

Child-friendly school commuting: A systematic literature review of frameworks, key determinants, and future directions

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ABSTRACT

A child-friendly commuting environment ensures that children can travel to and from school safely, independently and inclusively. It encompasses infrastructure, transportation systems, policy frameworks and social conditions that support children's mobility while addressing risks such as transportation hazards and social barriers. Despite the growing body of research on this topic, a comprehensive understanding of influencing factors and effective interventions is lacking. To address this aspect, this study conducted a systematic literature review of 58 studies, summarized key findings and research methods, and identified ways to optimize child-friendly commuting. The findings highlight five core dimensions that define child-friendly commuting environments: safety and security, accessibility and equity, child-centered participation, environmental comfort and aesthetics, and social and cultural support, providing a framework for assessment and planning of child-friendly commuting environments. The study further identified key challenges, including socio-economic disparities in commuter safety, limited child participation in urban planning, and the gap between policy and implementation. To address these issues, the study recommends strengthening infrastructure investments, integrating smart transportation solutions, implementing child-inclusive policies, and promoting community engagement. The findings provide actionable insights for policymakers, urban planners, and educators to create safer and more inclusive commuting environments for children.

1. Introduction

1.1. Background

The United Nations launched the Child-Friendly Cities (CFC) initiative in 1996 to support municipalities in promoting children's rights at the local level. The initiative focuses on ensuring children receive a good start in life, grow up healthy and well-cared for, and are protected from violence and abuse. It also promotes opportunities for children to express their views and influence decisions that affect them in their families, communities, and cities (United Nations Children's Fund, 2001).

Since then, the concept of child-friendly city has gained widespread recognition around the world. The initiative has expanded significantly,

reaching over 30 million children across 38 countries (United Nations Children's Fund, 2018). The Child-Friendly Cities Initiative is a universal initiative that envisages policy changes to protect the rights and interests of children in the most comprehensive way. In implementing the initiative, local governments interpret the concept of "child-friendly" according to their own social, cultural, and political contexts, placing emphasis on different categories of children's rights. Many developed and developing countries have promoted the development of child-friendly cities through practical initiatives and by contributing to the academic literature (Bridgman, 2004; Carroll et al., 2015; Corsi, 2002; Nam & Nam, 2018).

Over the past two to three decades, rapid urbanization and industrialization have led children to live in crowded, unsafe, and polluted

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environments, restricting their opportunities for learning, play, and social interaction. The high-density living environment has also led to indoor recreational activities gradually replacing outdoor activities (McKendrick et al., 2000). Urbanization exerts a multifaceted impact on children's commuting experiences and overall wellbeing. Children in urban areas have often outperformed their rural peers in terms of growth and development outcomes as well as access to healthcare, nutrition (Hardy et al., 2024; McDaniel et al., 2023), and education (Miller & Votruba-Drzal, 2013). However, these urban advantages have begun to diminish in the early 2020s, particularly in some high-income Western countries (Mishra et al., 2023). Additionally, various pressures in urban environments, such as traffic congestion, air and noise pollution, and increased social stress, may have negative effects on children's physical and mental health (Cortés-Morales, 2021; Leung & Loo, 2017). Urban construction and transportation development have made children's travel environment unsafe, reducing children's opportunities to move freely, explore nature and make friends with others (Björklid & Nordström, 2007).

Numerous child-related issues remain unresolved and are becoming increasingly urgent. These issues include children as victims of attacks, children as perpetrators, and neglect of children's rights (Ahmad Mus-thafa, 2021). With the increase in car ownership and use, the streets have become busier, resulting in cities that are now unfriendly and unattractive to children (Gill, 2008). In order to protect children from harm in the city, parents often ask children to stay away from play areas (to prevent harm from strangers) and streets (to prevent traffic accidents), but this approach further aggravates children's lack of freedom in urban environments (Tranter & Sharpe, 2008).

Even after measures have been taken, violence against children still occurs frequently in some areas, especially those with lower economic levels and lack of knowledge and education (Noverman et al., 2018). In addition, children have little understanding of child-friendly city policies (Nam & Nam, 2018). Child-friendly city policies often lack support from central and local municipalities (Oh et al., 2015). This is partly due to the fact that policymakers often lack sufficient understanding of children's rights (Ferguson, 2013), medical care requirements (Jeremic et al., 2016) and gender-based social inequalities (Bakar, 2017).

One of the most crucial aspects of children's lives is their school commute, as it directly impacts their daily experiences, development, and overall well-being (Ding & Feng, 2022; Friman et al., 2019; Ross, 2007). Children's satisfaction with their commute to and from school affects their overall life satisfaction (Friman et al., 2019). In child-friendly communities, a well-designed school commuting environment should ensure safety, accessibility, and social interaction opportunities for children. Children's paths to and from school are not only appropriate places for them to socialize, exercise, and develop autonomy, but also opportunities for them to reach out to their surroundings and interact with the outside world (Ross, 2007).

The process of commuting to school is a key element in a child's developmental environment. A child's commute to and from school is more than a transportation or safety issue; it is also an opportunity for children to explore their surroundings, get outdoors, build relationships, and develop independence (Gemmell et al., 2023; Masoumi, 2017; Mitra & Buliung, 2012; Ross, 2000).

1.2. Research aim

Child-Friendly Cities (CFCs) are a global agenda promoted by the United Nations Children's Fund (UNICEF) to safeguard children's rights through urban planning, policy and social collaboration (Liao & Furuya, 2023; Urinboyev et al., 2016). However, rapid urbanization and automobile-dominated transportation patterns are eroding children's ability to travel independently and threatening their physical and mental health (Mitra & Manaugh, 2020). Despite the growth in the number of studies, existing results are fragmented and lack systematic integration. While previous systematic reviews have identified a wide

range of social-ecological factors that influence children's independent mobility, such as age, parental attitudes, neighborhood density, and access to green space (Riazi et al., 2022), they have not specifically addressed the school commuting context. This review aims to fill this research gap by systematically analyzing studies on child-friendly school commuting environments.

The aim of this systematic literature review is to synthesize existing research to develop a comprehensive understanding of child-friendly school commuting environments, and to provide a structured foundation for future empirical research and policy design. To achieve this, the study is divided into three research objectives: 1). to synthesize key concepts and definitions of child-friendly school commuting environments and construct a multidimensional conceptual framework based on thematic analysis; 2). to conduct a comparative analysis of the research methodologies adopted in the selected studies, highlighting their strengths, limitations, and applicability across disciplinary and regional contexts; and 3). to identify existing research gaps and propose future directions for empirical investigation, interdisciplinary collaboration, and evidence-based urban planning and policy development.

1.3. Research significance

This study highlights the significance of examining child-friendly commuting environments in the context of rapid urbanization and increasing motorization. By synthesizing existing research, it identifies the need for an integrative framework that connects children's rights, participation, and sustainable urban development. Such a perspective is essential for addressing fragmented knowledge, guiding future empirical studies, and informing child-centered urban policies. The study therefore contributes to the broader discourse on creating inclusive and equitable urban environments that prioritize children's daily mobility and well-being.

2. Literature review

2.1. Children's school commuting

Children's commuting builds upon early foundational research in children's geographies and independent mobility. For instance, Hillman (1990) first introduced the concept of children's independent mobility and documented its significant decline due to increasing parental concerns and car-dominated urban environments. Subsequent scholars, such as Malone (2001) and Valentine (1997), emphasized that mobility is not merely a means of transportation but a socially constructed and experienced right that reflects children's agency and place-based identities. These early insights remain influential today in shaping contemporary understandings of children's commuting experiences as part of their rights and well-being.

Children who walk or bike to school tend to have high levels of well-being and autonomy, as active commuting allows them to interact with peers, develop spatial awareness, and experience their surroundings in a more engaged way (Leung & Loo, 2017). In contrast, psychological burdens associated with unsafe commuting environments, such as traffic hazards or social exclusion, can further exacerbate children's stress levels (Cortés-Morales, 2021).

2.2. Factors influencing school commuting patterns

The way children travel to school is influenced by urban design, cultural practices, economic conditions and policies (Pont et al., 2013). For example, in Halifax, Canada, over 40 % of children in urban areas walk or cycle to school, while only 5 % of children in rural areas do so, with over 80 % of rural children relying on school buses (Vitale et al., 2019). In the United States, national survey data show that while active commuting has increased, particularly among high school students, low-income and rural families remain highly dependent on school buses due

to longer commuting distances and limited alternative options (Lidbe et al., 2020). In Mexico, two-thirds of school-age children walk to school, particularly in rural and low-income areas, while urban high-income students primarily use motorized transportation (Ortiz-Hernández et al., 2019). In the urban Chinese context, Li and Zhao (2015) found that children from high-income families in Beijing are more likely to rely on private cars and school buses, while low-income groups are more likely to walk or cycle. These findings suggest that school travel patterns cannot be generalized based solely on income level or geographic location, rather, they reflect complex interactions between location, urban form, school siting, public infrastructure, and cultural norms.

In addition, gender also affects school commuting patterns, with girls' independent travel being more restricted in certain cultural contexts (Easton & Ferrari, 2015). The way children travel to school in many cities has been changing over the past few decades. Once, walking and biking were the most common choices for children, but now, more and more families are opting for private cars or school buses (Buliung et al., 2009; McDonald, 2007). There are multiple reasons behind this trend, such as increased traffic congestion, parental safety concerns, and increased commuting distances to school due to urban sprawl (Faulkner et al., 2009; Johansson, 2006; McDonald, 2008).

2.3. Challenges and emerging innovations

Review studies conducted ten years ago (Freeman & Tranter, 2012; Shaw et al., 2013) have further emphasized how these trends intersect with broader issues such as socio-spatial inequality, environmental sustainability, and children's reduced autonomy. These concerns have gained growing attention across disciplines including urban planning, transport studies, and childhood research.

However, some innovations are attempting to reverse this situation, such as "walking school buses" and "bicycle trains" (Agyeman et al., 2023). Parents or volunteers lead groups of children to school on foot or by bicycle, both to ensure safety and to encourage healthy travel habits (Simón-i-Mas & Honey-Rosés, 2024). These attempts show that sound policy guidance can influence the way children commute to school and promote healthier and sustainable choices.

3. Methodology

3.1. Review process based on PRISMA guidelines

A systematic literature review (SLR) is a scientific tool that helps distinguish between established and assumed knowledge by critically appraising, summarizing, and synthesizing large bodies of literature (Petticrew & Roberts, 2008). To address the fragmentation of current research on child-friendly commuting environments, a systematic literature review approach was adopted to synthesize existing findings, identify key trends, reveal potential research gaps, and provide theoretical support for future studies (Petticrew & Roberts, 2008). This study follows the 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses' (PRISMA) guidelines, with literature selected based on pre-defined eligibility criteria, including field of study, topic, research method, language, publication status, database, and publication year.

Research areas covering child-friendly commuting environments include psychology, education, natural sciences, social sciences, architecture, management, and medicine. As the research questions relate to the planning of child-friendly communities in relation to urban planning, traffic management, public policy and children's travel satisfaction, this review focuses on relevant literature from the social sciences and urban planning. These areas are more concerned with the overall situation of children's school commuting environment. Medicine and psychology focus on children's physical health, psychological development, neurocognitive abilities, and psychiatric disorders, so they are beyond the scope of this study.

3.2. Eligibility criteria

Studies eligible for inclusion in this review must meet the following criteria: 1). Databases Searched: Scopus and Web of Science (WoS) were selected for their comprehensive coverage of interdisciplinary peer-reviewed literature; 2). Time Period: Publications from January 2016 to March 2025 were included to capture recent developments in child-friendly commuting studies; 3). Final Search Date: March 04, 2025; 4). Language: Only English-language articles were considered due to consistency and accessibility; 5). Study Types: Empirical studies (both qualitative and quantitative), mixed-methods studies, theoretical papers related to child-friendly commuting. High-quality review articles were included to support the analysis of theoretical evolution and methodological development in the field of child-friendly commuting environments. Narrative reviews, conference abstracts, dissertations, and non-peer-reviewed materials were excluded; 6). Publication Status: Only peer-reviewed journal articles were included to ensure research quality.

The topic of this study is child-friendly school environment. Articles screened for this study had to include "child-friendly", "planning for children", or "children's mobility", as well as "school", "school travel", "school commute" or "school environment" in the title, abstract, or keywords. The specific search rules are in Supplementary file 1.

3.3. Screening process

The screening process followed the PRISMA guidelines. All articles retrieved through the search strategy described in Section 3.1 were imported into Excel software to remove duplicate records. The first author conducted an initial screening of all records based on their titles and abstracts. To enhance reliability, the second author reviewed the screening results. Any discrepancies were resolved through consensus. The inclusion and exclusion criteria were consistently applied during both the screening stage and the full-text review stage.

The final selection of 89 articles was based on reading the full text. Articles were required to report both the research methods and key findings of studies on child-friendly school environments. Of the 89 articles, 58 were eligible for analysis. The specific screening process is shown in Fig. 1.

3.4. Data extraction

The data included in the study were extracted using a standardized template (see Supplementary file 2), which contained the following information: author information, year, country, discipline, research purpose, research methods, key findings, limitations, and future directions. The first author extracted the data from all articles, and the second author reviewed a randomly selected sample of 10 %. Disagreements were resolved through joint review.

This study employs a narrative and thematic synthesis analysis method. Based on the conceptual alignment with UNICEF's five Areas of Benefit, this review developed a thematic framework comprising five dimensions: safety and security, accessibility and equity, child-centered participation, environmental comfort and aesthetics, and social and cultural support.

During the data extraction process, relevant content from each selected study was coded manually into these dimensions using an Excel-based matrix, which enabled cross-study comparison and synthesis. For studies addressing multiple dimensions, entries were duplicated accordingly. This thematic approach allowed us to identify patterns, gaps, and overlaps in the existing literature and to construct a multidimensional framework for child-friendly commuting environments. Subsequently, thematic cluster analysis was used to construct the conceptual framework in SECTION 4 and the methodological mapping in SECTION 5.

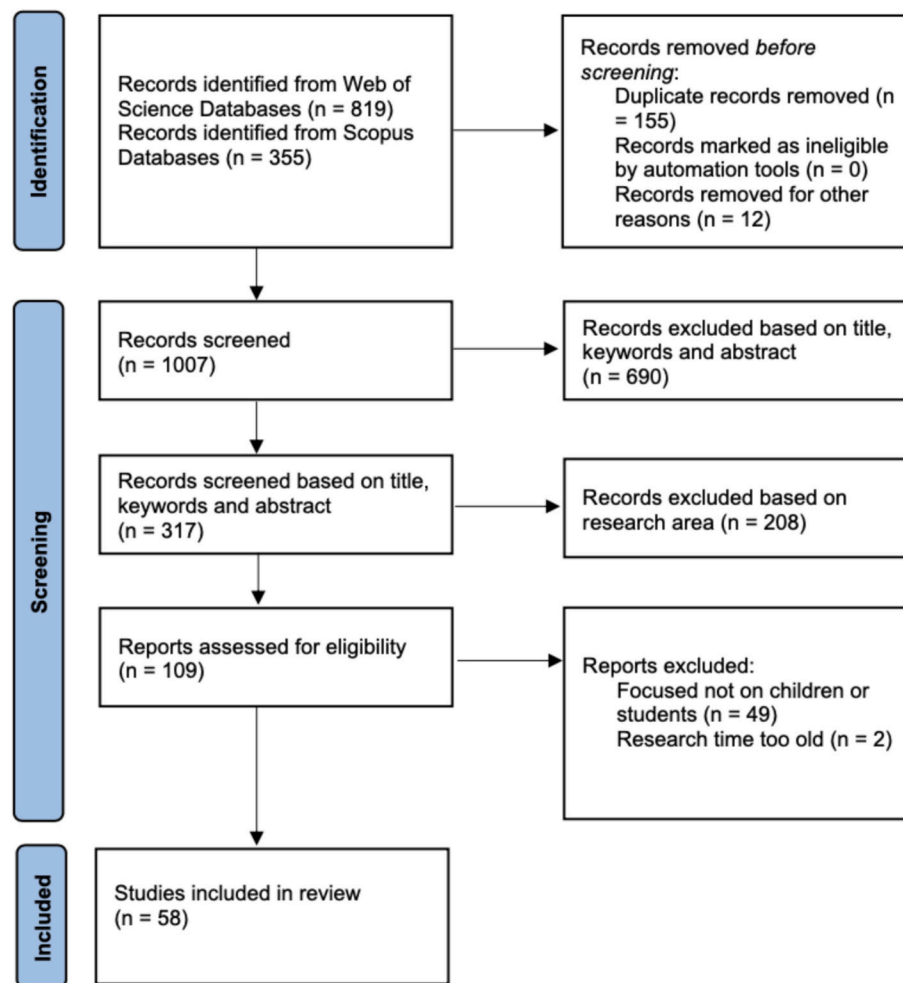


Fig. 1. Screening process of SLR.

