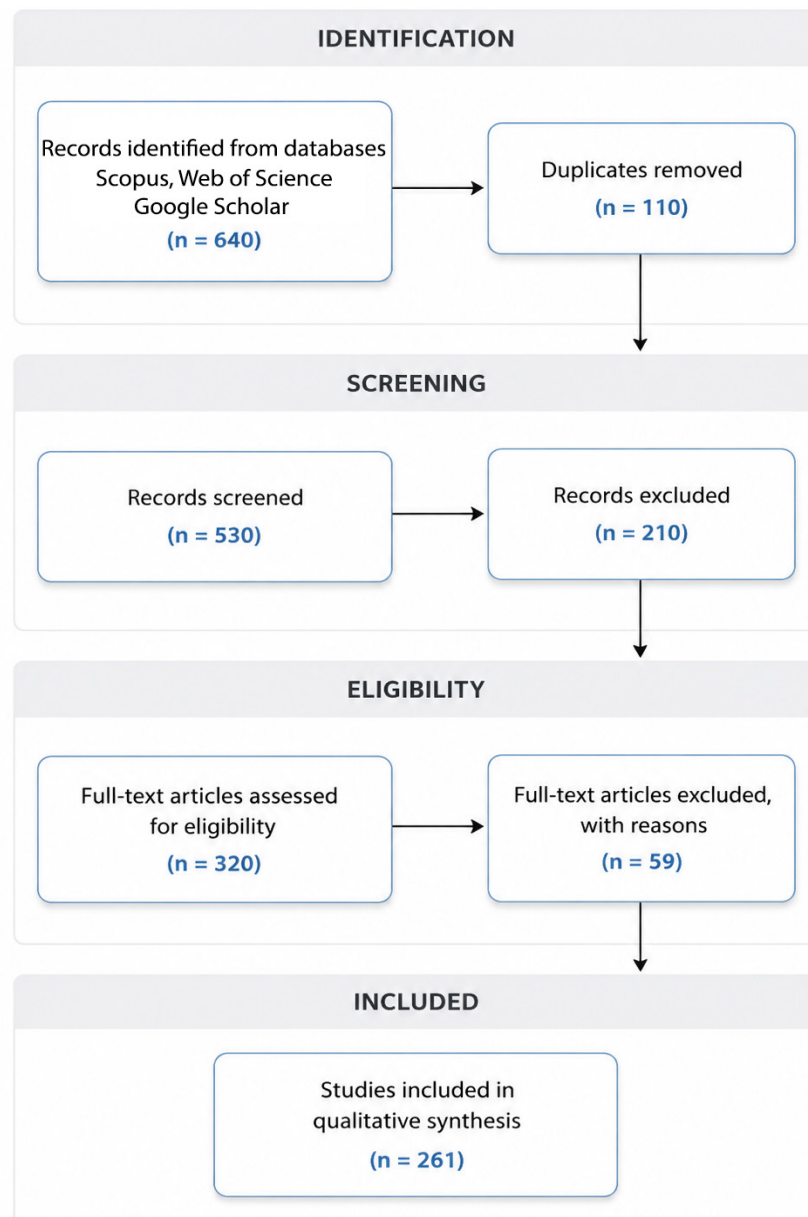


Fig. 1: PRISMA flow diagram of the systematic literature search and study selection process.

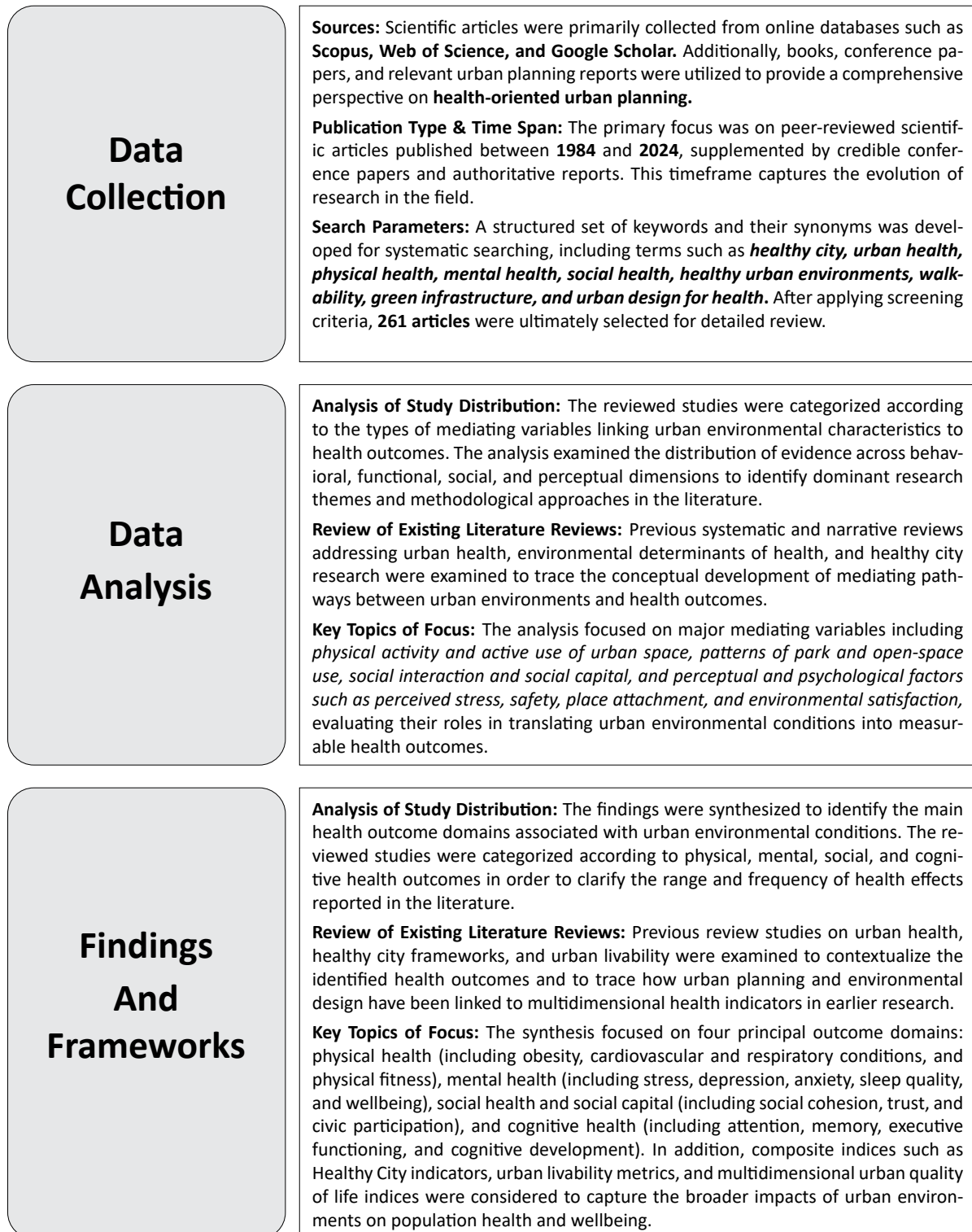


Fig. 2: Research process and analytical framework

Table 1: Five-period temporal framework for the development of research on urban environments and health (1984–2025)