3.5. Quality assessment

To assess the quality of the studies included in the review, we used the MMAT method (Supplementary file 2). Each article was scored based on core dimensions such as clarity of research objectives, methodological rigor, ethical considerations, and validity of results. The first author conducted the assessment of all studies and discussed the results with the second and third authors to reach a final assessment result. Studies that met five, four, and three requirements accounted for 20.69 %, 70.69 %, and 8.62 %, respectively (Supplementary file 3).

4. Results of children's school commuting studies

4.1. Characteristics of records

Despite the multiple restrictions that have been placed on the selected articles, they still demonstrate diversity in terms of field of research and year of publication. Fig. 2 shows the interdisciplinary composition of 58 studies using an UpSet plot. This plot reveals the overlapping areas between fields, such as the frequent crossover between transportation, planning, and health fields. This is because research related to child-friendly commuting is multidimensional and interdisciplinary.

Fig. 2 visualizes the intersection of five major research areas: transportation, public health, urban planning, geography, and education. As shown in Fig. 2, Transportation issues were most prominent in 32 studies, highlighting the central role of transportation in children's

school travel experiences. Public health appeared in 23 studies, often intertwined with transportation, looking at active commuting, physical health, and environmental exposures. Geography (13 studies) and urban planning (12 studies) also provided meaningful perspectives, particularly in the areas of spatial design, neighborhood structure, and environmental justice. Of the 58 studies, 35 adopted a single discipline perspective, primarily transportation (14 studies) and geography (8 studies). The remaining 23 studies reflected a variety of interdisciplinary combinations. For example, 10 studies combined transportation with health issues, while 8 studies involved transportation and planning or more disciplines, reflecting the growing trend of integration between mobility research and health equity and child well-being. This supports the view that child-friendly commuting is a complex cross-sectoral issue requiring an integrated planning perspective.

Fig. 3 illustrates the temporal evolution of child-friendly commuting research from 2016 to 2025. While early research findings were scarce, there was a significant increase after 2020, aligning with the academic boom in post-pandemic urban resilience, environmental health, and equitable mobility. The sharp increase in 2023 and 2024 indicates a growing global focus on children's independent mobility and school traffic safety issues, aligning with international policy agendas such as the Child-Friendly Cities Initiative.

To further understand the thematic structure and research focus of the selected literature, a keyword co-occurrence analysis was conducted using VOSviewer software. This tool visualizes the frequency and co-occurrence relationships among keywords extracted from the titles and abstracts of the 58 selected studies. Only keywords with a minimum

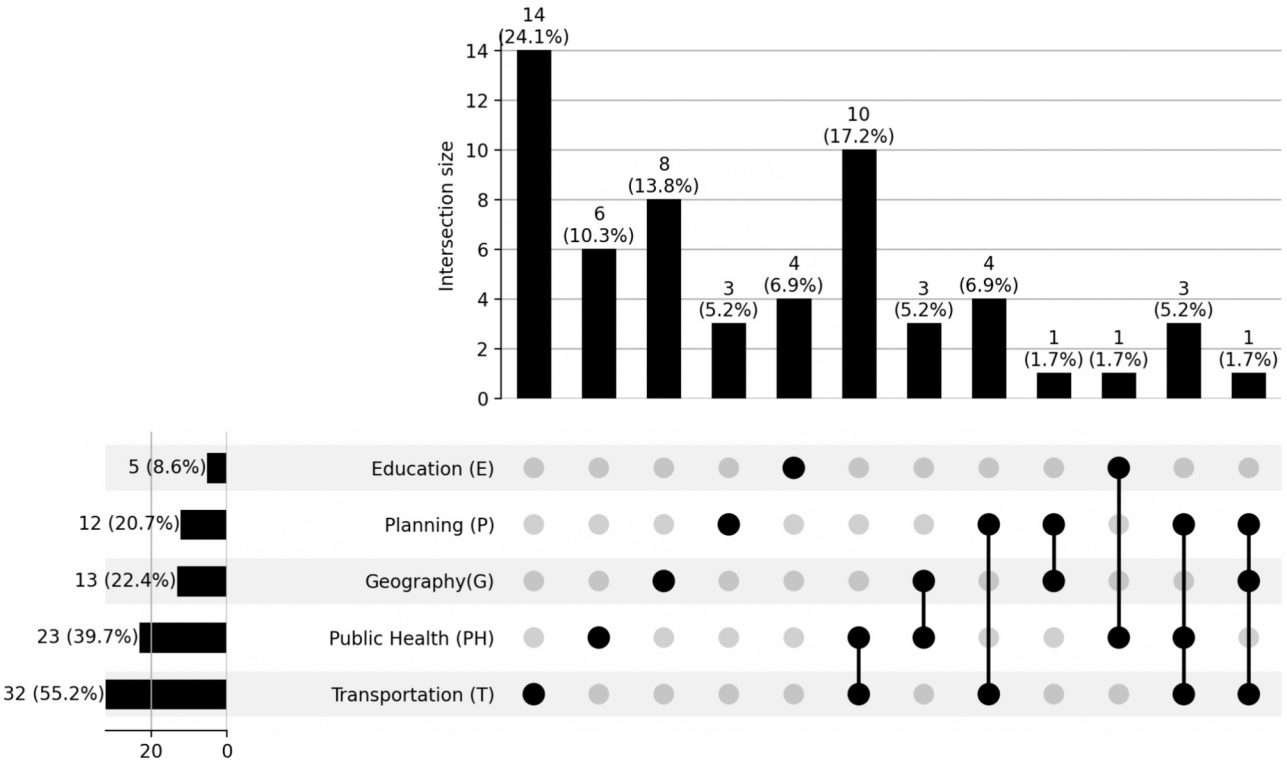


Fig. 2. Intersections of research fields in 58 reviewed studies.

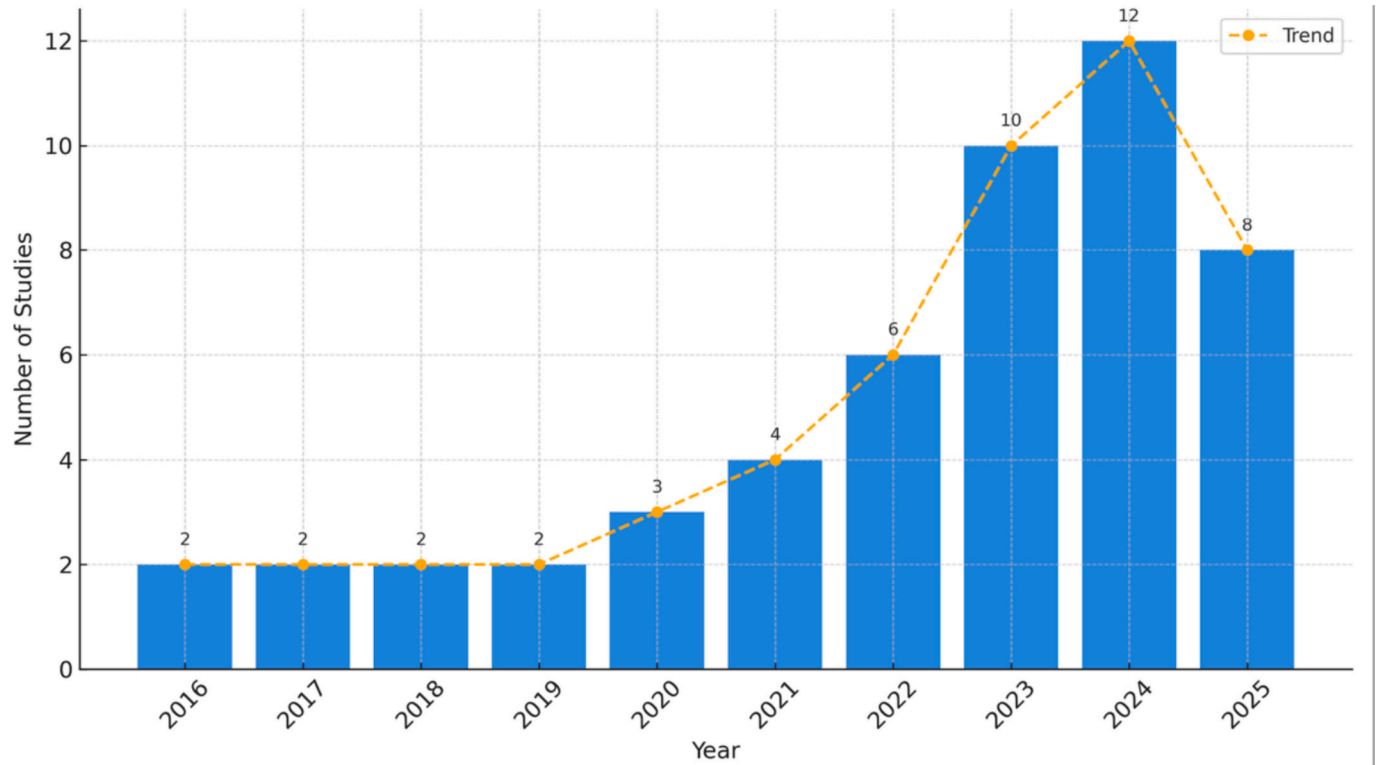


Fig. 3. Annual distribution of reviewed studies (2016–2025).

occurrence of 3 times were included in the analysis to ensure relevance and clarity. As shown in Fig. 4, the resulting network map reveals several key clusters, each representing a group of closely related concepts. For

example, keywords such as “child-friendly cities,” “physical activities,” “children’s independent mobility,” “walking” and “built environment” frequently occur, indicating the central themes in the current literature. The size of the nodes reflects the frequency of occurrence, while the

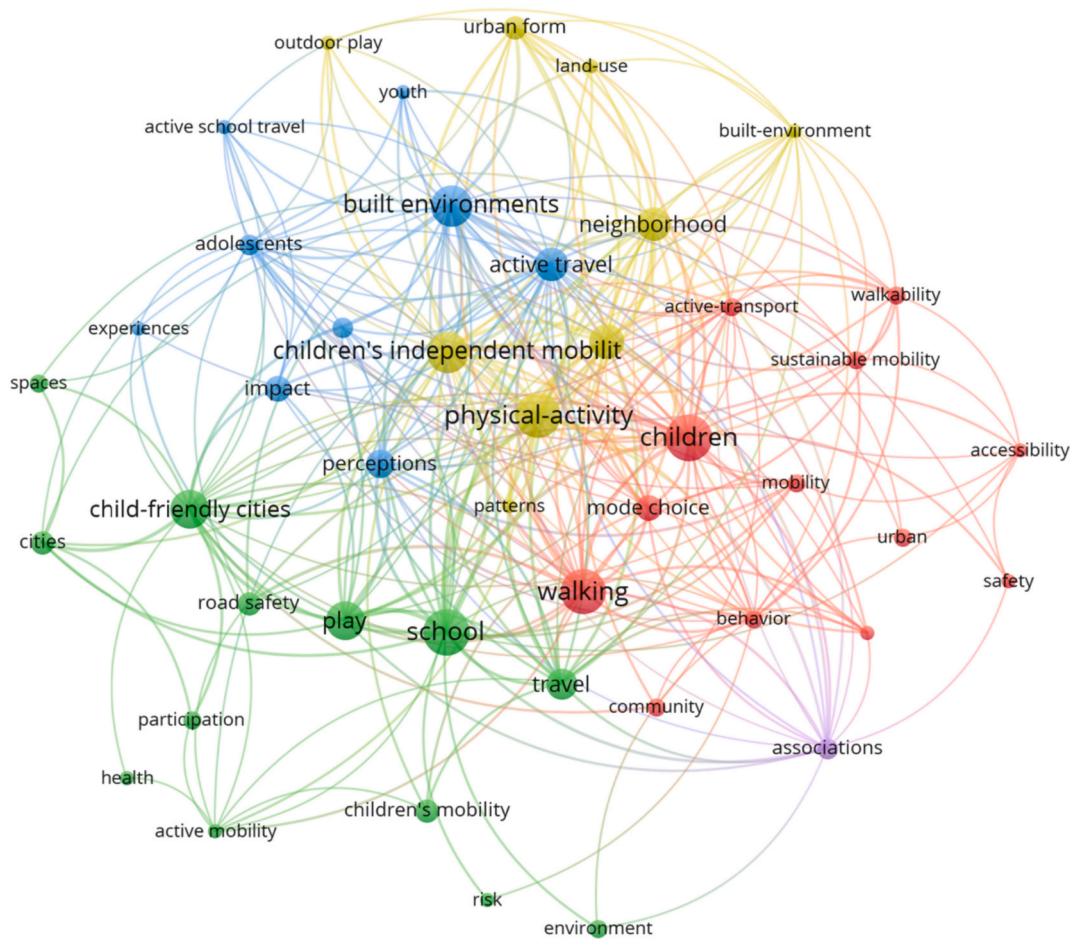


Fig. 4. Key words of the research.

proximity and link strength between nodes indicate the degree of co-occurrence. This visualization provides a comprehensive overview of the conceptual landscape in the field of child-friendly school commuting

environments. This study considered the country or region where the research was conducted rather than the nationality of the authors. A total of 23

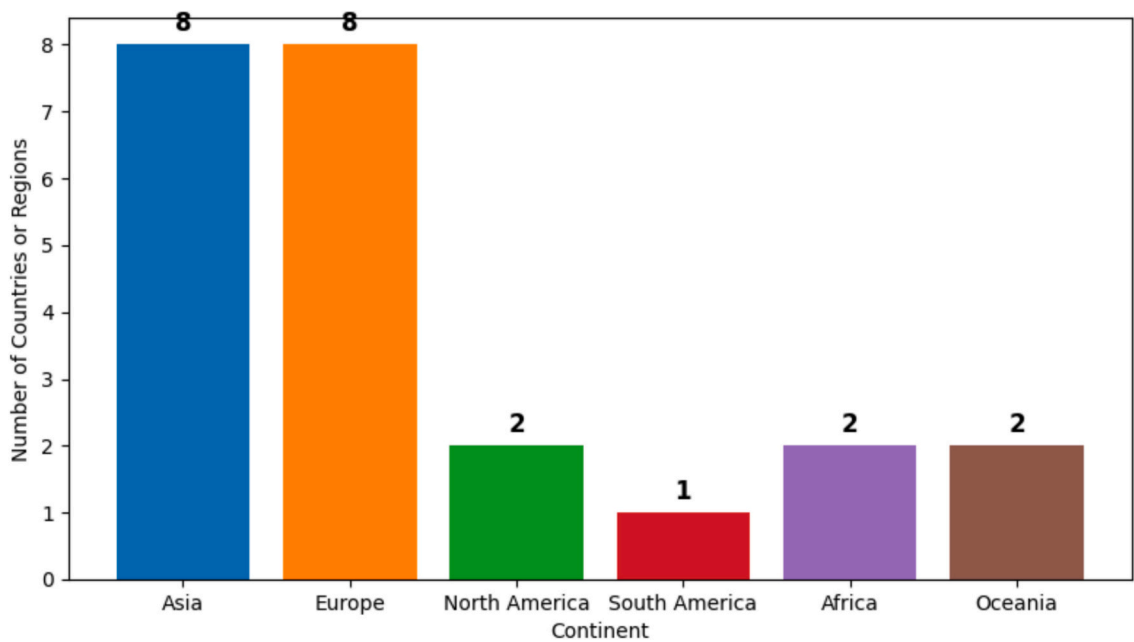


Fig. 5. Geographic distribution of study areas by continent.

countries or regions were mentioned in the 48 articles that explicitly identified the country or region where the research was conducted. China, Canada, Australia and the UK were the three most mentioned countries. Asia ($n = 8$) and Europe ($n = 8$) were the most frequently mentioned regions. Others included North America ($n = 2$), Africa ($n = 2$), Oceania ($n = 2$) and South America (Chile, $n = 1$). These distributions of study area countries or regions are illustrated in Fig. 5.

These countries or regions were grouped according to income levels, as categorized by the World Bank (2024). The case studies are highly concentrated in high-income countries (61 %), especially in Europe, the United States and developed East Asia. Upper middle-income countries (30 %) include mainly emerging economies such as China, Iran, and Turkey. Lower middle-income countries (9 %) are studied less frequently, covering only Bangladesh and Zimbabwe. Fig. 6 shows this distribution.

In addition to the study areas, this study examined the countries or regions of the authors' affiliated institutions. Across the 58 reviewed articles, authors were affiliated with institutions in 25 countries or regions. Thirteen studies reported international collaboration, which occurred between developed countries such as the United States and Canada, as well as Australia and New Zealand, and between developed and developing countries, including China, South Korea and the United States, and Bangladesh, England and Australia. The remaining studies were conducted by authors within a single country or region. Patterns of international collaboration at the country level are presented in Fig. 7. Among the 13 studies involving international collaboration, 7 were partnerships between developed countries, while 6 involved collaborations between developing and developed countries, with all research conducted within the corresponding developing nations. The detailed results are shown in Table A.1.

4.2. Concept of child-friendly commuting environment

The concept of a child-friendly commuting environment is closely linked to the broader Child-Friendly City (CFC) framework proposed by the United Nations Children's Fund (2018), which highlights children's rights to safe, inclusive, and engaging urban spaces and proposes five Areas of Benefit for children: health, safety, citizenship, environmental sustainability and prosperity. A child-friendly commuting environment refers to a transportation system and urban infrastructure that prioritize safety, accessibility, independence, and well-being for children traveling to and from school. It ensures that children can move through their neighborhoods securely, actively, and inclusively, whether by walking, cycling, or using public transportation (Adams et al., 2019). A well-designed commuting environment reduces traffic risks, promotes physical activity, and fosters children's social interactions and sense of autonomy. This systematic literature review adapts the five Area of Benefit proposed by UNICEF by identifying several core dimensions of child-friendly commuting environments to make them more appropriate for the scenario of school commuting environments. These dimensions include safety and security, accessibility and equity, child-centered participation, environmental comfort and aesthetics, and social and cultural support. The following sections elaborate on each of these key aspects.

4.2.1. Safety and security

Ensuring both the physical and emotional safety of children during their commute is fundamental to the development of a child-friendly commuting environment. Selected articles highlight several ways to improve safety. Well-designed pedestrian infrastructure, such as protected sidewalks, speed reduction measures, and well-marked crosswalks, play a critical role in reducing accident risk and increasing parental confidence in allowing children to travel independently (Ding et al., 2023; Leung et al., 2021; Wu et al., 2023). In addition to physical

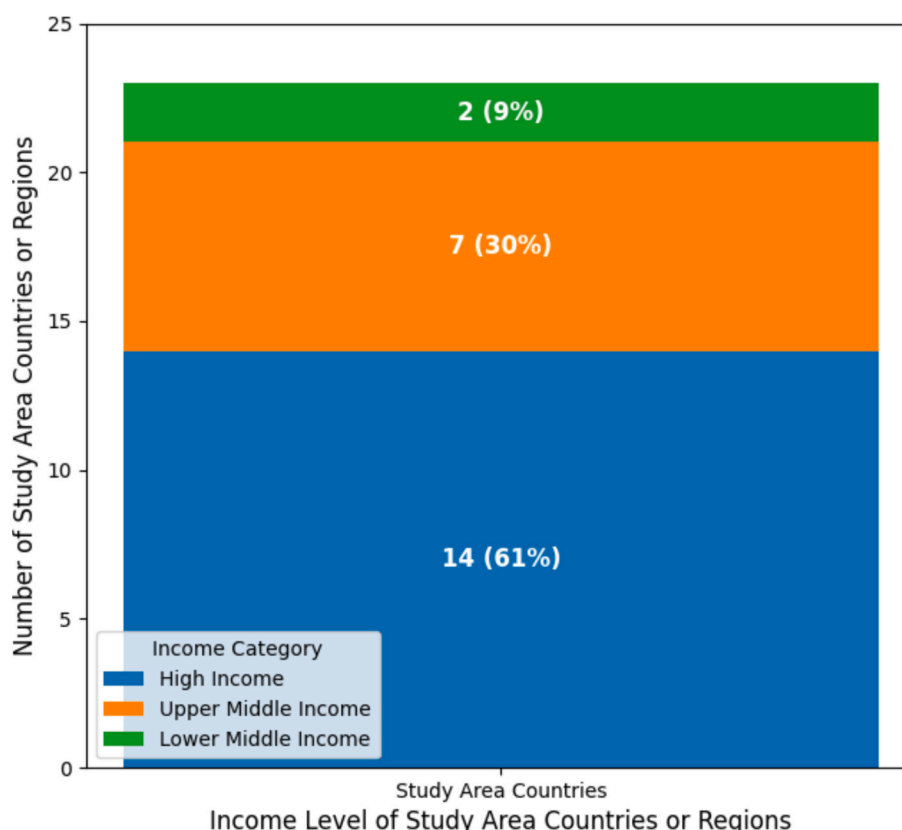


Fig. 6. Income level distribution of study areas.

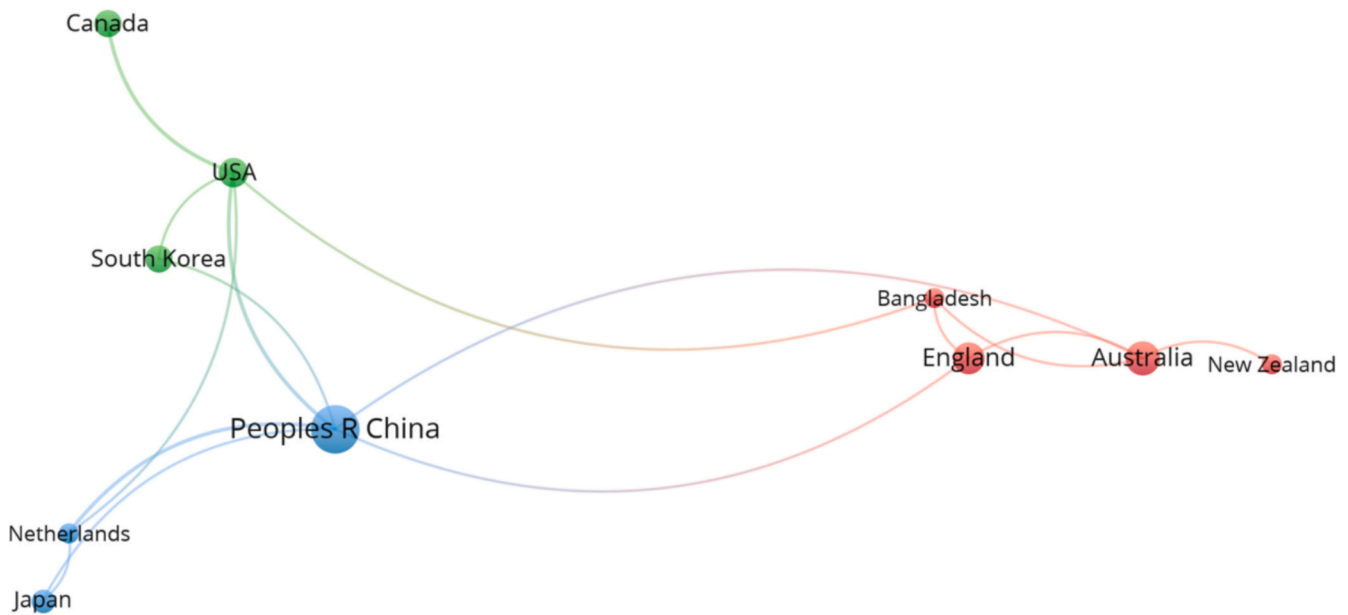


Fig. 7. Cooperation network between countries in selected research.

infrastructure, smart surveillance technologies, including AI-powered monitoring systems and geo-fencing, are increasingly being used as tools to improve commuter safety. However, the ethical implications of these technologies, especially as they relate to children's privacy and autonomy, remain a topic of debate (No et al., 2024; Yang et al., 2024). Apart from transportation issues, crime prevention measures such as improved street lighting, neighborhood patrols, and school zone surveillance are critical to creating a safe commuting environment (Manouchehri & Burns, 2023; Rachel et al., 2022).

4.2.2. Accessibility and equity

The selected articles also focus on children's equitable access to safe commuting options, which is an important element of urban transportation planning. Universal design principles emphasize the importance of infrastructure that meets the needs of all children, including those with disabilities. Features such as accessible routes, tactile paving, ramps, and accessible public transportation can greatly improve mobility for children with diverse needs (Manouchehri & Burns, 2023; Rachel et al., 2022; Zannat et al., 2023). However, economic disparities often affect transportation use, and low-income families face challenges in the affordability and availability of school transportation services.

In addition to infrastructure considerations, empirical case studies reveal persistent disparities shaped by institutional and economic barriers. For example, Zannat et al. (2023) documented that children in low-income urban areas of Bangladesh face not only poor infrastructure but also bureaucratic hurdles limiting access to subsidized school transport. Interviews with parents and children in rural China (Ding et al., 2023) highlight concerns over insufficient maintenance of walking paths and lack of community engagement in infrastructure decisions, which exacerbate safety risks. These qualitative insights underscore how systemic issues, beyond physical infrastructure, affect children's commuting experiences and call for integrated policy responses addressing institutional frameworks, funding equity, and community participation. Governments can bridge these gaps with policy measures that provide subsidized school buses and free public transportation for children (Gu et al., 2024; Liao & Dai, 2022). In addition, spatial justice has an impact on children's commuting experiences. Studies have shown that children in wealthier neighborhoods tend to benefit from safer walking routes and green spaces, while children in low-income neighborhoods face greater commuting hazards. Clear interventions to address these disparities and ensure equitable child-friendly

transportation should be proposed when conducting urban planning (Khanian, Laszkiewicz, & Kronenberg, 2024; Laszkiewicz & Sikorska, 2020; Zannat et al., 2023).

4.2.3. Child-centered participation

Urban planning conducted by adults can result in a misunderstanding of children's needs, and truly child-friendly commuting environments must be shaped by children's own voices and experiences (Abatay, 2019). Selected articles emphasize the importance of participatory planning methods that actively involve children in urban transportation decision-making (Jung & Kim, 2024; Leung et al., 2021; Michail & Torun, 2024). Tools such as child-led mapping, co-design workshops, and digital engagement platforms have been successfully applied in several projects to incorporate children's perspectives into transportation policy (Jung & Kim, 2024; Loureiro et al., 2020; Tori et al., 2024). Ensuring children's participation requires institutional mechanisms such as children's advisory committees and participatory urban governance frameworks to ensure that children's voices are heard as well as integrated into long-term planning strategies (Urinboyev et al., 2016).

4.2.4. Environmental comfort

Child-friendly school commuting also encompasses the comfort of the commuting environment, which can affect children's travel choices and overall health. Studies have emphasized the role of green infrastructure in enhancing the commuting experience. Tree-lined streets, shade-covered sidewalks, and urban parks along schools can help provide more comfortable and enjoyable journeys while also mitigating the urban heat island effect (Meng et al., 2023; Russo & Andreucci, 2023). In addition, incorporating play elements such as sidewalk play, interactive public art, and informal play spaces can transform commuter routes into engaging and stimulating environments for children (Caldwell et al., 2022; Weir, 2023). Moreover, traffic noise, poor air quality, and crowded pedestrian areas can stress children and discourage active commuting (Wang et al., 2023; Yang et al., 2025). The overall commuting experience for children can be enhanced by implementing traffic management strategies, reducing pollution near schools, and optimizing urban design to minimize children's sensory discomfort.

4.2.5. Social and cultural support

Social and cultural contexts play an important role in shaping child-

friendly school commuting environments. Community-school partnerships help create safe and supportive commuting environments for children. Parent-school partnerships, community-led safe routes programs, and government initiatives aimed at increasing traffic safety can create a more inclusive commuting culture (Smith et al., 2022; Tori et al., 2024). Cultural norms and gender-specific transportation restrictions also influence commuting patterns in different areas. In some communities, concerns about safety or social norms may exacerbate gender differences in mobility by limiting girls' freedom to travel independently (Manouchehri & Burns, 2023; Ningsih, 2020).

4.2.6. Framework of child-friendly school commuting environment

To ensure the framework is grounded in empirical evidence, each element is linked to representative studies identified in the systematic review. Table 1 presents the refined framework for child-friendly school commuting, structured along five core dimensions, with supporting references provided for each key element.

Child-friendly commuting environments include physical infrastructure, as well as elements of safety, accessibility, participatory governance, environmental quality and social inclusion. The articles reviewed emphasize the need for a multidimensional approach in urban planning processes, combining planning, policy interventions and technological innovations to create truly child-friendly commuting systems.

The framework proposed in this study is grounded in empirical evidence synthesized from 58 peer-reviewed studies. As outlined in Sections 4.2.1 to 4.2.5, each of the five dimensions is informed by multiple research findings across diverse regional and socio-economic contexts.

For instance, studies conducted in China (Ding et al., 2023; Wu et al., 2023) emphasize the role of traffic safety infrastructure in reducing accident risk and supporting independent travel. Jung and Kim (2024) highlight participatory planning approaches that incorporate children's voices into mobility design in South Korea. Evidence from low-income and middle-income countries further points to the need for transport subsidies and spatial equity measures to improve access for marginalized populations. Collectively, these studies offer practical validation for the framework's components and reflect current directions in child-

friendly commuting research.

4.2.7. Theoretical foundation of the framework

To enrich the theoretical depth of the proposed framework and address key perspectives in childhood studies, such as children's rights and child agency, this section integrates four theoretical lenses: Children's Rights Theory, Child Participation Theory, Sustainable Development Theory, and Maslow's Hierarchy of Needs.

Children's Rights Theory was proposed by the United Nations Convention on the Rights of the Child (UNCRC), which clearly outlines children's rights to protection, security, and participation in all aspects of life. It provides a normative framework for assessing the extent to which urban environments safeguard children's rights to safety, mobility, and well-being (Lansdown, 2005; Unicef, 1989). Child participation theory emphasizes the importance of involving children in meaningful ways in the design and governance of urban environments. Children are not merely passive recipients of adult decisions, but active social participants with unique insights and life experiences, whose perspectives should be incorporated into planning and policy-making (Hart, 1992). Sustainable development theory provides a broad framework linking child-friendly commuting with the broader goals of urban sustainability. This theory emphasizes equity, environmental protection, and long-term social well-being (Keeble, 1988). Maslow's hierarchy of needs provides a psychological framework for understanding how commuting environments meet children's needs, ranging from basic physical safety to belonging, autonomy, and self-actualization (Maslow, 1943).