Time period (AD)	Number of studies	General research characteristics	Percentage of total sample
1984–1999	30	Foundational phase of the “healthy city” agenda and uncovering the links between nature, pollution, and health	11.5%
2000–2009	6	Transitional phase from urban hygiene to health-oriented urban planning and design	2.3%
2010–2015	25	Phase of systematisation of the built environment and health research (onset of the wave of reviews and conceptual frameworks)	9.6%
2016–2019	60	Phase of empirical maturation and expansion of systematic reviews, meta-analyses, and the emergence of spatial health equity debates	23.0%
2020–2025	140	Phase of evidence expansion and consolidation of comprehensive frameworks for health-oriented urban planning and design (with emphasis on quality, smart cities, and pandemics)	53.6%
Total	261		100%

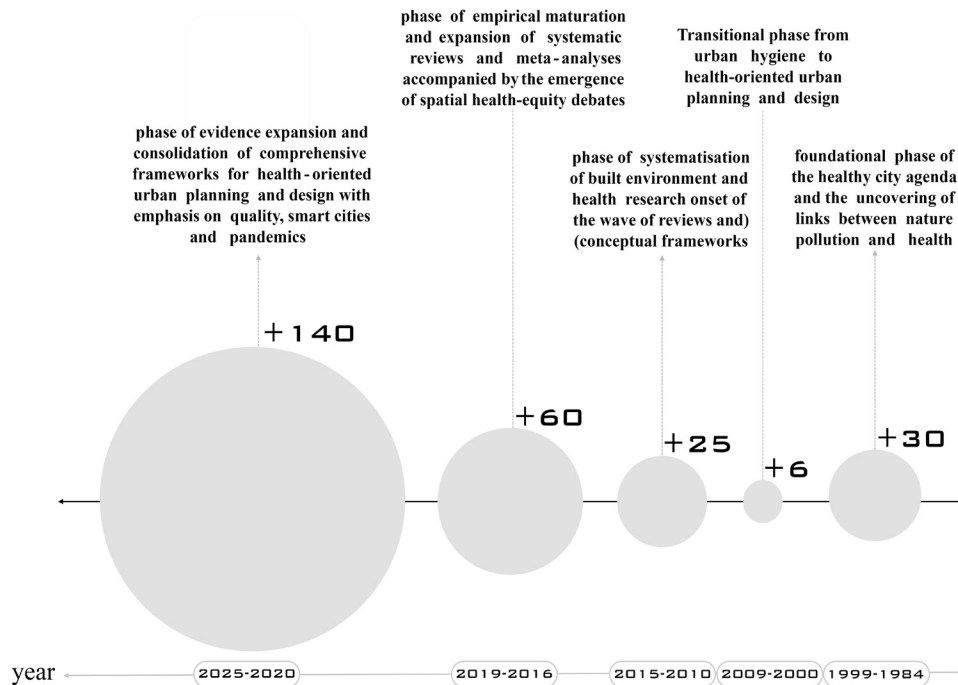
elements. Between 2000 and 2009, only six studies were identified (2.3%), reflecting the transitional stage of research on the built environment-health relationship, which had not yet consolidated as a distinct research stream within urban planning scholarship. This pattern may also be partly associated with the gradual expansion of journal indexing in major international citation databases during the early 2000s. Furthermore, the strict inclusion criteria applied in this review—particularly the requirement that studies explicitly link urban design variables with measurable health outcomes—reduced the number of eligible studies during this period. Research output increased between 2010 and 2015, with 25 studies published (9.6% of the total sample). Studies in this period more frequently examined measurable associations between built environment characteristics and specific health indicators. Between 2016 and 2019, the number of publications increased to 60 studies (23.0% of the total sample). Quantitative methods, spatial analysis techniques, and systematic review approaches were applied more frequently to assess associations between urban environmental characteristics

and health outcomes such as physical activity, noncommunicable diseases, mental health indicators, and quality of life. The highest concentration of publications occurred between 2020 and 2025, with 140 studies identified (53.6% of the total sample). More than half of all included studies were published during this period. Research topics during these years increasingly addressed health equity, distribution of environmental resources, urban resilience, smart city initiatives, environmental quality, and health implications associated with pandemics.

Fig. 3 further illustrates this temporal trajectory and shows that 200 of the 261 studies, equivalent to 76.6% of the sample, were published after 2015. This pattern confirms that research on urban environments and health has expanded markedly in recent years, shifting from exploratory environmental-health observations toward more integrated and evidence-based frameworks for health-oriented urban planning and design.

Topical classification of studies on urban environmental exposures and health outcomes

To examine the distribution of evidence within the



Evolution of health-oriented urban design research: A temporal analysis of urban and health studies, 1984–2025

Fig. 3: Temporal distribution of included studies examining the relationship between urban environments and health (1984–2025).

reviewed literature, the 261 included studies were classified into seven thematic domains based on the primary type of urban environmental exposure and the associated health outcomes investigated. Each study was assigned to the domain that most closely reflected its central research focus. This classification provides a structured overview of how research on health-oriented urban planning and design is distributed across different dimensions of the built and natural environment and their related health outcomes. As presented in Table 2, the thematic distribution of the reviewed studies indicates a strong concentration of evidence in two dominant domains. Studies on green spaces, open spaces, and the urban landscape constitute the largest cluster ($n=110$), reflecting substantial empirical attention to the relationships between exposure to urban nature and outcomes such as psychological restoration, stress reduction, and overall well-being. The second major cluster concerns the built environment, urban form, and walkability ($n=55$), highlighting the importance of urban morphology, street network configuration, and spatial design characteristics in shaping physical activity patterns and

noncommunicable disease outcomes. Together, these two domains account for the majority of the reviewed literature and underscore the central role of both natural and built urban environments in influencing health. Two mid-sized domains—healthy cities and policy frameworks ($n=30$) and public and collective spaces ($n=30$)—provide an important conceptual and social complement to the physical environment literature. Studies in these domains emphasise policy-oriented determinants of health, the role of governance and planning frameworks, and the importance of everyday public environments in supporting social cohesion, place attachment, and social health. Although numerically smaller, the domains of environmental quality and environmental risks ($n=14$) and leisure and recreational environments ($n=14$) contribute important insights into direct environmental exposures, such as air pollution, noise, and heat, as well as lifestyle-related factors associated with recreational settings and subjective well-being. Finally, the foundational conceptual literature ($n=8$) provides the theoretical basis required to interpret the diverse health outcomes identified across the seven thematic domains.

Table 2: Thematic classification of studies by type of urban environmental exposure and health outcomes

Thematic domain of studies	Brief description of the domain	Number of studies
Green spaces, open spaces and urban landscape, and health outcomes	This domain includes studies examining the role of parks, green spaces, green-blue infrastructure, urban forests, and landscape quality in shaping health outcomes. Commonly investigated outcomes include physical and mental health, quality of life, subjective wellbeing, psychological restoration, stress reduction, decreased depressive symptoms, and increased vitality among residents. The domain also includes several large-scale systematic reviews and metaanalyses assessing the relationship between exposure to green and blue spaces and a wide range of health outcomes at the global level.	110
Built environment, urban form, walkability, transport and physical characteristics of the built environment and health	This domain comprises studies focusing on the structural and physical characteristics of the built environment, including urban form, street networks, density, landuse mix, walkability indicators, pedestrian routes, subcentre design, and urban morphology. These studies investigate how such characteristics are associated with physical activity, obesity, noncommunicable diseases, general health, and mental health outcomes. Systematic reviews and metaanalyses addressing relationships between the built environment and physical activity are also included in this category.	55
Healthy cities, urban health, conceptual and policy frameworks, and indicators of health and quality of life	This domain includes literature addressing conceptual and policy frameworks related to healthy cities and urban health. Topics covered include urban liveability, the right to urban health, health equity, social determinants of health, and the integration of health considerations into urban planning and development strategies. The category also includes studies examining international initiatives, policy frameworks, and broader conceptual discussions of the relationship between urban environments and population health.	30
Public and collective spaces, urban hangouts, markets and streets, social interactions, social capital and place attachment	This domain encompasses studies focusing on public spaces such as squares, streets, pedestrian corridors, markets, bazaars, urban gathering spaces, and cultural or recreational complexes. These studies examine outcomes related to social interaction, social cohesion, social capital, social trust, sense of belonging, place attachment, urban vitality, place meaning, and intergroup cohesion. A substantial portion of the Iranian literature on public space, together with several international studies assessing the quality and performance of public environments, is included within this category.	30
Environmental quality, air pollution, noise pollution, environmental risks, and physical and mental health outcomes	This domain comprises studies investigating environmental exposures within urban settings, including ambient air pollution, environmental and traffic noise, urban heat, and other environmental risks. These studies examine their associations with mortality, cardiovascular and respiratory diseases, blood pressure, sleep disorders, stress, and other physical and mental health outcomes. Both classic epidemiological studies on air pollution and more recent research on urban soundscapes are represented within this category.	14

Thematic domain of studies	Brief description of the domain	Number of studies
Leisure, recreational spaces, tourism facilities, recreational sports, and health and well-being	This domain focuses on urban leisure and recreational environments, including amusement and recreational parks, tourism facilities, cultural complexes, recreational sports spaces, and temporary urban programmes such as carfree events. Research in this category often examines outcomes such as mental health, happiness, vitality, life satisfaction, subjective wellbeing, social cohesion, and local social development.	14
Theoretical and foundational literature on mental health, social health, and broader supporting texts on health	This category includes theoretical and conceptual references related to mental health, social health, happiness, and wellbeing that provide the conceptual foundation for interpreting health outcomes in the context of healthoriented urban planning and design. Although these works do not directly analyse urban environmental exposures, they contribute to the theoretical framing of health dimensions used in the review.	8
Total		261

Overall, the thematic classification presented in [Table 2](#) highlights both the dominant lines of inquiry within the field and the relatively limited number of studies addressing environmental risks and leisure environments. This distribution not only clarifies the balance of current evidence across thematic areas, but also establishes the analytical structure for the subsequent sections, where specific environmental indicators, exposure pathways, and health outcomes are examined in greater detail.

The distribution of studies indicates a strong concentration of research in two primary domains. Studies on green spaces, open spaces, and the urban landscape constitute the largest cluster (n=110), reflecting substantial empirical attention to the relationships between exposure to urban nature and outcomes such as psychological restoration, stress reduction, and overall wellbeing. The second major cluster concerns the built environment, urban form, and walkability (n=55), highlighting the importance of urban morphology, streetnetwork configuration, and spatial design characteristics in shaping physical activity patterns and noncommunicable disease outcomes.

Variables and indicators for assessing the urban environment and health in the research literature

Research on the relationship between cities and health has moved beyond simple indicators such as per capita green space or Euclidean distance to the nearest park. Contemporary studies increasingly conceptualise the urban environment as a multi-dimensional

system and assess it through a combination of morphological, spatial, environmental, perceptual, and behavioural indicators linked to diverse health outcomes ([GilesCorti et al., 2016](#); [Yang et al., 2018](#); [Pineo, 2020](#)). These variables are measured at different spatial scales. At the macro scale, research commonly examines urban form, street-network configuration, land-use patterns, density, and neighbourhood structure. At the micro scale, studies focus on streetscape attributes, street furniture, visual quality, and fine-grained environmental characteristics. In parallel, many studies assess direct environmental exposures such as air pollution, noise, and heat, as well as perceived environmental quality, place experience, and patterns of social interaction ([Ruszanov et al., 2023](#); [Helia Sareminia et al., 2023](#)). Together, these variables form an integrated analytical framework linking characteristics of the urban environment to multiple dimensions of human health. In the literature, these relationships are typically conceptualised as a causal chain connecting environmental conditions, intermediate behavioural and social processes, and health outcomes. The indicators discussed in the following subsections are therefore organised according to their position within this environment–exposure–behaviour–health pathway, encompassing physical, mental, social, and cognitive health outcomes among urban residents.

Physical and morphological indicators of the urban environment

At the first analytical layer, the physical form and

spatial structure of cities are operationalised through a range of morphological indicators. Commonly applied variables include net and gross residential density, building density, site coverage ratio, floor area ratio, average building height, intersection density, urban grain and block size, as well as ratios such as street length relative to parcel or census unit area. Additional indicators frequently used in empirical studies include block radius, compactness, and measures of street network connectivity and spatial integration. These variables constitute the core measurement framework in research examining walkability, health-oriented urban form, and the design of active urban environments (Sallis *et al.*, 2016; Smith *et al.*, 2017; Barnett *et al.*, 2017; Fathi *et al.*, 2020; Tcymbal *et al.*, 2020; Abusaada & Elshater, 2024; Mouratidis, 2021; Andalib *et al.*, 2024). In addition to these morphological measures, many studies analyse the functional and spatial composition of neighbourhoods. Indicators commonly used include land use mix, permeability of the urban fabric, the proportion of pedestrian-oriented versus car-oriented streets, continuity of pedestrian networks, street hierarchy, and spatial legibility. Across diverse geographical contexts—including North American, European, Middle Eastern, and Iranian cities—empirical research has examined the associations between these structural characteristics and outcomes such as walking behaviour, patterns of social interaction, and residents' mental wellbeing (Hakimian, 2016; Hossein Abadi, 2021; Barati *et al.*, 2021; Khasto & Kiaei, 2021; Dehghan, Golkar & Hakimian, 2022; Enayati *et al.*, 2021). A further methodological approach focuses on the configurational properties of street networks. Using space configuration techniques, studies analyse the topology of urban networks through indicators such as centrality, connectivity, relative depth, the length of continuous pedestrian paths, the number of high through movement nodes, and the hierarchical distribution of the network. These metrics are used to explain patterns of movement, spatial utilisation, and the frequency of face-to-face encounters within urban environments (Sheng *et al.*, 2021; Shao *et al.*, 2021). Complementing these spatial configuration measures, field-based studies of streets and public spaces have operationalised the quality of the public realm through microscale urban design indicators. These include street width and cross-section profile, the availability of pause and resting spaces, degree of edge

activation, façade transparency, functional diversity along street frontages, and the intensity of land use mix. Such indicators are widely recognised as fundamental components shaping the physical and social performance of public spaces (Montgomery, 1998; Madani Pour, 1996; Mehta, 2014; Andersson, 2016; Torkaman *et al.*, 2017; Takiehkah *et al.*, 2013).

Indicators of accessibility, configuration, and quantity of green, blue, and public spaces

The second layer of indicators focuses on the spatial architecture and accessibility structure of networks of green, blue, and public spaces. In the literature, spatial accessibility to urban nature has most commonly been operationalised through measures such as Euclidean or network distance to the nearest park or green space, walking or driving time to green areas, and the number of parks located within different service radii. Additional metrics frequently include per capita green space at neighbourhood, district, and city scales, the percentage of green cover within analytical units, and the ratio of green surface to total developable land (Lee & Maheswaran, 2011; WHO, 2016; James *et al.*, 2015; Browning *et al.*, 2022; Banwell *et al.*, 2024; Bressane *et al.*, 2024; Twohig-Bennett & Jones, 2018).