These four perspectives together form the five-dimensional analytical framework proposed in this study, covering safety and protection, accessibility and equity, child participation, environmental comfort, and social and cultural support. Table 2 shows how the theoretical basis connects to these five dimensions.

This integrative mapping reveals that the five dimensions of child-friendly commuting respond to practical planning challenges and embody theoretical commitments to multidimensional child development. For instance, the Safety & Security dimension reflects the right to protection articulated in the UNCRC and aligns with the foundational

Table 1
Conceptual framework of a child-friendly school commuting environment and supporting studies.

Dimension	Core objective	Key elements	Policy & implementation tools	Representative studies
Safety & security	Minimizing physical & psychological risks during commuting	Traffic safety infrastructure (sidewalks, speed bumps, bike lanes) Smart surveillance (AI, CCTV)	Mandatory speed limits in school zones Smart monitoring systems for high-risk commuting areas	Ding et al. (2023); Leung et al. (2021) No et al. (2024); Yang et al. (2024)
Accessibility & equity	Ensuring equitable access to safe commuting options for all children	Crime prevention (lighting, community patrols) Universal design (tactile paving, ramps) Affordable transport (subsidized school buses) Spatial justice (equal distribution of green spaces & safe routes)	Improved street lighting & police patrols in school zones Subsidized transport policies for low-income families Urban planning reforms to ensure equitable access	Manouchehri and Burns (2023); Rachel et al. (2022) Zannat et al. (2023); Rachel et al. (2022) Gu et al. (2024); Liao and Dai (2022)
Child-centered participation	Recognizing children as active participants in mobility planning	Participatory tools (workshops, digital platforms) Policy inclusion mechanisms (child advisory councils)	Establish child advisory councils in urban planning Digital reporting systems for child feedback on commuting issues	Khanian, Laszkiewicz, and Kronenberg (2024); Laszkiewicz and Sikorska (2020) Jung and Kim (2024); Loureiro et al. (2020) Tori et al. (2024); Urinboyev et al. (2016);
Environmental comfort & aesthetics	Creating a psychologically & physically pleasant commuting environment	Green infrastructure (shaded walkways, street trees) Playful elements (sidewalk games, public art) Sensory optimization (noise reduction, air quality control)	Tree-lined walkways & shaded pedestrian zones Integration of art & play areas into commuting routes Noise pollution control and air quality monitoring near schools	Meng et al. (2023); Russo and Andreucci (2023) Weir et al. (2023); Caldwell et al. (2022) Yang et al. (2025); Wang et al. (2023);
Social & cultural support	Embedding school commuting within community & cultural contexts	Community collaboration (parent-school partnerships) Culturally sensitive design (gender-inclusive transport options)	Parental volunteer programs for safe school routes Gender-sensitive mobility planning in conservative regions	Tori et al. (2024); Smith et al. (2022) Manouchehri and Burns (2023)

Table 2

Theoretical support for child-friendly commuting.

Framework dimension	Children's rights theory	Child participation theory	Sustainable development theory	Maslow's hierarchy of needs
Safety & security	Right to protection		Intergenerational equity	Safety needs
Accessibility & equity	Right to education & mobility		Social and spatial justice	Physiological & safety needs
Child-centered participation	Right to be heard	Active participation		Esteem needs
Environmental comfort & aesthetics			Ecological well-being	Belonging, aesthetics
Social & cultural support	Cultural rights	Community inclusion	Social sustainability	Love & belonging

“safety needs” in Maslow’s model. Similarly, the Child-Centered Participation dimension operationalizes children’s agency and voice as emphasized in participation theory, while addressing higher-order esteem needs. Although these four theoretical perspectives provide a solid foundation for constructing a child-friendly commuting framework, this literature review indicates that empirical research has only partially realized the concretization of these concepts. For instance, while children’s safety is frequently discussed, their agency and emotional experiences are often overlooked. This suggests that future research must more systematically reflect upon and integrate theoretical principles, incorporating them into research design, analysis, and policy recommendations.

5. Research methods of selected articles

The reviewed literature employs diverse research methods to examine child-friendly commuting environments, primarily falling into qualitative, quantitative, and mixed-methods approaches. Table 3 shows the research methods of the reviewed literature. These include techniques such as interviews and focus groups, surveys and statistical modeling, experiments and simulations, policy and content analysis, and bibliometric assessments. The selection and application of these methods depend on the research objectives, data access conditions, and the need for interdisciplinary considerations. The following is a comparative analysis of the methodological characteristics, applicable scenarios and limitations.

These articles cover a total of 28 journals, mainly in the social sciences. Highly frequent journals include Children’s Geographies, Sustainability, and International Journal of Environmental Research and Public Health. Urban Studies and Public Administration accounted for 42 % and 25 % respectively. There has been significant growth in articles since 2020, with 88 % of articles published after 2020, 60 % of which are published after 2023. Empirical studies accounted for 86 % and theoretical studies for 14 %. Table 4 shows the classification.

5.1. Qualitative and quantitative methods

Qualitative methods, such as focus group interviews, ethnographic research, and observation, are uniquely positioned to capture children’s subjective experiences and deeper needs. For example, Adams et al. (2019) reveal children’s desire for natural spaces in low-income neighborhoods through focus group interviews, while Cortés-Morales (2021) presents an ethnographic study from a “posthumanism”

Table 3

Classification of research methods.

Research methods	Code	Total	Percentage
Quantitative methods	L2, L3, L4, L5, L8, L10, L13, L14, L17, L21, L22, L23, L27, L28, L29, L30, L32, L33, L34, L35, L45, L48, L50, L51, L52, L53, L54, L56, L57, L58	30	51.72 %
Qualitative methods	L1, L6, L7, L9, L11, L12, L16, L19, L20, L24, L25, L31, L36, L37, L38, L39, L43, L46	18	31.03 %
Mixed methods	L15, L18, L26, L40, L41, L42, L44, L47, L49, L55	10	17.24 %

Table 4

Research nature and methods distribution.

Research type	Qualitative methods	Quantitative methods	Mixed methods	Total
Empirical research	14	28	8	50
Theoretical research	4	2	2	8
Total	18	30	10	58

perspective by tracking children’s interactions with material objects, such as strollers and electronic devices. However, qualitative methods usually have small sample sizes, for example, Weir (2023) only included 17 children in this study on children’s activity space, and the generalizability of its findings is limited. In contrast, quantitative methods, such as large-scale questionnaire surveys, structural equation modeling, and GIS spatial analysis, enhance the objectivity and generalizability of the study through a data-driven approach. For example, the Rural School Commuting in China study identified children’s urgent need for transportation facilities based on 992 questionnaire data (Ding et al., 2023), while Khanian, Laszkiewicz, and Kronenberg (2024) used GIS analysis to reveal significant associations between socioeconomic status and children’s exposure to greening for commuting in Lodz City, Poland. The limitation of quantitative methods is that they may ignore complex socio-cultural contexts. For example, Leung and Loo (2017) found that children’s independent travel was negatively associated with well-being, but did not delve deeper into the underlying security anxieties and cultural norms in Hong Kong.

5.2. Mixed-methods and participatory design

Mixed-methods approach combines qualitative and quantitative data to analyze the mechanisms influencing children’s commuting behaviors in multiple dimensions. For example, Cadima et al. (2024) quantified parental constraints on children’s independent travel via an online survey. This was complemented by focus group discussions exploring how “car-centrism” influences family travel decisions. Participatory research further integrates children as co-creators in study design. For example, in Busan, South Korea, children participated directly in planning safe walking routes around their schools through mapping exercises and workshops. The results were subsequently adopted by the local government as a basis for policy (Jung & Kim, 2024). Such approaches not only enhance the practical value of research but also challenge the traditional paradigm that treats children as passive subjects. However, mixed methods are costly to implement and need to address the logical consistency of data integration, such as the Australian study by Gilbert et al. (2023), which noted that quantitative data reflect parental preferences, while children’s perspectives needed to be supplemented by qualitative ones.

5.3. Bibliometrics and case studies

The bibliometric analysis mapped the evolution of research on child-friendly cities at the macro level, noting that research themes have expanded from “infrastructure safety” to “children’s right to participation” and “environmental justice” since 2017 (Liao & Furuya, 2023; Shu

& Zheng, 2025). The meta-analysis further quantifies the impact of the built environment on children’s independent travel, finding a positive effect of closed roads and residential land use, while mixed land use may inhibit children’s willingness to travel due to traffic complexity (Sharmin & Kamruzzaman, 2017). Case studies, such as comparing the School Streets policy in two Canadian cities, provide micro-level insights into the factors that are critical to the success or failure of the policy (Smith et al., 2022). Case studies allow for in-depth research within the study area but come with limitations for replication. The shortcomings of single-context studies need to be bridged through cross-case comparisons (Torres et al., 2022).

5.4. Technology-driven research

Emerging technologies are reshaping research methods. For example, No et al. (2024) used computer vision to analyze children’s movement trajectories in surveillance videos and identify behavioral patterns such as “speeding up” and “stopping”. And Yang et al. (2024) attempted to automate the assessment of street children’s friendliness by using street view images and deep learning. Such technologies enhance the efficiency and scale of data collection, but also face ethical controversies regarding privacy protection and the risk of algorithmic bias (Yang et al., 2024). Future research needs to balance technological innovation with humanistic concerns, such as combining children’s subjective feedback with machine learning models to build more inclusive assessment frameworks (Loureiro et al., 2020).

5.5. Advantages and disadvantages of different types of methods

The reviewed literature adopts a range of research methods, with quantitative approaches being the most common, followed by qualitative and mixed methods designs. While these methods contribute to different aspects of understanding child-friendly school commuting, their application across studies reflects uneven attention to subjective experience, policy integration, and child participation.

Quantitative methods, often based on cross-sectional surveys and spatial data analysis, are used to examine commuting distances, traffic exposure, and travel mode choice. These methods allow for statistical generalization and are useful in identifying large-scale trends. However, their use tends to focus on observable variables and parent-reported outcomes, with limited engagement of children themselves. In some cases, children are treated as data points rather than participants, resulting in an adult-centric research perspective.

Qualitative studies, although fewer in number, offer more detailed accounts of how children perceive their commuting environment. Common methods include interviews, drawing exercises, walking tours, and participatory mapping. These approaches generate context-rich findings that highlight children’s views on safety, autonomy, and emotional comfort. However, they often involve small sample sizes and are more limited in scope, which may affect their perceived generalizability and influence on policy.

Mixed-methods studies aim to combine the scale of quantitative research with the depth of qualitative insights, but only a small number

of studies adopt such designs. These studies often integrate spatial analysis with participatory techniques or interviews. Despite their potential to bridge methodological gaps, they are more resource-intensive and remain underrepresented in the literature.

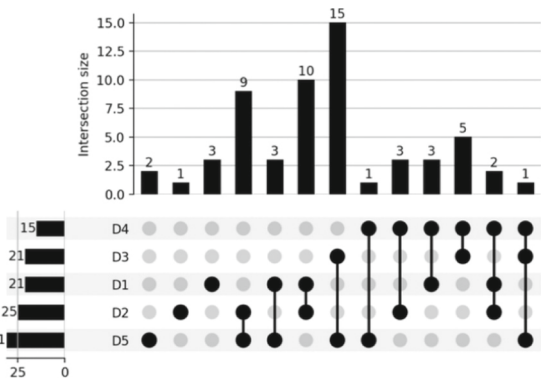
Overall, the dominance of quantitative methods reflects a broader pattern in urban mobility research. However, in the context of child-friendly planning, greater attention to qualitative and participatory approaches is needed. These methods are better suited to capturing children’s subjective experiences and identifying design interventions that align with their needs and preferences.

A comparative summary of the methodological approaches used across the reviewed studies is presented in Table 5. The table highlights common applications, relative strengths, and key limitations of quantitative, qualitative, and mixed-methods designs within the context of child-friendly commuting research.

5.6. Integration of conceptual dimensions and methodological patterns

To further strengthen the link between the conceptual framework and methodological characteristics, we synthesized the thematic focus of each included study based on the five proposed dimensions. Fig. 8 visualizes the intersection of the five core dimensions of child-friendly commuting environments across the 58 reviewed studies. The highest co-occurrence was found between “Child-Centered Participation” and “Social & Cultural Support”, followed by overlaps between “Safety & Security” and “Accessibility & Equity”.

Fig. 9 presents a mosaic diagram illustrating the relationship between key research themes and the methodological approaches employed in 58 studies on child-friendly school commuting. The thematic categories of these studies include transportation, public health, urban planning, geography, and education, while the research methods are categorized as quantitative, qualitative, or mixed methods. The visualization reveals that transportation and public health are the



* "D1"= "Safety & Security"; "D2"="Accessibility & Equity"; "D3"= "Child Participation"; "D4"="Environmental Comfort"; "D5"="Social & Cultural Support

Fig. 8. Intersection of research themes across reviewed studies.

Table 5
Summary of methodological approaches in reviewed studies.

Method type	Strengths	Limitations	Suitability in child-friendly commuting research	Representative studies
Quantitative	Enables generalization - Handles large datasets - Reveals behavioral patterns	Excludes children’s voices - Lacks contextual depth	Useful for identifying macro-level commuting trends and policy targets, but insufficient for capturing children’s lived experiences	Ding et al. (2023); Wu et al. (2023)
Qualitative	Captures children’s perspectives - Rich in context and emotion - Explores psychosocial aspects	Small samples - Limited generalizability - Sometimes lacks policy influence	Ideal for exploring children’s subjective experiences of safety, autonomy, and comfort	Jung and Kim (2024); Loureiro et al. (2020)
Mixed-methods	Integrates quantitative scale with qualitative depth - Enhances triangulation and validity	Methodologically complex - Resource-intensive - Rarely implemented fully	Promising for inclusive and interdisciplinary planning; underused in this field	Tori et al. (2024); Caldwell et al. (2022)

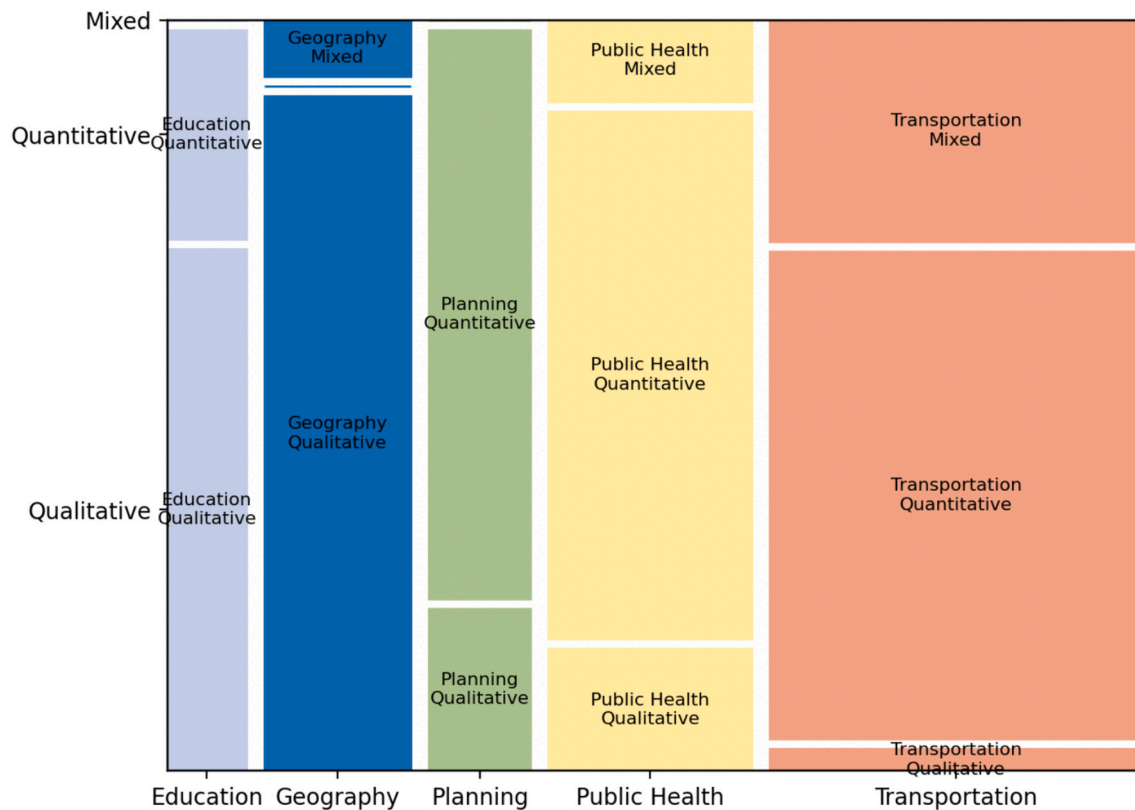


Fig. 9. Integration of research themes and methodological approaches in child-friendly school commuting studies.

primary research focuses, with a significant reliance on quantitative methods, reflecting the widespread use of data-driven statistical analysis in these fields. In contrast, themes such as geography and education tend to balance or lean more toward qualitative and mixed methods, indicating an emphasis on spatial contexts and participatory or interpretive approaches.