These indicators have been applied in both global comparative studies and context-specific case studies, including research focusing on Iranian cities. With the increasing availability of spatial datasets and remote-sensing imagery, exposure to urban nature has also been operationalised through vegetation and canopy metrics derived from satellite data. Frequently used measures include the Normalized Difference Vegetation Index (NDVI), tree canopy density and height, the proportion of visible greenery within the pedestrian field of view, and the ratio of street trees to street length. These indicators have been widely linked to multiple physical and mental health outcomes across diverse climatic and socioeconomic contexts (Gascon *et al.*, 2015; Fong *et al.*, 2018; Engemann *et al.*, 2019; Ji *et al.*, 2019; Lee *et al.*, 2020; Liu *et al.*, 2023; Xie *et al.*, 2024; Xian *et al.*, 2024). At the scale of parks and urban open spaces, a further set of indicators captures spatial configuration and functional characteristics. These include park area and service radius, patch geometry, compactness or elongation of green patches, and structural diversity within parks, such as combinations of trees, shrubs, lawns, open areas,

hard surfaces, and water elements. Additional indicators describe the number and diversity of facilities—such as playgrounds, running tracks, sports fields, seating areas, cafés, and sanitary facilities—as well as the density and spatial distribution of entrances, the continuity of internal path networks, and their integration with surrounding street networks (McCormack et al., 2010; Kaczynski et al., 2008; McCormack et al., 2014). Comparable indicator frameworks have also been applied in studies of urban parks and recreation systems in Iranian cities, including Hamedan, Gorgan, Tabriz, Birjand, and Borujerd. In these studies, variables such as per capita green space, service radius, continuity of pedestrian paths, number of entrances, lighting conditions, perceived and actual safety, furniture quality, the presence of incompatible land uses, and the spatial distribution of green and blue elements are analysed in relation to user experience and health-related behaviours (Hosseini Mand et al., 2021; Arasteh & Heydarzadeh, 2020; Taheri, Ghasemi Seychani & Shabani, 2021). With respect to blue spaces and green–blue infrastructure, the literature employs indicators such as distance to rivers, canals, lakes, and urban water bodies, the length of accessible waterfronts, the number of pedestrian access points to the water edge, and the quality of spatial connections between blue spaces and the wider openspace network. These indicators are frequently analysed alongside their contributions to microclimate regulation, opportunities for physical activity, and processes of psychological restoration in urban environments (Gascon et al., 2017; Tiegues et al., 2022; Leporelli & Santi, 2019; Orsetti et al., 2022; Barton, 2005).

Indicators of environmental quality, perception, and experience

Quantitative spatial and physical indicators alone cannot fully explain the relationship between urban environments and health without considering environmental quality and lived experience. Consequently, a substantial body of research has developed conceptual and empirical frameworks under the heading of perceived environmental quality. These frameworks encompass dimensions such as spatial legibility and clarity of urban structure, visual coherence and order, spatial and functional diversity, aesthetic quality, perceived safety, thermal and acoustic comfort, cleanliness and maintenance, accessibility for

different population groups, and the perceived vitality and liveability of urban environments (Mouratidis, 2021; Nguyen et al., 2021; RíosRodríguez et al., 2021; Veen et al., 2020; Stangierska et al., 2022). In empirical studies, these attributes are typically measured using multiitem Likertscale questionnaires and analysed as latent constructs representing perceived publicspace quality, perceived greenspace quality, soundscape quality, or overall neighbourhood environmental quality (Nguyen et al., 2021; Stangierska et al., 2022; Zhang, H. et al., 2022; Wu et al., 2024). The theoretical foundations of these constructs can be traced to classic work emphasising environmental legibility, mental image formation, aesthetic preference, and direct experiences of nature in shaping behaviour and psychological wellbeing (Kaplan & Kaplan, 1989; Kaplan, 1995; Hartig et al., 1991; Hartig et al., 2014; Marcus & Francis, 1998; Madani Pour, 1996). Empirical applications of these frameworks appear in studies conducted across diverse geographic contexts, including Northern Europe and Southwest Asia. Research focusing on Iranian cities has operationalised perceived environmental quality through indicators such as visual and landscape quality, spatial and functional diversity, landuse mix and compatibility, perceived safety during day and night, visual pollution, the presence and quality of green and blue elements, lighting conditions, seating provision, the presence of other users, perceived vitality, and the quality of leisure experiences in parks and pedestrian environments (Abrun et al., 2018; Azimi et al., 2020; Akbarian, 2019; Hosseini Mand et al., 2021; Taheri, Ghasemi Seychani & Shabani, 2021; Karimi et al., 2022; Gharavi Roodsari, 2023; Taheri & Taheri, 2019; Abdollahzadeh Fard & Shamseddini, 2020; Ghaffari Gilandeh & Mohammadi, 2023). Within this domain, a specific subset of indicators addresses the restorative potential of urban environments. These include experiences of psychological “being away” from daily pressures, attentional immersion, environmental coherence, compatibility between environmental characteristics and individual preferences, opportunities for solitude, and sensations of freshness and revitalisation. Such indicators have been widely applied in studies of parks, urban forests, blue spaces, and humanoriented streets, where their associations with reduced stress, improved mood, lower mental fatigue, and increased vitality have been demonstrated across different cultural and climatic contexts (Ulrich,

1984; Ulrich *et al.*, 1991; Hartig *et al.*, 1991; Hartig *et al.*, 2014; Patuano, 2020; RíosRodríguez *et al.*, 2021; Wu *et al.*, 2024; Stoltz, 2022; WajchmanŚwitalska *et al.*, 2021; Smyth *et al.*, 2022; Browning *et al.*, 2022).

Indicators of environmental exposure: air pollution, noise, heat, and environmental risks

The urban environmental epidemiology literature has established a standardised set of indicators for quantifying exposure to air pollution, environmental noise, thermal stress, and related urban risks. These indicators form the core measurement layer linking urban environmental conditions to physiological and psychological health outcomes.

Air pollution exposure

In the domain of air pollution, exposure is commonly operationalised using average daily and annual concentrations of fine particulate matter (PM_{2.5} and PM₁₀), nitrogen dioxide (NO₂), ozone (O₃), and other regulated pollutants. Measurements are derived from fixed monitoring stations, interpolated grid cells, landuse regression models, or streetlevel monitoring along transport corridors. These indicators have been extensively applied in crosssectional, timeseries, and longitudinal cohort studies across global urban contexts (Dockery *et al.*, 1992; Dockery *et al.*, 1993; Schwartz & Dockery, 1992; Schwartz, 1993; Pope *et al.*, 1995; Katsouyanni *et al.*, 1997; Yang *et al.*, 2018; Muonde *et al.*, 2024). Analytically, pollutant concentrations are integrated into regression and survival models to estimate associations with allcause and causespecific mortality, as well as cardiovascular and respiratory morbidity. This body of evidence constitutes one of the most methodologically consolidated segments of the urban health literature.

Environmental noise exposure

In the field of environmental noise, exposure is typically quantified using equivalent continuous sound pressure levels (LAeq), as well as timespecific indicators including Lday, Levening, and Lnight. The composite Lden index, representing weighted day–evening–night exposure, is widely used in European and international assessments. These indicators are derived from in situ measurements, acoustic propagation models, and traffic noise mapping (Pulles *et al.*, 1990; Lercher, 1996; Regecová & Kellerová, 1995; Muonde *et al.*, 2024). Empirical studies em-

ploy these metrics to examine associations with hypertension, cardiovascular disease, sleep disturbance, psychological stress, and behavioural problems in children. More recent research has expanded beyond purely quantitative decibel measures by incorporating the concept of the soundscape, which integrates the diversity and quality of sound sources, perceived annoyance, and the presence of natural sounds within urban environments (Gascon *et al.*, 2017; Zarei *et al.*, 2024).

Urban heat and thermal exposure

In relation to urban heat and climate change, exposure is assessed using indicators such as landsurface temperature derived from remote sensing, nearpedestrian air temperature, urban heatisland intensity, and the frequency and duration of heat waves. Composite thermal stress indices, including the Universal Thermal Climate Index (UTCI), are increasingly used to capture physiologically relevant thermal burden (Iungman *et al.*, 2023; Orsetti *et al.*, 2022; Frumkin *et al.*, 2020; Gao, 2024). These indicators are frequently analysed alongside urban morphological and ecological variables, such as vegetation structure, surface permeability, and shading patterns, to assess how spatial configuration moderates thermal exposure in public spaces.

Composite environmentalrisk indices

Within the healthcity and liveability literature, composite environmentalrisk indices have been developed to integrate multiple stressors into single neighbourhood or citylevel indicators. These indices typically combine air pollution, environmental noise, insufficient greenery, excessive density, service deficits, traffic unsafety, and related environmental burdens. Applications of such composite metrics are documented in European and Australian cities, as well as in rapidly urbanising regions and Iranian case studies addressing environmental risk and liveability (GilesCorti *et al.*, 2016; Yang *et al.*, 2018; Kruize *et al.*, 2019; Prokofyeva & LebedevaNesevrya, 2018; Esmaeilzadeh Farid *et al.*, 2025; Mahdi, 2020; Zarei *et al.*, 2024; Marques *et al.*, 2020). Together, these exposure indicators represent the environmental component of the causal pathway linking urban form and environmental conditions to behavioural responses, physiological stress, and longterm health outcomes.

Behavioural, functional, and social mediating variables

Between environmental exposures and health outcomes lies a range of behavioural, functional, and social mediating variables that play a critical role in explaining causal pathways between urban environments and health. In empirical models of urban health, these mediators capture the behavioural responses, patterns of social interaction, and subjective experiences through which environmental conditions influence physical and psychological outcomes.

Behavioural activity indicators

The most widely examined behavioural mediators relate to physical activity and active use of urban space. These constructs are commonly operationalised through indicators such as weekly minutes of Moderate to Vigorous Physical Activity (MVPA), daily step counts, duration of walking for transport and leisure, frequency of park and trail use, participation in recreational sports, and patterns of using streets and public spaces for physical activity (Ferdinand et al., 2012; Sallis et al., 2016; Smith et al., 2017; Tcymbal et al., 2020; Barnett et al., 2017; Wang et al., 2019; McCormack et al., 2014; Grigoletto et al., 2021; Kostrzewska, 2017; Cilliers & Ledwoń, 2024; Hartley et al., 2020). These indicators have been employed both in large international cohort studies and in more localised research conducted in Iranian cities. Such studies examine behaviours including daily walking, bicycle use, participation in park-based sports, and engagement with “health trails” as mediating mechanisms linking urban form and environmental characteristics to health outcomes (Hakimian, 2016; Khasto & Kiaei, 2021; Barati et al., 2021).

Activity patterns within parks and public spaces

Research focusing on parks and urban open spaces has also examined behavioural patterns occurring within specific settings. Indicators frequently include the type of activity performed (such as walking, running, playing, sitting, or observing), duration of stay, movement patterns within the space, and the age and gender composition of users. These variables provide insight into how spatial attributes influence patterns of space use and, in turn, affect both physical activity levels and psychological wellbeing (McCormack et al., 2010; Sheng et al., 2021).

Social interaction and community processes

At the social level, mediating variables capture patterns of interaction and the structure of social networks embedded in everyday urban life. Indicators in this domain include the frequency and quality of face-to-face contacts, the number and diversity of everyday social interactions, participation in community events and collective activities, the breadth and strength of informal local networks, perceived social support, sense of community belonging, and engagement in civic networks (Mehta, 2014; Qi et al., 2024; Setiawan & Ningtyas, 2023; Purnomo, 2022; Andersson, 2016; OluOwolabi et al., 2023). These constructs are widely operationalised under conceptual frameworks such as social capital, social cohesion, social trust, civic participation, and perceived social security. Empirical studies in both international contexts and Iranian cities have investigated how the structure and quality of urban spaces, access to public spaces, and the density of opportunities for interaction influence these social processes (Sam Aram, 2009; Vesali et al., 2016; Abbasi et al., 2018; Sami et al., 2025; Alizadeh et al., 2022; Sarvar et al., 2025).

Perceptual and psychological mediators

A further group of mediators relates to perceptual and psychological processes through which individuals interpret and experience their environment. Commonly examined constructs include perceived stress, feelings of crowding and environmental pressure, perceived control over everyday life, place attachment, neighbourhood belonging, place meaning and identity, residential satisfaction, and perceived spatial justice (Hartig et al., 2014; Markevych et al., 2017; RíosRodríguez et al., 2021; Pykett et al., 2020; Nguyen et al., 2021; Wu et al., 2024; Menezes & Smaniotto Costa, 2024; Zhang, H. et al., 2022). These constructs have been applied across diverse urban contexts, including studies of mental health in Iranian cities. In such research, variables such as place attachment and dependence, neighbourhood satisfaction, sense of belonging, perceived vitality, quality of everyday presence, and perceived neighbourhood quality are analysed as mediating mechanisms linking urban design characteristics to psychological wellbeing (Mirgholami et al., 2017; Hakimian, 2019; Shahabi Shahmiri & Khatami, 2020; Khatami & Shahabi Shahmiri, 2021; Zeynali Azim et al., 2024; Nasiri, 2023; Dehghan, Golkar & Hakimian, 2022).

Indicators of physical, mental, social, and cognitive health outcomes

At the outcome layer, the city–health literature encompasses a wide spectrum of health indicators that can be broadly grouped into four domains: physical, mental, social, and cognitive health. These indicators represent the endpoint of the causal chain linking urban environmental characteristics, environmental exposures, behavioural responses, and social processes to measurable health outcomes.

Physical health outcomes

In the physical health domain, commonly examined variables include body mass index (BMI), prevalence of overweight and obesity, systolic and diastolic blood pressure, diabetes and other components of metabolic syndrome, and the prevalence or incidence of cardiovascular and respiratory diseases. Childhood asthma has also been frequently analysed in relation to urban environmental conditions. At the most aggregate level, studies have examined all-cause and cause-specific mortality, particularly cardiovascular and respiratory mortality, in relation to environmental exposures and urban form characteristics across different regions of the world (Ferdinand *et al.*, 2012; Barnett *et al.*, 2017; Hartley *et al.*, 2020; TwohigBennett & Jones, 2018; Yang *et al.*, 2018; Wies *et al.*, 2024; Muonde *et al.*, 2024; Helia Sareminia *et al.*, 2023). Several studies have also synthesised these variables into composite indices capturing the risk of noncommunicable diseases within urban populations (Mogo *et al.*, 2022; Abusaada & Elshater, 2024).