These findings underscore opportunities for closer integration between conceptual frameworks and research methods. For example, incorporating more qualitative research and participatory methods into transportation studies can deepen our understanding of children's subjective experiences. Alternatively, broader use of quantitative tools in education-focused research can enhance the generalizability of research findings. By combining methodological choices with research topics in more innovative ways, future research may yield richer, more multidimensional insights.

6. Discussion of key gaps and strategic directions for future research

The selected articles provide a comprehensive framework for the construction and evaluation of child-friendly school commuting environments, yet significant challenges and research gaps persist. To enhance future research impact, we prioritize the following key directions.

6.1. Geographic and socioeconomic imbalance

Current research in this field disproportionately focuses on high-income countries, with limited attention to low-income or rapidly urbanizing regions. For example, while studies have explored school commuting experiences in specific contexts such as South Africa (Adams et al., 2019), rural China (Ding et al., 2023), or Polish cities (Khanian, Laszkiewicz, & Kronenberg, 2024), broader cross-cultural comparisons remain scarce. Only about 6 % of the reviewed studies investigated

environments in lower-income settings, such as in Bangladesh (Zannat et al., 2023). This limitation undermines the generalizability of findings and neglects context-specific challenges such as infrastructural inadequacies, informal urban development, and rapid urban sprawl. Future research should prioritize comparative studies that explore variations in child mobility differ across economic and cultural contexts, building on recent efforts such as Liao and Furuya (2023).

Among the 25 studies conducted in developing countries, six involved international collaboration with institutions from high-income countries, while the remaining studies were conducted independently. Both collaborative and independent studies employed a variety of research methods, including surveys, qualitative interviews, observational studies, and advanced modeling techniques such as Generalized Additive Mixed Models, Structural Equation Modeling, and eXtreme Gradient Boosting. Collaborative studies did not extend the research areas beyond developing countries and the core research methods and focus areas were similar to those of independent studies. Existing studies reveal similarities between collaborative and independent research in terms of research focus, key findings, and limitations. For instance, both approaches rely on data from a single study region and lack longitudinal tracking. This indicates that while international collaboration can provide methodological support and resource sharing, it does not necessarily alter core research outcomes or priority areas. Future research could enhance the universality and policy relevance of findings by conducting cross-national comparative studies that integrate international collaboration with local insights.

Beyond quantitative disparities, qualitative data from various regions demonstrate the complex social and institutional barriers that influence child mobility. For instance, focus groups conducted by Adams et al. (2019) in South African townships reveal parental fears rooted in crime and social exclusion, which restrict children's independent travel despite available infrastructure. Similarly, in Poland, ethnographic research by Khanian, Laszkiewicz, and Kronenberg (2024) illustrates how local governance practices and funding allocation shape unequal

access to green and safe commuting routes. Incorporating such empirical and qualitative perspectives helps deepen understanding of the challenges faced by children commuting to school and reinforces the call for context-sensitive and equity-oriented policy frameworks.

6.2. Methodological limitations and interdisciplinary potential

Many studies reviewed rely heavily on cross-sectional data, limiting their ability to assess long-term impacts of interventions on children's commuting experiences (Alderton et al., 2022; Chakma et al., 2025; Leung & Loo, 2017). Longitudinal research is needed to track changes over time in response to infrastructure upgrades, policy implementation, or children's commuting behaviors. Standardized longitudinal frameworks would allow for the monitoring of outcomes such as children's safety perceptions, independence, and active mobility.

In addition, the future of child-friendly mobility research may benefit from integrating diverse data sources and interdisciplinary approaches. Currently, most studies remain anchored within single disciplines, which restricts both the scope of inquiry and methodological innovation. For example, public health studies often rely on self-reported surveys, whereas transport studies tend to use GPS tracking or travel diaries, highlighting a lack of methodological convergence. Future research that closely unites transportation, public health, urban planning, education, and psychology may yield more comprehensive insights. From the above data, cross-sector data integration, such as combining travel behavior surveys with geospatial, health, or school data, has the potential to reveal complex interdependencies. The use of participatory and qualitative methods alongside AI-supported data analysis, such as predictive modeling and trajectory tracking, may further improve the accuracy of assessments, provided that privacy and ethical considerations are carefully addressed. This interdisciplinary research approach and multi-sourced data integration strategy help advance the field's theoretical foundations and policy relevance.

6.3. Limited inclusion of children's voices and participation

Despite growing awareness of the importance of child participation, most studies still rely on adult perspectives, including those of parents, planners, and teachers (Cadima et al., 2024; Farstad, 2023; Rachel et al., 2022). Hart (1992) defined and divided the scope of youth participation in decision-making into several key steps, from adults' manipulation, window dressing, and superficiality to adults assigning tasks to children but informing children, adults consulting with children and informing, adults initiating a joint decision with children, children initiates adults' guidance, children initiate joint decision with adults. However, the first three stages are generally considered to be "fake participation" under the guise of "child participation" activities, and only the last five stages can be described as "real participation" (Wenyue & Ke, 2022). Children's participation can be divided into two forms: active participation, which involves decision-making and expressing opinions, and passive participation, which involves participating in programs and research for children's guardians (Nam & Nam, 2018). Only a small number of studies incorporate such active participatory methods. For instance, Loureiro et al. (2020) used child-led mapping and storytelling to explore children's perceived safe routes; Jung and Kim (2024) facilitated co-design workshops with children to develop interventions for safer school environments; and Loureiro et al. (2020) analyzed children's drawings to determine the school environment they desire. Future research should more actively adopt participatory planning approaches that engage children as active contributors to the design and evaluation of commuting environments. This could involve combining qualitative techniques, such as child-led interviews, drawing, or photography, with spatial analysis tools like GIS to represent both experiential and spatial dimensions of child mobility. Such methods not only deepen the understanding of children's lived experiences but also challenge adult-centric assumptions in urban design.

6.4. Policy-practice disconnection

Although various policies have been introduced to promote child-friendly commuting methods, such as speed limits around schools, redesign of school zones, or urban greening, many of these policies have been poorly implemented or lack long-term oversight. For example, safety guidelines may exist in theory but are not reflected in street-level interventions (Ding et al., 2023). Similarly, despite growing concern about climate-related discomfort during school commutes, cooling strategies have not been well integrated into transportation planning (Meng et al., 2023). Successful localized projects, such as the Streets for Schools initiative (Smith et al., 2022), often struggle to scale up due to a lack of institutional support. In the face of evolving political or financial conditions, there is an urgent need to establish an implementation framework that promotes replication, scalability, and long-term sustainability (Chakma et al., 2025; Simón-i-Mas & Honey-Rosés, 2024).

6.5. Understudied emotional and social factors

While most studies on school commuting have focused on physical safety and infrastructure, children's emotional and social experiences have not been adequately explored. Increasing evidence suggests that factors such as fear of crime, sense of autonomy, social belonging, and enjoyment significantly influence children's perceptions and choices regarding commuting routes (Cortés-Morales, 2021; Leung & Loo, 2017). For example, even in physically safe environments, children may feel unsafe due to hostile social cues or the absence of peer companionship. Similarly, an efficient and well-designed route may still be perceived as unpleasant or isolating if it lacks green spaces or familiar landmarks (Wu et al., 2023; Zannat et al., 2023).

6.6. Ethical consideration

The rise of digital surveillance and data-driven urban management has brought about new ethical considerations. Technologies such as GPS tracking, closed-circuit television surveillance, biometric technology, and AI-based pattern analysis are increasingly being used to monitor and model children's movement patterns (No et al., 2024; Yang et al., 2024). While such tools may offer new insights for enhancing route safety or optimizing planning, they also raise significant concerns about children's privacy rights, informed consent, and digital autonomy. For minors, who cannot legally consent like adults, the collection and use of behavioral data require explicit ethical safeguards. Additionally, surveillance technologies may exacerbate social inequalities, such as unequal deployment in low-income or minority communities (Simón-i-Mas & Honey-Rosés, 2024). Current research rarely delves deeply into these issues, and frameworks for assessing the trade-offs between safety and surveillance are largely absent.

6.7. Implications for future urban planning and policy

From a methodological and policy perspective, this study highlights core research themes, spatial biases, and evolving methodological orientations. It analyzes the research focus and methods of children's commuting in different disciplinary contexts, while noting limitations of participatory and child-led approaches. At the policy and practice level, the study provides actionable insights for relevant practitioners, including government officials, community workers, and child welfare professionals, to further improve child-friendly school commuting environments. These contributions bridge the gap between conceptual research and practical implementation, emphasizing the centrality of children's rights and lived experiences.

The article constructs a five-dimensional child-friendly commuting framework, which provides urban planners and policymakers with a structured tool for diagnosing and improving the environment for children traveling to and from school. To enhance its practical relevance, we

propose the following targeted strategies for each of the five dimensions:

Safety and protection: Establishing traffic-calmed school zones, enforcing vehicle speed limits near schools, and implementing Safe Routes to School (SRTS) programs with community policing and surveillance technologies can significantly reduce traffic hazards.

Accessibility and equity: Municipalities should prioritize inclusive infrastructure such as barrier-free sidewalks and tactile paving, offer subsidized or free school transport for children in underserved areas, and improve public transport accessibility in low-income neighborhoods.

Child participation: Planning processes should institutionalize child-inclusive practices such as participatory mapping, walk-along interviews, and child-led audits to incorporate children's lived experiences and preferences into design decisions.

Environmental comfort and aesthetics: School routes should be designed with attention to microclimate and sensory experience, integrating green buffers, shaded corridors, seating/rest nodes, and artwork to create an engaging, child-scaled environment.

Socio-cultural support: Communities should be empowered to initiate child-friendly mobility projects, such as walking school buses, intergenerational walk groups, or street play initiatives, while also ensuring that cultural diversity is reflected in the urban environment to foster belonging and identity.

From a theoretical perspective, the review highlights that while the proposed five-dimensional framework integrates key concepts from Children's Rights Theory, Child Participation Theory, Sustainable Development, and Maslow's Hierarchy of Needs, many existing studies have only partially addressed these dimensions. Issues such as socio-economic disparities, limited child participation, underexplored emotional and social factors, and ethical considerations reveal gaps in operationalizing theoretical constructs. Future research should more systematically validate and reflect upon all framework dimensions, ensuring that theoretical principles are consistently embedded in study design, empirical analysis, and policy recommendations.

7. Conclusion

This study systematically reviewed 58 peer-reviewed articles to address three core research objectives. First, through thematic analysis, it synthesized key concepts and definitions related to child-friendly school commuting environments and constructed a multidimensional conceptual framework grounded in five critical dimensions. Second, it conducted a comparative analysis of the research methodologies used in the selected studies, highlighting the strengths, limitations, and disciplinary or regional preferences associated with different approaches. Third, it identified key research gaps and proposed future directions, emphasizing the need for more empirical validation, interdisciplinary collaboration, and context-sensitive, evidence-based approaches to urban planning and policy design.

One key contribution of this study lies in identifying critical shortcomings in existing research, particularly in terms of socio-economic disparities, and the lack of stronger frameworks for child participation, which urgently need further research and improvement to truly empower children to have a voice in urban planning. By integrating four theoretical perspectives, children's rights, participation, sustainable development, and hierarchy of needs, this study constructs a comprehensive analytical framework, thereby contributing to theoretical development in this field.

From a methodological perspective, this study provides a systematic review of interdisciplinary research methods, spatial and regional research preferences, and evolving methodological approaches in the existing literature. At the policy level, the proposed five-dimensional framework highlights key areas for improving the commuting environment, providing potential reference for future policy-making and urban

design.

As a systematic literature review, this study has inherent limitations, as it relies only on peer-reviewed academic papers and may have omitted government reports, policy documents, or community-led practical experiences, which could provide more relevant and applied insights. In addition, the selected literature is predominantly from high-income countries, which may limit its applicability to low-income countries and rapidly urbanizing regions, which face different opportunities and challenges. Nonetheless, this study provides a structured overview and framework for research on child-friendly commuting environments and lays the foundation for future empirical research.

Several critical areas warrant further exploration in future research. First, the child-friendly school commuting framework proposed in this study requires empirical research to validate the utility and integrity of the framework. Second, the framework may need to be adapted in different economic and cultural contexts by incorporating local policies as a guide. Finally, interdisciplinary collaborations between urban planning, public health, education and digital ethics can provide a more holistic approach to child-friendly commuting. In particular, future breakthroughs may come from integrating diverse data sources such as mobility data, school records, and health indicators, which could reveal complex interdependencies between children's commuting experiences and their social, physical, and emotional well-being. Although some studies involved international collaboration, no clear differences were found in methods, focus, findings, or limitations between collaborative and independent studies within developing countries. However, future research may benefit from closer and more systematic international collaborations to share expertise, data, and methodological innovations. This will require closer cooperation among urban planners, public health professionals, educators, and data scientists, who together can develop ethically sound, context-sensitive, and evidence-based strategies.

As cities continue to grow, integrating children's rights, needs, and perspectives into transportation policy is not only a moral imperative, but also a foundational step toward building more equitable, inclusive, and sustainable urban futures. Moreover, future research should systematically reflect upon and operationalize theoretical principles from children's rights, child participation, sustainable development, and psychosocial frameworks, ensuring that empirical studies and policy recommendations are consistently informed by multidimensional conceptual understandings.

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CRediT authorship contribution statement

Zhiying Quan: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. Rosilawati Binti Zainol: Writing – review & editing, Supervision, Project administration. Melasutra Binti Md Dali: Supervision.

Patient consent statement

This study does not involve any individual participants.

Consent to publish

All of the authors give consent for the publication of all identifiable details.

Ethics approval statement

The research was conducted in accordance with ethical principles.

Declaration of competing interest

The authors have no relevant financial or non-financial interests to disclose.

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Appendix A. The characteristics of the included studies

Table A.1

List of included articles with code, study area and method.

No	Title	Author (year)	Countries of affiliated institutions	International collaboration	Study area	Method
L1	Child Rights, Classroom and School Management: A Systematic Literature Review	Urinboyev et al. (2016)	Sweden	No	Global (systematic review)	Systematic literature review (42 studies from 1990 to 2014)
L2	Child-Friendly, Active, Healthy Neighborhoods: Physical Characteristics and Children's Time Outdoors	Islam et al. (2016)	Bangladesh USA	Yes	Dhaka, Bangladesh	Survey, GIS-based urban analysis, regression analysis
L3	Alarming Changes in Youth Mobility: Primary School Pupils in Novo Mesto	Plevnik et al. (2017)	Slovenia	No	Novo Mesto, Slovenia	Time-series and cross-sectional analysis
L4	Association Between the Built Environment and Children's Independent Mobility: A Meta-Analytic Review	Sharmin and Kamruzzaman (2017)	Australia	No	Global	Meta-analysis
L5	Association of Children's Mobility and Wellbeing: A Case Study in Hong Kong	Leung and Loo (2017)	Peoples R China	No	Hong Kong	Survey study (393 primary school students)
L6	Children's everyday freedoms: Local government policies on children and sustainable mobility in two Australian states	Gilbert et al. (2018)	Australia	No	Victoria & South Australia, Australia	Policy review study (Analysis of 25 child-friendly policies and 19 sustainable transport policies)
L7	Considering the Natural Environment in the Creation of Child-Friendly Cities: Implications for Children's Subjective Well-Being	Adams et al. (2019)	South Africa	No	Cape Flats, Cape Town, Western Cape Province, South Africa	Qualitative research, focus group interviews
L8	A Social-Ecological Conceptualization of Children's Mobility	Mitra and Manaugh (2020)	Canada	No	Canada, multi-country review	Social-ecological model analysis
L9	Analyzing Drawings to Explore Children's Concepts of an Ideal School	Loureiro et al. (2020)	Luxembourg	No	Luxembourg	Visual grounded theory analysis of children's drawings
L10	Children's Green Walk to School: An Evaluation of Welfare-Related Disparities in the Visibility of Greenery Among Children	Laszkiewicz and Sikorska (2020)	Poland	No	Łódź, Poland	GIS-based spatial analysis (Visibility analysis, Street Greenery Index calculation)
L11	Mental Revolution Education Strategy in Realizing Child-Friendly Schools Based on Character Education Strengthening	Ningsih (2020)	Indonesia	No	Banyumas, Indonesia	Qualitative study, observations, interviews, document analysis
L12	Bracelets around their wrists, bracelets around their worlds: materialities and mobilities in (researching) young children's lives	Cortés-Morales (2021)	Chile	No	Chile & United Kingdom	Ethnographic study (fieldwork with children and families)
L13	Paving the Way for Outdoor Play: Examining Socio-Environmental Barriers to Community-Based Outdoor Play	Loebach et al. (2021)	USA Canada	Yes	Ontario, Canada	Survey-based study with multilevel regression analysis
L14	Research on the Impact of the Built Environment on the Characteristics of Metropolis Rail Transit School Commuting—Take Wuhan as an Example	Peng et al. (2021)	Peoples R China	No	Wuhan, China	Stepwise regression, geographically weighted regression
L15	To Cross or Not to Cross: A Closer Look at Children's Decision-Making on the Road	Leung et al. (2021)	Peoples R China	No	Hong Kong	Experimental study (906 children, combining neuropsychological tests, surveys, and road-crossing experiments)
L16	A Tale of Two Cities: Unpacking the Success and Failure of School Street Interventions in Two Canadian Cities	Smith et al. (2022)	Canada	No	Kingston, ON & Montreal, QC, Canada	Critical realist evaluation, document analysis, interviews
L17	Access to and Quality of Neighbourhood Public Open Space and Children's Mental Health Outcomes: Evidence from Population Linked Data across Eight Australian Capital Cities	Alderton et al. (2022)	Australia	No	Eight Australian capital cities: Adelaide, Brisbane, Canberra, Darwin, Hobart, Melbourne, Perth, Sydney	Cross-sectional population linked data analysis; multilevel logistic regression models
L18	Associations Between the Streetscape Built Environment and Walking to School Among Primary Schoolchildren in Beijing, China	Wang et al. (2022)	Peoples R China	No	Beijing, China	Household travel survey + Street view imagery + Generalized Additive Mixed Models
L19	Child-Friendly Environments—What, How and by Whom?	Jansson et al. (2022)	Sweden	No	Sweden	Structured literature review

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Table A.1 (continued)

No	Title	Author (year)	Countries of affiliated institutions	International collaboration	Study area	Method
L20	Contributions of Social Research Methodologies to Social Change: Giving Voice to the Voiceless	Tawodzera et al. (2022)	South Africa	No	Zimbabwe	Qualitative research, interpretive phenomenological study
L21	Evaluation and Optimization of Walkability of Children's School Travel Road for Accessibility and Safety Improvement	Zhao et al. (2022)	Peoples R China	No	Tianjin, China	Space syntax analysis + GIS evaluation
L22	Is "Attending Nearby School" Near? An Analysis of Travel-to-School Distances of Primary Students in Beijing Using Smart Card Data	Liao and Dai (2022)	Peoples R China	No	Beijing, China	Quantitative analysis using smart card data
L23	More-Than-Human: A Cross-Sectional Study Exploring Children's Perceptions of Health and Health-Promoting Neighbourhoods in Aotearoa New Zealand	Williams et al. (2022)	New Zealand	No	New Zealand	Cross-sectional study (93 children, participatory methods)
L24	Parents' Perspectives on Children's Independent Mobility in Selected Rural Towns in South Africa: A Human Capabilities Perspective	Rachel et al. (2022)	South Africa	No	Rural towns in South Africa (Western Cape, Northern Cape, Free State)	Qualitative study, semi-structured interviews
L25	Play-Friendly Communities in Nova Scotia, Canada: A Content Analysis of Physical Activity and Active Transportation Strategies	Caldwell et al. (2022)	Canada USA	Yes	Nova Scotia, Canada	Content analysis (Applying Play-Friendly Cities framework to analyze community strategy documents)
L26	Relationship between Children's Independent Activities and the Built Environment of Outdoor Activity Space in Residential Neighborhoods: A Case Study of Nanjing	Zhou et al. (2022)	Peoples R China	No	Nanjing, China	Field observation, questionnaire survey, correlation analysis
L27	The Built Environment and Children's Active Commuting to School: A Case Study of San Pedro De Macoris, the Dominican Republic	Torres et al. (2022)	South Korea	No	San Pedro de Macoris, Dominican Republic	Built environment audit, surveys, statistical modeling
L28	A Bibliometric Analysis of Child-Friendly Cities: A Cross-Database Analysis from 2000 to 2022	Liao and Furuya (2023)	Japan	No	Global	Bibliometric analysis (Web of Science & CNKI databases)
L29	Adolescents' Environmental Perceptions Mediate Associations Between Streetscape Environments and Active School Travel	Wang et al. (2023)	Peoples R China Japan Netherlands	Yes	Guangzhou, China	Survey (473 adolescents) + Street view imagery + Structural Equation Modeling (SEM)
L30	Child friendliness of rural school travel road: Improvement strategies based on rural children's perception	Ding et al. (2023)	Peoples R China	No	Rural areas in Sichuan Province, China	Survey study (28 rural schools, 992 valid questionnaires) + IPA & TOPSIS models
L31	Displaced Children's Experience of Places and Play: A Scoping Review	Weir et al. (2023)	England Wales	No	Global (scoping review)	Systematic literature review (1001 studies screened, 33 included)
L32	Does children's independent mobility matter? Insights into escorting practices in a developing country	Zannat et al. (2023)	Bangladesh England	Yes	Chattogram, Bangladesh	Multinomial logistic regression analysis, travel diary survey of 398 children
L33	Exploring Associations Between Built Environment and Crash Risk of Children in School Commuting	Wu et al. (2023)	Peoples R China	No	Shenzhen, China	Traffic accident data + Mixed geographically weighted regression (MGWR)
L34	How Accessibility to Schools Is Not (Just) a Transport Problem: The Case of Public School Choice in Malmö, Sweden	Nichols and Ryan (2023)	Germany Sweden	Yes	Malmö, Sweden	Geospatial analysis, accessibility modeling
L35	Investigation of Heat Stress on Urban Roadways for Commuting Children and Mitigation Strategies from the Perspective of Urban Design	Meng et al. (2023)	Peoples R China England	Yes	Nanjing, China	Numerical simulation and field investigation
L36	Perception, Concern, Competency: Children's Understanding of Physical and Non-Physical Aspects of the Urban Environment in Iran	Manouchehri and Burns (2023)	Australia New Zealand	Yes	Iran	Qualitative research, interviews, and observations
L37	Raising Healthy Children: Promoting the Multiple Benefits of Green Open Spaces through Biophilic Design	Russo and Andreucci (2023)	England Italy	Yes	Global	Literature review and case study analysis
L38	Responsibility at a distance: Parents' accounts of their children's unaccompanied travelling	Farstad (2023)	Norway	No	Norway	Qualitative study (Interviews with parents of children aged 5–11)
L39	Spaces for Children's Play and Travel Close to Home: The Importance of Threshold Spaces	Weir (2023)	England	No	London, UK	Go-along interviews + Qualitative methods (mapping, travel diaries, workshops) with 9–10 year-olds
L40	Understanding the complexity of children's everyday mobilities: Non-instrumental aspects in sustainable transport and planning policy making in Australia	Gilbert et al. (2023)	Australia Denmark	Yes	Melbourne & Adelaide, Australia	Mixed-methods study (296 children and 84 parents surveyed)

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Table A.1 (continued)

No	Title	Author (year)	Countries of affiliated institutions	International collaboration	Study area	Method
L41	'There is a lot of traffic at the school gate in the morning which makes me nervous': Exploring Children's Current and Desired School Commutes	Tori et al. (2024)	Belgium	No	Brussels, Belgium	Surveys, workshops with children
L42	A Global Overview of Bike Bus: A Journey Toward a Child-Friendly City	Simón-i-Mas and Honey-Rosés (2024)	Spain	No	Global	Mixed-methods: archival analysis, surveys, and interviews
L43	Advancing Children's Participation Rights in Healthcare Through Play	Glos (2024)	Chile	No	Chile	Theoretical & legal analysis
L44	Beyond Car-Centred Adulthood? Exploring Parental Influences on Children's Mobility	Cadima et al. (2024)	Portugal Norway	Yes	Matosinhos & Braga, Portugal	Mixed-methods (online survey, focus groups, school director interviews)
L45	Building Child-Friendly Cities for Sustainable Child Development: Child-Friendly City Scale-Child Form	Sapsaglam and Eryilmaz (2024)	Turkiye	No	Turkey	Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA)
L46	Children as Key Actors in Participatory Planning: Co-Working Experience of Community Planning for Walking Safety Around Bongrae Elementary School in South Korea	Jung and Kim (2024)	South Korea	No	Busan, South Korea	Case study, participatory planning process
L47	Constructing Child-Friendly Cities: Comprehensive Evaluation of Street-Level Child-Friendliness Using the Method of Empathy-Based Stories, Street View Images, and Deep Learning	Yang et al. (2024)	Peoples R China USA South Korea	Yes	Nanjing, China	Comprehensive assessment (Empathy-based stories, street view images, deep learning)
L48	Evaluating the Quality of Children's Active School Travel Spaces and the Mechanisms of School District Friendliness Impact Based on Multi-Source Big Data	Lu et al. (2024)	Peoples R China	No	Lanzhou, China	Spatial analysis using GIS and big data
L49	Exposure to Greenery During Children's Home-School Walks: Socio-Economic Inequalities in Alternative Routes	Khanian, Laszkiewicz, and Kronenberg (2024)	Poland	No	Łódź, Poland	Mixed methods (Viewshed analysis, Space Syntax, Network analysis)
L50	How Do Children Move and Behave on Streets? Vision-Based Movement Behavior Analysis Using Children's Trajectories in Urban Surveillance Systems	No et al. (2024)	South Korea Turkiye	No	South Korea	Computer vision, urban surveillance analysis
L51	Non-linear Effects of Children's Daily Travel Distance on Their Travel Mode Choice Considering Different Destinations	Long et al. (2024)	Peoples R China	No	Shuangliu District, Chengdu, China	Quantitative modeling using XGBoost
L52	School Bus Transport Service Strategies' Policy-Making Mechanism – An Evolutionary Game Approach	Gu et al. (2024)	Peoples R China Australia	Yes	Suzhou, China	Evolutionary Game Theory model, case study
L53	Urban Heterogeneity of the Trade-Offs Between Exposure to Greenery and Walking Distance in Children's Home-School Routes	Khanian, Laszkiewicz, and Kronenberg (2024)	Poland	No	Łódź, Poland	Spatial data analysis (GIS, walkability networks, green space distribution)
L54	Walking to School: What Streets Do Children Prefer?	Michail and Torun (2024)	England	No	Newcastle, UK	GIS analysis and street observations
L55	A Paradigm Shift to CA in Spatial Indicators of Children's Environment: an Investigation of Children's Participation in Design and Relation to SCI: Case of CFC of BAM, 2005–2020	Kamelnia (2024)	Iran	No	Bam, Iran	Participatory action research (PAR), correlation analysis
L56	Bibliometric Analysis of Research on Child-Friendly Cities from the Web of Science, 2004–2024	Shu and Zheng (2025)	Peoples R China	No	Global	Bibliometric analysis using CiteSpace
L57	Exploring the Impact of Built Environment on Traffic Risk Perception of School-Aged Children: A Case Study of Old Residential Neighborhoods in Changsha City, Hunan Province, China	Yang et al. (2025)	Peoples R China	No	Changsha, China	Survey (404 children) + Hierarchical ordered logit model
L58	Impact of Traffic Park Use on Children's Traffic Rule Awareness and Behavioral Intentions: Case Study in Toyohashi City	Chakma et al. (2025)	Japan	No	Toyohashi City, Japan	Web-based questionnaire survey; Structural Equation Modeling (SEM)

Table A.2

List of included articles with research focuses and key findings.