Mental health outcomes

Within the mental health domain, commonly examined outcomes include overall mental health scores, depressive symptoms, anxiety, perceived stress, psychosomatic complaints, sleep quality, life satisfaction, subjective wellbeing, and happiness. These outcomes are frequently analysed in relation to access to green spaces, exposure to environmental stressors, and the quality of urban environments (Gong *et al.*, 2016; Moore *et al.*, 2018; Hartig *et al.*, 2014; Fong *et al.*, 2018; Vanaken & Danckaerts, 2018; LečićToševski, 2019; Browning *et al.*, 2022; Liu *et al.*, 2023; Hu *et al.*, 2025; Xu *et al.*, 2025; Xian *et al.*, 2024). Parallel research in Iranian cities has operationalised mental health using standardised questionnaires and psychometric instruments, including depression

and anxiety scales, general health indices, happiness scales, and lifesatisfaction measures. These studies relate mental health outcomes to the characteristics of green spaces, parks, recreational areas, neighbourhood environments, and public spaces (Akbarian, 2019; Abrun *et al.*, 2018; Azimi *et al.*, 2020; Enayati *et al.*, 2021; Gharavi Roodsari, 2023; Hosseini Mand *et al.*, 2021; Taheri, Ghasemi Seychani & Shabani, 2021; Karimi *et al.*, 2022; Ghaffari Gilandeh & Mohammadi, 2023; Shahvaran & Asadpour, 2024).

Social health outcomes

Social health and social capital constitute another key domain of outcome variables. Indicators commonly include perceived social health, social cohesion and solidarity, interpersonal and institutional trust, civic engagement, participation in formal and informal networks, and perceptions of justice and social security (Qi *et al.*, 2024; Setiawan & Ningtyas, 2023; Lee, 2020; OluOwolabi *et al.*, 2023). These constructs are operationalised in both international and Iranian studies examining neighbourhood residents and occupational groups. Empirical research investigates how the structure and quality of urban spaces, access to public spaces, and the density of opportunities for interaction influence levels of social cohesion and collective life (Sam Aram, 2009; Vesali *et al.*, 2016; Abbasi *et al.*, 2018; Sami *et al.*, 2025; Qi *et al.*, 2024; Alizadeh *et al.*, 2022).

Cognitive health outcomes

An expanding segment of the literature focuses on cognitive outcomes associated with urban environmental exposure. Indicators in this domain include attention and concentration, memory performance, executive functioning, children's cognitive development, educational performance, and the risk of cognitive impairment or decline among older adults. These outcomes are commonly analysed in relation to both short-term and long-term exposure to green spaces, neighbourhood environmental quality, and levels of environmental pollution (Engemann *et al.*, 2019; Islam *et al.*, 2020; Buttazzoni *et al.*, 2022; Trott *et al.*, 2025; Wies *et al.*, 2024; Xian *et al.*, 2024; McIntyre *et al.*, 2023; Vanaken & Danckaerts, 2018).

Composite health and liveability indices

At a broader analytical scale, the concepts of urban health and healthy cities are frequently op-

Analytical Framework for Health-Oriented Urban Planning

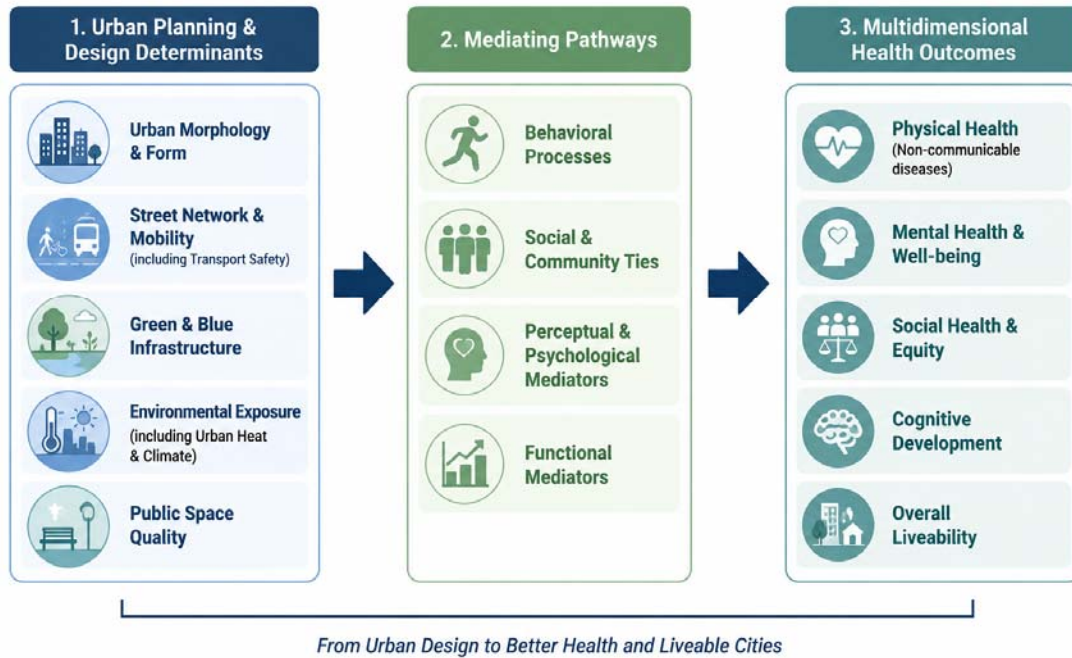


Fig. 4: Conceptual framework of health-oriented urban planning and design

erationalised through composite multidimensional indices that integrate physical, mental, social, environmental, and institutional dimensions. These indices are used to capture broader constructs such as urban liveability, urban quality of life, and overall urban health performance (Ashton *et al.*, 1986; Barton, 2005; Kent & Thompson, 2012; Yang *et al.*, 2018; Mouratidis, 2021; Pineo, 2020; Capolongo *et al.*, 2020; Marques *et al.*, 2020; Cilliers & Ledwoń, 2024). Such frameworks have been applied both in international comparative studies and in research conducted in Iranian cities. In these studies, multidimensional subjective indices of healthy city, neighbourhood liveability, urban health, and quality of life are used to evaluate the health performance of different urban contexts (Rahimi & Pazand, 2017; Ahmadi *et al.*, 2019; Taghipour *et al.*, 2023; Sarvar *et al.*, 2025; Taghizadeh *et al.*, 2025; Hemmati *et al.*, 2024; Esmaeilzadeh Farid *et al.*, 2025). Taken together, this constellation of indicators reflects a clear shift in the literature from onedimensional and purely biomedical measurements towards genuinely multilevel conceptualisations of urban health. In these frameworks, urban form and spatial struc-

ture, environmental quality and lived experience, behavioural responses and social interactions, and subjective perceptions are analysed as successive links in a causal chain connecting urban design, environmental exposure, mediating processes, and multidimensional health outcomes. This integrated perspective underpins the development of health-oriented analytical and intervention frameworks in which urban planning and design are guided not by single variables but by the deliberate combination of environmental, behavioural, social, and multidimensional health indicators.

Fig. 4 presents the conceptual framework derived from the systematic review, synthesizing the core relationships between urban planning and design determinants and multidimensional health outcomes. The framework consolidates the diverse body of evidence into a structured set of strategic domains, clarifying how spatial configurations, environmental qualities, mobility systems, and sociospatial conditions collectively influence human health in urban environments. By articulating the principal pathways linking urban form and planning interventions to physical, mental, and social health outcomes, the

framework provides an integrative analytical structure for interpreting the findings of the review. However, the systematic extraction and coding of the reviewed literature identified a substantially broader range of operational indicators and subcomponents associated with health-oriented urban planning and design. Incorporating all identified elements into the primary framework would compromise visual clarity and reduce the conceptual readability of the model. Therefore, to balance conceptual clarity with methodological transparency, the comprehensive taxonomy of the identified indicators and their detailed classifications is structured into three hierarchical levels, as illustrated in Figs. 5, 6, and 7. Specifically, Fig. 5 delineates the conceptual pathways through which urban environmental indicators influence health outcomes, establishing a logical flow from physical design interventions to physiological and psychological well-being. Together, these figures document the full analytical mapping derived from the reviewed studies and serve as a detailed reference for researchers seeking to operationalize or replicate this framework in future empirical investigations.