No	Research focuses	Key findings	T	PH	P	G	E
L1	1. Implementation of child rights in schools 2. Teacher-pupil relations and participatory school management 3. Child rights education in school curricula	1. Schools play a critical role in enforcing child rights but face implementation challenges 2. Teacher attitudes significantly impact how children's rights are practiced in schools 3. Lack of global standardization in child rights education	0	0	0	0	1
L2	1. How neighborhood design influences children's outdoor activity 2. Built environment factors associated with time spent outdoors 3. Safety perception's role in children's mobility	1. More outdoor time is associated with adjacent open space, cul-de-sac streets, and high perceived safety. 2. Dense urban settings with limited open space reduce children's outdoor activity. 3. Boys tend to spend more time outdoors than girls in the study area.	0	1	0	0	0
L3	1. Changes in children's travel habits over 30 years 2. Impact of motorization on youth mobility 3. Role of school locations, catchment areas, and traffic regulations	1. Active school travel decreased significantly from 91 % in 1991 to 46 % in 2001, with car use rising. 2. Increased car ownership has led to higher dependence on motorized transport for school commutes. 3. Traffic management around schools has not effectively countered this trend.	1	0	1	0	0
L4	1. Relationship between built environment (BE) factors and children's independent mobility (CIM) 2. Identification of positive and negative BE influences on CIM 3. Policy implications for child-friendly urban design	1. Dead-end streets, residential land percentage, and commercial land percentage positively impact CIM. 2. High road density, major road proportion, and land-use mix negatively impact CIM. 3. Built environment factors have different effects in developed vs. developing countries.	1	0	0	0	0
L5	1. Children's mode of school travel (walking, public transport, parental accompaniment) 2. Impact of independent mobility on psychological wellbeing 3. Relationship between mobility and children's happiness	1. Children using active transport (walking) rated their journeys as happier than those using motorized transport 2. Children with independent mobility had lower happiness scores, possibly due to safety concerns 3. Self-care ability is positively correlated with children's overall wellbeing	1	0	0	0	0
L6	1. Integration of child-friendly city policies with sustainable mobility 2. Local governments' approach to children's mobility rights 3. Policy gaps and opportunities for improvement	1. There is limited integration between child-friendly policies and sustainable mobility policies. 2. Active travel (walking, cycling) is often overlooked in local transport strategies. 3. Policies tend to focus on children's safety but not their independence in mobility.	1	0	0	0	0
L7	1. Children's perceptions of the natural environment 2. Impact of nature on children's subjective well-being 3. Children's participation in community planning	1. Natural environments significantly impact children's well-being, especially in low-income communities. 2. Children desire more safe natural spaces in their communities. 3. Schools should enhance environmental education to foster children's environmental awareness.	0	1	0	1	0
L8	1. Multilevel factors influencing children's mobility 2. Role of family, community, and policy in children's independent mobility 3. How modern society impacts children's freedom of movement	1. Children's independent mobility has significantly declined due to multiple factors, including parental concerns, school policies, and urban environments. 2. Increased car dependency and parental overprotection contribute to mobility restrictions. 3. Urban planning should create safer streets and policies that encourage children's independent travel.	1	0	0	0	0
L9	1. Children's perspectives on their ideal school environment 2. Key design elements that enhance children's well-being 3. Role of school spaces in children's development	1. Children prioritize playgrounds, open spaces, and engaging classrooms. 2. Beyond physical design, children emphasize social relationships in schools. 3. Schools should incorporate children's perspectives in planning.	0	0	0	1	0
L10	1. Visibility of greenery along home-school walking routes 2. Differences in greenery exposure for low-income vs. high-income children 3. Relationship between greenery visibility and children's walking experience	1. Low-income children have less visible greenery along their routes, potentially affecting their walking experience and aesthetic enjoyment 2. Greenery visibility is lower at short distances (5–10 m) and in tree-dense areas 3. Unequal green space distribution may discourage independent walking among children	0	1	0	0	0
L11	1. Role of character education in child-friendly schools 2. Strategies for implementing mental revolution education 3. Impact of madrasa culture on student behavior	1. Humanistic education fosters a child-friendly school environment. 2. Extracurricular activities (e.g., Quran literacy, arts, sports) reinforce students' character education. 3. School culture, such as morning greetings and religious activities, strengthens moral values.	0	0	0	0	1
L12	1. The role of material objects in children's mobility 2. The interdependence between children and mobile artefacts 3. The concept of "entanglements" in children's lives	1. Mobility is not only about children's independent movement but also the objects and people around them. 2. Material objects (e.g., iPads, pushchairs, bracelets) shape children's experiences of mobility. 3. The study challenges the traditional focus on independent mobility by introducing a post-humanist perspective.	0	0	0	1	0
L13	1. Social and environmental factors influencing children's outdoor play 2. Parental perceptions of neighborhood safety 3. Impact of screen-based activities on outdoor play	1. Younger children and boys are more likely to engage in outdoor play. 2. Parental perceptions of neighborhood social cohesion positively affect outdoor play time. 3. Fear of outdoor dangers and screen-based activities reduce children's time outdoors.	0	1	0	0	0
L14	1. Built environment factors influencing school commuting via rail transit 2. Role of land use, transit station density, and accessibility 3. Relationship between urban form and children's travel behavior	1. 60 % of students commute one-way using rail transit; 88.6 % travel less than 10 km. 2. Floor area ratio, bus station density, and transfer stations positively affect student commuting volume. 3. Mixed land use and road density negatively affect commuting distance.	1	1	0	0	0

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Table A.2 (continued)

No	Research focuses	Key findings	T	PH	P	G	E
L15	1. Factors influencing children's road-crossing decisions (traffic conditions, neuropsychological traits, parental influence) 2. Relationship between age and safe decision-making 3. Impact of visual distractions on children's judgment	1. Younger children perform significantly worse in road-crossing decisions, especially when vehicles travel over 30 km/h 2. Visual distractions severely reduce children's ability to make safe decisions 3. Parents and educators should reinforce road safety training for children	1	0	0	0	0
L16	1. Implementation of School Street interventions 2. Factors influencing success or failure 3. Role of municipal and school support	1. School Street intervention succeeded in Kingston but failed in Montreal. 2. Strong municipal and school support were crucial for success. 3. Community engagement and legitimacy were key factors in implementation.	1	1	0	0	0
L17	1. Access and quality of public open space (POS) in relation to child mental health. 2. Socioeconomic inequities in POS access. 3. Maternal education as a modifier of POS effects.	1. Children with access to POS within 800 m had lower odds of mental health difficulties and higher odds of competence. 2. Child-friendly POS showed stronger associations with competence. 3. Socioeconomic gradients in access to high-quality POS.	0	1	0	0	0
L18	1. Non-linear relationships between streetscape features and walking to school 2. Impact of socio-economic status (SES) on walking behavior 3. Built environment attributes at home vs. school surroundings	1. Higher street enclosure associated with more walking 2. Children from higher-income families walk more in low-walkability neighborhoods 3. Non-linear relationship between street safety features and walking odds	1	1	0	0	0
L19	1. Definitions of child-friendly environments (CFE) 2. Key socio-physical qualities of CFE 3. The role of various stakeholders in shaping child-friendly environments	1. CFE require a balance between social and physical qualities. 2. The realization of CFE depends on safety, accessibility, and multi-stakeholder involvement. 3. Green and open spaces are crucial for child-friendly urban design.	0	1	0	1	0
L20	1. Impact of social research on policy and social change 2. Children's experiences as left-behind children (LBC) 3. Methodological challenges in social change research	1. Social research methodologies can amplify the voices of marginalized groups. 2. Left-behind children (LBC) face significant educational and emotional challenges. 3. Policy recommendations should be based on children's lived experiences.	0	0	0	0	1
L21	1. Factors affecting children's walkability for school travel 2. Assessment and optimization of children's walking routes 3. Impact of traffic flow and visual connectivity on children's pedestrian experience	1. Walking width, street connectivity, and traffic flow significantly impact children's walking safety 2. Intersection design and improvements in school-front areas can enhance safety 3. Simulation tests after optimization showed overall improvement in walkability	1	1	0	0	0
L22	1. Travel-to-school distances under the proximity-based enrollment system 2. Relationship between school commute distance and housing price 3. Impact of school gentrification on student distribution	1. Over 80 % of students traveled more than 5 km, indicating that the policy of attending nearby schools does not guarantee short commutes. 2. Long distances to school correlate negatively with house prices and building age. 3. School gentrification leads to families buying school-district houses but living far away.	1	0	0	0	0
L23	1. Children's perceptions of health and health-promoting environments 2. Role of nature, social interactions, and physical activity in child wellbeing 3. Neighborhood design and safety factors	1. Children associate health with connections to nature, social interactions, and active play 2. Neighborhood safety, proximity to green spaces, and clean air are key health-promoting factors 3. Children recognize the interdependence between human and non-human environments	0	1	0	1	0
L24	1. Parental perceptions of children's independent mobility 2. Safety concerns affecting children's freedom of movement 3. Community factors influencing mobility restrictions	1. Parents are highly concerned about community safety, leading to strict supervision of children's movements. 2. Many children are escorted to school or rely on arranged transport, limiting their independence. 3. Stakeholders need to promote safe, child-friendly environments to restore children's independent mobility.	1	0	1	0	0
L25	1. Children's participation in decision-making 2. Safe and active routes around the community 3. Safe and accessible informal play environments 4. Evidence-informed design of formal play spaces	1. Community strategies paid little attention to children's participation in decision-making, while focusing more on safe and active routes. 2. Most community strategies aim to provide safer walking and cycling environments by improving infrastructure and street design. 3. Some communities addressed accessibility, but there was limited discussion on informal play environments for children.	0	1	0	0	0
L26	1. Relationship between children's independent activities (CIAs) and outdoor built environments 2. The role of residential neighborhood design in fostering CIAs 3. Parents' safety concerns and their impact on CIAs	1. Higher tree coverage and soft paving promote CIAs, while high functional mix inhibits them 2. Gated communities, high residential density, and diverse activity facilities encourage CIAs 3. Parents prioritize site safety, and previous incidents at locations reduce willingness to allow CIAs	1	1	1	0	0
L27	1. Relationship between built environment and children's active commuting 2. Differences between public and private school students' commuting behaviors 3. Impact of land use, safety, and infrastructure on mobility	1. Public school students were nearly four times more likely to walk or bike to school than private school students. 2. Safety concerns, such as abandoned buildings and industrial land use, significantly reduce active commuting. 3. Children in high-traffic areas were more likely to walk due to lack of alternative transport.	1	1	0	0	0
L28	1. Global and domestic research trends on child-friendly cities (CFCs) 2. Key themes, hotspots, and research gaps in CFC studies 3. Policy implications for CFC development	1. CFC research is increasing globally, with different focuses in Western and Chinese studies. 2. Economic development influences the advancement of CFC research and construction. 3. There is a need to expand child participation in urban planning.	0	0	1	0	0
L29	1. Objective vs. perceived streetscape characteristics 2. Perceived safety, walkability, and air pollution as mediators	1. Street safety, vitality, greenery, and vehicle volume positively related to AST 2. Higher pavement ratio associated with lower AST 3. Perceived walkability and air pollution mediate AST decisions	1	1	0	0	0

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Table A.2 (continued)

No	Research focuses	Key findings	T	PH	P	G	E
L30	3. Built environment factors influencing active school travel (AST)						
	1. Key factors affecting child-friendliness of rural school travel roads	1. Rural children identified sidewalks, crosswalks, speed limit signs, traffic signals, and speed bumps as the most important but least available infrastructure.	1	0	0	0	0
	2. Differences between children's perceived importance and satisfaction with their travel environment	2. Children were relatively satisfied with road width, maintenance, and lighting conditions.					
L31	3. Priority ranking for rural road improvements	3. The study proposed child-centered strategies to improve rural school travel safety.					
	1. Experience of place among displaced children	1. Place attachment helps displaced children develop stability and well-being	0	0	0	1	0
	2. Role of place attachment in well-being	2. Play opportunities aid in adapting to new environments					
L32	3. Impact of play on adaptation and resilience	3. Displaced children often lack access to child-friendly spaces					
	1. Factors influencing children's independent mobility	1. Children's individual factors (e.g., education level) and household socioeconomic status significantly influence independent mobility	1	0	0	0	0
	2. Analysis of parental escorting practices	2. School facilities and surrounding environments affect parental willingness to allow independent school travel					
L33	3. Impact of housing, income, and school environment on children's mobility	3. Children from low-income families are more likely to travel independently but face higher safety risks					
	1. Built environment factors influencing crash risk (CR)	1. Higher road network density and more bus routes increase CR	1	0	0	0	0
	2. Spatial-temporal heterogeneity in CR	2. On-street parking and well-planned educational facilities reduce CR					
L34	3. Impact of road network density, bus routes, and parking on safety	3. MGWR model outperforms other spatial models in predicting CR					
	1. Impact of school admission policies on school accessibility	1. Changes in school admission policy significantly altered school accessibility and socioeconomic distribution.	0	0	1	0	0
	2. Role of public transport investment in accessibility	2. Public transport investments affected accessibility but did not fully mitigate socioeconomic disparities.					
L35	3. Socioeconomic redistribution in school access	3. Independent mobility of teenagers plays a crucial role in school access.					
	1. Impact of urban heat stress on children's school commutes	1. Building shade reduces surface temperatures by 3.22 °C to 21.25 °C, which is more effective than tree shade (0.02 °C to 6.04 °C).	1	1	0	0	0
	2. Effects of building shade, road orientation, and tree species on roadway temperature	2. Increasing shaded areas along north-south roads significantly mitigates heat stress (in the Northern Hemisphere).					
L36	3. Urban design strategies for mitigating children's heat stress	3. Strategic tree planting can enhance thermal comfort along school routes.					
	1. Children's perceptions of urban environments	1. Children recognize deficiencies in urban environments, such as a lack of safe play spaces and uneven distribution of urban facilities.	0	0	0	1	0
	2. Children's concerns about urban space usage	2. Children express needs beyond UNICEF guidelines, including higher social integration and a stronger sense of belonging.					
L37	3. Children's autonomy in urban environments	3. Urban planning should integrate children's perspectives to create truly child-friendly environments.					
	1. Relationship between green open spaces and children's well-being	1. Green spaces improve children's mental health, cognitive development, and social interactions.	0	1	0	0	1
	2. Biophilic design principles for child-friendly spaces	2. Lack of urban greenery is linked to increased childhood obesity, stress, and behavioral issues.					
L38	3. Health and psychological benefits of nature exposure	3. Biophilic design can enhance children's physical and psychological well-being, supporting urban sustainability.					
	1. Parents' perspectives on children traveling alone	1. Parents who let children travel alone often feel the need to justify their decisions due to social scrutiny.	0	0	0	1	0
	2. Social expectations of responsible parenting	2. Parents use strategies such as emphasizing children's competence and preparedness to construct a responsible image.					
L39	3. Discursive strategies used by parents to justify children's independent travel	3. Despite concerns about public perception, some parents support children's independence for skill development.					
	1. Role of "threshold spaces" (semi-public transition spaces) in play and mobility	1. Threshold spaces (e.g., courtyards, driveways) are critical for children's play and mobility	0	0	0	1	0
	2. Gender differences in play and space perception	2. Girls are more sensitive to environmental signals that encourage play					
L40	3. Interaction between play and independent mobility	3. Children's mobility includes meandering and playfulness, not just destination-based travel					
	1. Non-instrumental factors in children's mobility decisions	1. Children's travel decisions are influenced by emotional, social, and cultural factors beyond simple distance and time considerations.	0	0	0	1	0
	2. The impact of car dependency on sustainable mobility	2. Australian parents tend to prefer car transport for safety, convenience, and habit.					
L41	3. Household dynamics in transport choices	3. Sustainable transport policies often fail to integrate child-friendly mobility solutions.					
	1. Children's perspectives on school commutes	1. There is a significant gap between children's current and preferred travel modes, with cycling being highly desired but underutilized.	1	1	0	0	0
	2. Barriers to active mobility (walking, cycling)	2. Traffic safety is a major concern, affecting children's willingness to walk or cycle.					
L42	3. Impact of urban design on children's travel behavior	3. Children's key suggestions include better walking/cycling infrastructure and restricting car access near schools.					
	1. Origins and development of Bike Bus initiatives	1. Bike Bus initiatives have grown rapidly worldwide, driven by social media and climate action movements.	1	0	0	0	0
	2. Impact of Bike Bus on children's mobility and urban cycling culture	2. The average Bike Bus has 29 participants and covers 2.8 km per trip.					
L43	3. Policy recommendations for integrating Bike Bus into child-friendly cities	3. Long-term sustainability depends on funding and local government collaboration.					
	1. Children's right to participate in healthcare	1. Play can help children process medical information and participate without fear.	0	0	0	0	1
	2. The role of play in making medical processes more child-friendly	2. The right to play (Article 31 of the UNCRC) is often overlooked in healthcare.					