CONCLUSION

This systematic review synthesises international evidence on the relationships between characteristics of the urban environment and multiple dimensions of human health. The reviewed literature demonstrates consistent associations between several domains of the urban environment and population health outcomes. Urban green and blue spaces are widely associated with improvements in mental well-being, reductions in stress and depressive symptoms, and lower risks of cardiovascular and respiratory morbidity. Characteristics of the built environment, including residential density, land use mix, street connectivity, walkability, and transport systems, are closely related to patterns of physical activity and to major non-communicable diseases such as obesity and diabetes. A substantial body of epidemiological research also links environmental exposures, particularly air pollution, environmental noise, and urban heat, to mortality, cardiovascular and respiratory conditions, sleep disturbance, and psychological stress. Evidence concerning streets and public spaces further highlights the importance of the public realm in shaping social interaction, social cohesion, and place attachment. Despite these advances, several important gaps re-

main in the current body of knowledge. Many empirical studies rely on relatively coarse spatial indicators, such as density measures, proximity metrics, or per capita provision, while the detailed spatial and design characteristics that structure everyday urban experience are rarely operationalised as measurable variables. Sensory environmental qualities, including sound environments, microclimatic conditions, tactile and olfactory dimensions, and the temporal distribution of shade and sunlight, are also largely absent from prevailing indicator systems. In addition, the differentiated experiences of diverse social groups remain insufficiently examined, with limited attention to women, children, older adults, and people with disabilities. Governance and institutional dimensions, including coordination between sectors, participatory planning processes, and monitoring frameworks for health-oriented urban interventions, are similarly underrepresented in many approaches that assess the relationship between environment and health.

Addressing these limitations requires several directions for future research. First, there is a need to develop measurable indicators that capture detailed spatial and sensory characteristics of urban environments and allow them to be incorporated into quantitative and mixed-method analyses of urban health. Second, future studies should more systematically investigate the experiences and mobility patterns of different population groups through longitudinal research designs, spatial tracking techniques, and integrated qualitative and quantitative approaches. Third, greater attention should be given to underutilised and informal urban spaces, including vacant land and marginal parcels within the urban fabric, as potential opportunities for creating recreational and social environments that support health and well-being. From a planning and design perspective, improving urban health requires moving beyond general correlations between environmental provision and health indicators. Urban planning and design strategies should incorporate detailed spatial qualities, inclusive design principles, and governance mechanisms capable of translating scientific evidence into effective spatial interventions. Strengthening the connections between environmental indicators, spatial design decisions, and measurable health outcomes is therefore essential for advancing health-oriented urban planning and design in diverse urban contexts.

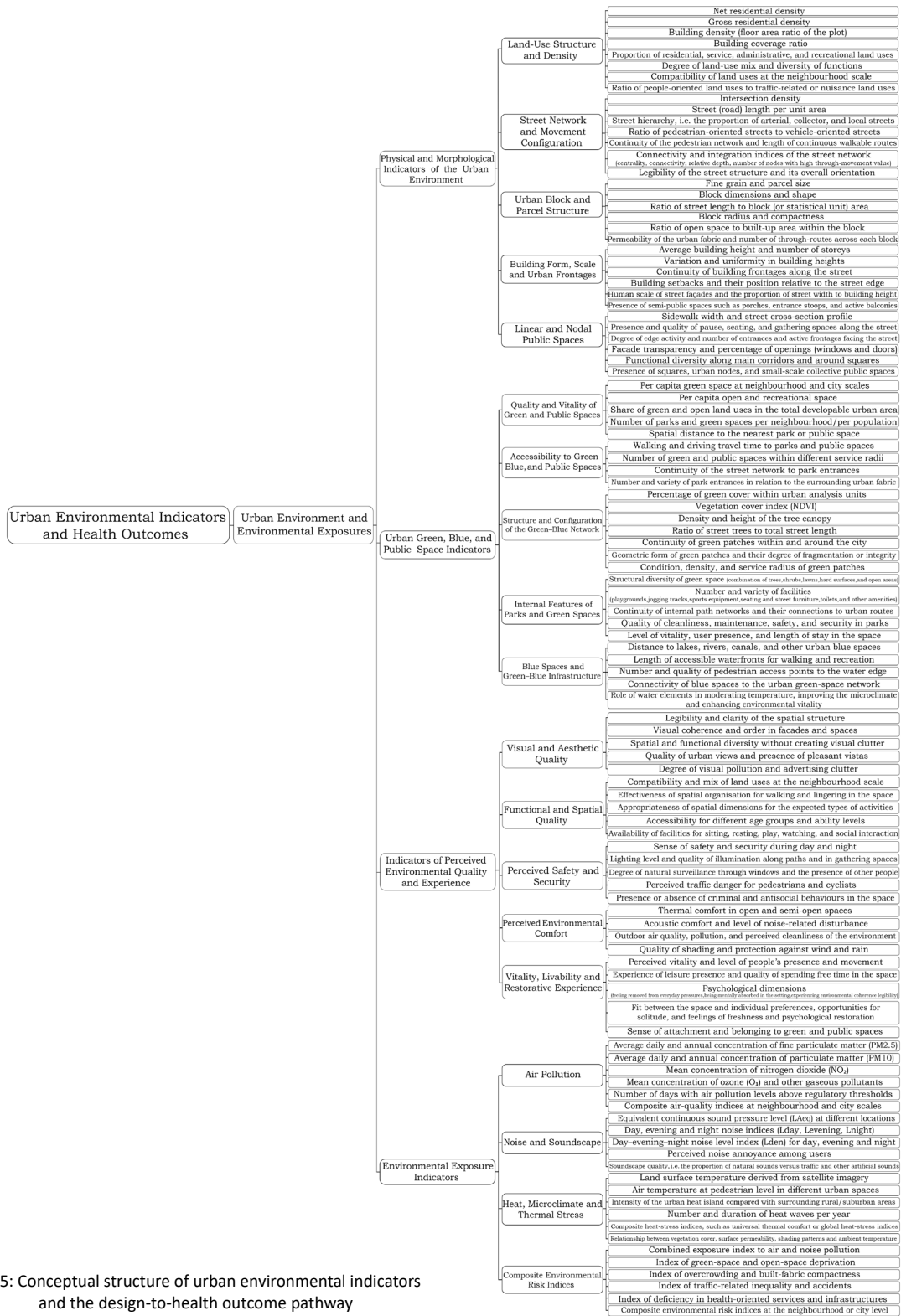


Fig. 5: Conceptual structure of urban environmental indicators and the design-to-health outcome pathway

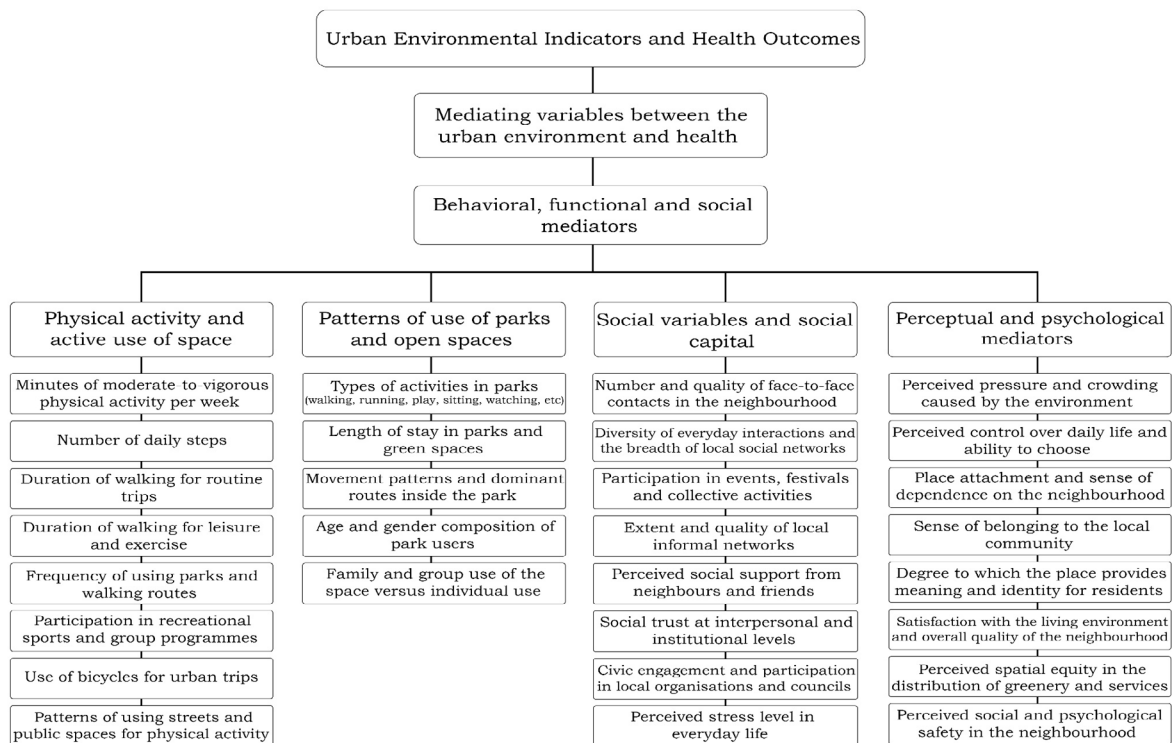


Fig. 6: Taxonomy of behavioral, functional, and social mediators in the urban environment-health nexus.

AUTHOR CONTRIBUTIONS

M. Beyrami had primary responsibility for all core stages of the study, including the conceptualization of the research, development and refinement of the review protocol and search strategy, definition of inclusion and exclusion criteria, systematic screening, data extraction and coding, thematic and comparative synthesis of the evidence, preparation of tables and figures, and drafting as well as substantive revision of the manuscript. A. Molaei provided overall supervision and methodological guidance, contributed to the development and consolidation of the analytical and conceptual framework, helped resolve ambiguities in study selection and interpretation of the evidence, and critically reviewed and edited the manuscript for intellectual rigor and coherence. M. Ayashm contributed to the development of the conceptual framework and positioning of the study within the broader field of health-oriented urban design, assisted in the interpretation and contextualization of the findings, and critically reviewed the manuscript for clarity, consistency, and scholarly quality.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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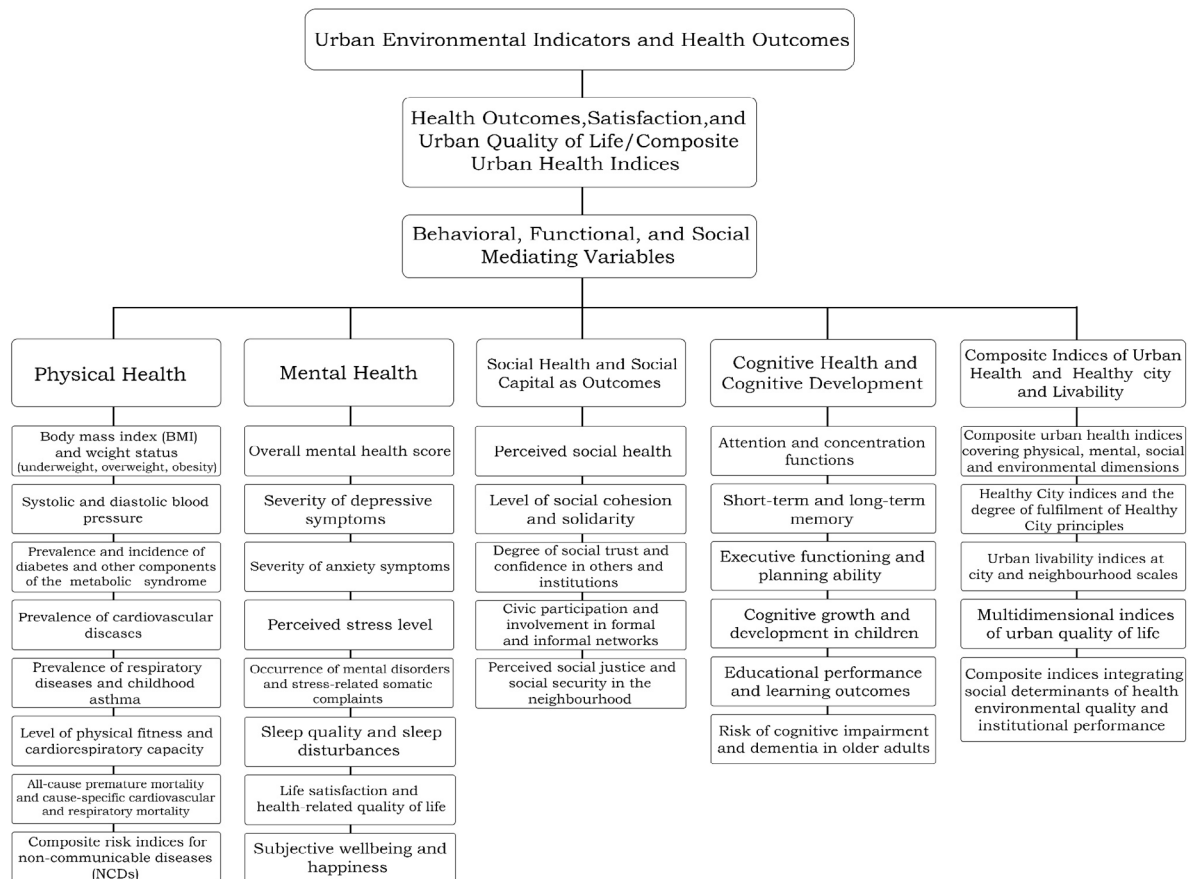


Fig. 7: Taxonomy of health outcomes, urban quality of life, and composite urban health indices

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ABBREVIATIONS

PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
AD	Anno Domini (Gregorian calendar year)
BMI	Body mass index
LAeq	Equivalent continuous A-weighted sound pressure level
Lday	A-weighted long-term average sound level for daytime period
Levening	A-weighted long-term average sound level for evening period

Night	A-weighted long-term average sound level for night-time period
Lden	Day-evening-night noise level indicator
MVPA	Moderate-to-vigorous physical activity
NO ₂	Nitrogen dioxide
O ₃	Ozone
PM _{2.5}	Particulate matter with aerodynamic diameter ≤ 2.5 µm
PM ₁₀	Particulate matter with aerodynamic diameter ≤ 10 µm
UTCI	Universal Thermal Climate Index
NDVI	Normalized Difference Vegetation Index
UTCI	Universal Thermal Climate Index
MVPA	Moderate-to-Vigorous Physical Activity

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