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Table A.2 (continued)

No	Research focuses	Key findings	T	PH	P	G	E
L44	3. Legal and philosophical arguments for play as a participation tool 1. Parental decision-making in children's mobility 2. Barriers/enablers to independent mobility 3. Impact of car-centric urban planning on children's autonomy	3. Play should be recognized as a means to strengthen children's participation in medical decision-making. 1. Car-centric urban planning and parental safety concerns significantly restrict children's independent mobility. 2. Parents' reliance on cars is reinforced by time constraints, work routines, and safety concerns. 3. Schools can play a role in promoting walking and cycling through interventions.	1	0	1	0	0
L45	1. Development of the Child-Friendly City Scale-Child Form 2. Validation of the scale through empirical testing 3. Impact of urban environment on children's development	1. The scale identifies eight dimensions of child-friendly cities. 2. The tool is validated and reliable for assessing children's perceptions of urban environments. 3. Child-friendly cities significantly contribute to children's well-being and development.	0	1	0	0	0
L46	1. Children's role in participatory urban planning 2. Community planning for school zone safety 3. Impact of children's participation on urban design	1. Children actively contribute to urban planning when engaged through structured processes. 2. Participatory tools like mapping and workshops enhance children's involvement in decision-making. 3. School zone safety improvements should incorporate children's perspectives.	0	0	1	1	0
L47	1. Analyzing urban child-friendliness through street view image analysis 2. Using deep learning techniques to assess the suitability of street environments for children	1. The method effectively identifies child-friendly street characteristics 2. Machine learning models can extract child-friendliness elements from large-scale street view images 3. Data-driven assessment provides a valuable reference for child-friendly city development	1	0	1	1	0
L48	1. Quality of active school travel spaces (ASTS) 2. Impact of school district characteristics on child-friendly commuting 3. Spatial distribution of child-friendliness in school routes	1. Child-friendliness of school travel spaces varies significantly across districts. 2. Population density and transportation accessibility positively impact friendliness. 3. School size and centrality negatively affect friendliness.	1	1	0	0	0
L49	1. Greenery exposure in different home-school routes (shortest, easiest, greenest) 2. Socio-economic disparities in greenery exposure 3. Walkability and environmental justice	Children from lower socio-economic status (SES) are exposed to less greenery during their home-school walks compared to higher SES children, even when choosing the "greenest" route	1	1	1	0	0
L50	1. Children's movement behaviors on streets 2. Impact of urban environment on children's mobility 3. Applications of AI in urban planning for child-friendly spaces	1. Identified five movement behaviors: walking, staying, running, accelerating, and decelerating. 2. Street environments influence children's movement choices and behavior patterns. 3. Vision-based analysis provides scalable insights into child-friendly urban planning.	1	0	0	0	0
L51	1. Relationship between children's travel distance and mode choice 2. Threshold effects in travel behavior 3. Community planning for child-friendly mobility	1. Travel distance has a significant non-linear effect on mode choice, with threshold effects observed. 2. Walking is preferred for short distances, while longer distances lead to non-walking modes. 3. Child-friendly city planning should integrate travel behavior insights.	1	0	0	0	0
L52	1. Decision-making process of school bus transport policies 2. Interaction between schools and governments in transport policy 3. Cost-benefit equilibrium in school transport services	1. When both schools and governments provide services, schools tend to withdraw due to competition. 2. Policy interventions (e.g., financial incentives, service improvements) can help maintain equilibrium in school transport services. 3. Public school bus services reduce traffic congestion and improve environmental sustainability.	1	0	0	0	0
L53	1. Trade-offs between walking distance and greenery exposure 2. Differences in greenery exposure between urban core and outer areas 3. The role of green space distribution in walkability	1. Choosing the greenest route increases greenery exposure by 18 % but extends walking distance by 9.5 % (46 m) 2. Children in urban cores face a greater trade-off between walking distance and greenery exposure 3. Uneven green space distribution affects children's walking accessibility	1	1	1	0	0
L54	1. Children's route choices for walking to school 2. Urban design factors influencing children's commuting experience 3. Street planning strategies to promote active school travel	1. Children prefer streets with high connectivity, wide sidewalks, and visually appealing elements. 2. Traffic calming measures (e.g., speed limits, wide sidewalks) significantly enhance children's walking safety perception. 3. Space syntax analysis shows that streets with higher accessibility and visibility have higher walking-to-school rates.	1	0	1	0	0
L55	1. Relationship between sense of community (SCI) and children's spatial preferences 2. Changes in children's design priorities over time 3. Long-term impacts of participatory design in child-friendly cities	1. High SCI correlates with stable design priorities over time. 2. Children prioritize green spaces, shaded areas, and natural elements in urban design. 3. Participatory design in child-friendly cities fosters a strong sense of community.	0	0	0	1	0
L56	1. Research trends on child-friendly cities (CFC) 2. Key themes and research hotspots 3. Influence of policy, urban planning, and environmental sustainability on CFC research	1. CFC research has increased significantly since 2017. 2. Top research themes include urban sustainability, child participation, and environmental risks. 3. The field is highly interdisciplinary, involving urban planning, public health, and environmental studies.	0	0	1	0	0
L57	1. Individual and environmental factors affecting traffic risk perception 2. Influence of obstructed views, road damage, and parking on safety perception 3. Gender differences in perceived risk	1. Girls report higher perceived traffic risks than boys 2. Low population density and well-maintained roads reduce perceived risk 3. Obstructed intersections and curbside parking increase risk perception	1	1	0	0	0
L58	1. Impact of Traffic Park (TP) use on children's traffic rule awareness.	1. TP use before school significantly improves traffic rule awareness ($\beta = 0.16$) and behavioral intentions ($\beta = 0.09$).	1	0	0	0	0

(continued on next page)

Table A.2 (continued)

No	Research focuses	Key findings	T	PH	P	G	E
2.	Impact of TP use on children's behavioral intentions.	2. TP use after school has no significant effect.					
3.	Effect of TP use before and after school entry.	3. Awareness indirectly improves behavioral intentions ($\beta = 0.74$).					

T = transportation, PH = public health, P = planning, G = geography, E = education

Data availability

The data that support the findings of this study are available upon reasonable request.

References

Abatay, G. (2019). *Children's active commuting to schools in different neighbourhoods: Design of streets as child friendly environments*. Turkey: Izmir Institute of Technology.

Adams, S., Savahl, S., Florence, M., & Jackson, K. (2019). Considering the natural environment in the creation of child-friendly cities: Implications for children's subjective well-being. *Child Indicators Research*, 12(2), 545–567. <https://doi.org/10.1007/s12187-018-9531-x>

Agyeman, S., Alimo, P. K., Donkoh, V., & Cheng, L. (2023). Toward cleaner production of walking school buses and bicycle trains: A systematic review. *Journal of Cleaner Production*, 426, Article 139031. <https://doi.org/10.1016/j.jclepro.2023.139031>

Ahmad Muthafa, A. (2021). Realizing a child friendly city as protection towards children in Indonesia. *Constitutionale*, 2(2), 89–102. <https://doi.org/10.25041/constitutionale.v2i2.2420>

Alderton, A., O'Connor, M., Badland, H., Gunn, L., Boulange, C., & Villanueva, K. (2022). Access to and quality of neighbourhood public open space and children's mental health outcomes: Evidence from population linked data across eight Australian capital cities. *International Journal of Environmental Research and Public Health*, 19 (11), Article 6780. <https://doi.org/10.3390/ijerph19116780>

Bakar, H. A. (2017). Pemetaan Pusat Pelayanan Terpadu Pemberdayaan Perempuan dan Anak (P2TP2A) Provinsi Sumatera Barat. *Kafa'ah: Journal of Gender Studies*, 7(1), 107–122.

Björklid, P., & Nordström, M. (2007). Environmental child-friendliness: Collaboration and future research. *Children, Youth & Environments*, 17(4), 388–401. <https://search.ebscohost.com/login.aspx?direct=true&AuthType=shib&db=sih&AN=31380679&site=eds-live&custid=s8370378>

Bridgman, R. (2004). Child-friendly cities: Canadian perspectives. *Children, Youth and Environments*, 14(2), 178–200.

Buliung, R. N., Mitra, R., & Faulkner, G. (2009). Active school transportation in the Greater Toronto Area, Canada: An exploration of trends in space and time (1986–2006). *Preventive Medicine*, 48(6), 507–512.

Cadima, C., von Schönfeld, K., & Ferreira, A. (2024). Beyond car-centred adulthood? Exploring parental influences on children's mobility. *Urban Planning*, 9, Article 8643. <https://doi.org/10.17645/up.8643>

Caldwell, H. A., Yusuf, J., Arthur, M., Friesen, C. L. H., & Kirk, S. F. (2022). Play-friendly communities in Nova Scotia, Canada: A content analysis of physical activity and active transportation strategies. *International Journal of Environmental Research and Public Health*, 19(5), Article 2984. <https://doi.org/10.3390/ijerph19052984>

Carroll, P., Witten, K., Kearns, R., & Donovan, P. (2015). Kids in the City: Children's use and experiences of urban neighbourhoods in Auckland, New Zealand. *Journal of Urban Design*, 20(4), 417–436.

Chakma, M., Matsuo, K., & Sugiki, N. (2025). Impact of traffic park use on children's traffic rule awareness and behavioral intentions: Case study in Toyohashi City. *Sustainability*, 17(3), Article 937. <https://doi.org/10.3390/su17030937>

Corsi, M. (2002). The child friendly cities initiative in Italy. *Environment and Urbanization*, 14(2), 169–179.

Cortés-Morales, S. (2021). Bracelets around their wrists, bracelets around their worlds: Materialities and mobilities in (researching) young children's lives. *Childrens Geographies*, 19(3), 364–376. <https://doi.org/10.1080/14733285.2020.1789559>

Ding, P., & Feng, S. (2022). How school travel affects children's psychological well-being and academic achievement in China. *International Journal of Environmental Research and Public Health*, 19(21), Article 13881.

Ding, X., Ao, Y., & Bahmani, H. (2023). Child friendliness of rural school travel road: Improvement strategies based on rural children's perception. *JOURNAL OF TRANSPORT & HEALTH*, 32, Article 101674. <https://doi.org/10.1016/j.jth.2023.101674>

Easton, S., & Ferrari, E. (2015). Children's travel to school—The interaction of individual, neighbourhood and school factors. *Transport Policy*, 44, 9–18.

Farstad, I. E. (2023). Responsibility at a distance: Parents' accounts of their children's unaccompanied travelling. *Childrens Geographies*, 21(3), 533–546. <https://doi.org/10.1080/14733285.2022.2084602>

Faulkner, G. E., Buliung, R. N., Flora, P. K., & Fusco, C. (2009). Active school transport, physical activity levels and body weight of children and youth: A systematic review. *Preventive Medicine*, 48(1), 3–8.

Ferguson, L. (2013). Not merely rights for children but children's rights: The theory gap and the assumption of the importance of children's rights. *The International Journal of Children's Rights*, 21(2), 177–208. <https://doi.org/10.1163/15718182-55680015>

Freeman, C., & Tranter, P. (2012). *Children and their urban environment: Changing worlds*. Routledge.

Friman, M., Westman, J., & Olsson, L. E. (2019). Children's life satisfaction and satisfaction with school travel. *Child Indicators Research*, 12, 1319–1332.

Gemmell, E., Ramsden, R., Brussoni, M., & Brauer, M. (2023). Influence of neighborhood built environments on the outdoor free play of young children: A systematic, mixed-studies review and thematic synthesis. *Journal of Urban Health*, 100(1), 118–150.

Gilbert, H., Lanng, D. B., Wind, S., & Allan, A. (2023). Understanding the complexity of children's everyday mobilities: Non-instrumental aspects in sustainable transport and planning policy making in Australia. *Applied Mobilities*, 8(4), 341–360. <https://doi.org/10.1080/23800127.2022.2071060>

Gilbert, H., Whitzman, C., Pieters, J., & Allan, A. (2018). Children's everyday freedoms: Local government policies on children and sustainable mobility in two Australian states. *Journal of Transport Geography*, 71, 116–129. <https://doi.org/10.1016/j.jtrangeo.2018.07.007>

Gill, T. (2008). Space-oriented children's policy: Creating child-friendly communities to improve children's well-being. *Children & Society*, 22(2), 136–142. <https://doi.org/10.1111/j.1099-0860.2007.00139.x>

Glos, A. (2024). Advancing children's participation rights in healthcare through play. *International Journal of Childrens Rights*, 32(3), 799–830. <https://doi.org/10.1163/15718182-32030007>

Gu, T., Xu, W., Liang, H., He, Q., & Zheng, N. (2024). School bus transport service strategies' policy-making mechanism - An evolutionary game approach. *Transportation Research Part A-Policy and Practice*, 182, Article 104014. <https://doi.org/10.1016/j.tra.2024.104014>

Hardy, R. Y., Boch, S. J., Davenport, M. A., Chavez, L. J., & Kelleher, K. J. (2024). Rural-urban differences in social and emotional protective factors and their association with child health and flourishing. *The Journal of Rural Health*, 40(2), 314–325.

Hart, R. A. (1992). *Children's participation: From tokenism to citizenship*. *Innocenti essays no. 4* (978-88-85401-05-11014-7829).

Hillman, M. (1990). *One false move: A study of children's independent mobility*. Policy Studies Institute XLV.

Islam, M. Z., Moore, R., & Cosco, N. (2016). Child-friendly, active, healthy neighborhoods: Physical characteristics and children's time outdoors. *Environment and Behavior*, 48(5), 711–736. <https://doi.org/10.1177/0013916514554694>

Jansson, M., Herbert, E., Zalar, A., & Johansson, M. (2022). Child-friendly environments—What, how and by whom? *Sustainability (2071-1050)*, 14(8). <https://doi.org/10.3390/su14084852>

Jeremic, V., Sénécal, K., Borry, P., Chokoshvili, D., & Vears, D. F. (2016). Participation of children in medical decision-making: Challenges and potential solutions. *Journal of Bioethical Inquiry*, 13(4), 525–534.

Johansson, M. (2006). Environment and parental factors as determinants of mode for children's leisure travel. *Journal of Environmental Psychology*, 26(2), 156–169.

Jung, B.-K., & Kim, D. (2024). Children as key actors in participatory planning: Co-working experience of community planning for walking safety around bongrae elementary school in south korea. *Planning Theory & Practice*, 25(3), 321–351. <https://doi.org/10.1080/14649357.2024.2363790>

Kamelnia, H. (2024). A paradigm shift to CA in spatial indicators of children's environment: An investigation of children's participation in design and relation to SCI: Case of CFC of BAM, 2005-2020. *Child Indicators Research*. <https://doi.org/10.1007/s12187-024-10191-w>

Keeble, B. R. (1988). The Brundtland report: 'Our common future'. *Medicine and War*, 4 (1), 17–25.

Khanian, M., Laszkiewicz, E., & Kronenberg, J. (2024). Exposure to greenery during children's home-school walks: Socio-economic inequalities in alternative routes. *Transportation Research Part D-Transport and Environment*, 130, Article 104162. <https://doi.org/10.1016/j.trd.2024.104162>

Lansdown, G. (2005). *The evolving capacities of the child*.

Laszkiewicz, E., & Sikorska, D. (2020). Children's green walk to school: An evaluation of welfare-related disparities in the visibility of greenery among children. *Environmental Science & Policy*, 110, 1–13. <https://doi.org/10.1016/j.envsci.2020.05.009>

Leung, K. Y., & Loo, B. P. (2017). Association of children's mobility and wellbeing: A case study in Hong Kong. *Travel Behaviour and Society*, 9, 95–104. <https://doi.org/10.1016/j.tbs.2017.07.004>

Leung, K. Y., Loo, B. P., Tsui, K., So, F., & Fok, E. (2021). To cross or not to cross: A closer look at children's decision-making on the road. *Transportation Research Part A-Policy and Practice*, 149, 1–11. <https://doi.org/10.1016/j.tra.2021.04.011>

Li, S., & Zhao, P. (2015). The determinants of commuting mode choice among school children in Beijing. *Journal of Transport Geography*, 46, 112–121.

Liao, C., & Dai, T. (2022). Is "attending nearby school" near? An analysis of travel-to-school distances of primary students in Beijing using smart card data. *Sustainability*, 14(7), Article 4344. <https://doi.org/10.3390/su14074344>

Liao, Y., & Furuya, K. (2023). A bibliometric analysis of child-friendly cities: A cross-database analysis from 2000 to 2022. *Land*, 12(10), Article 1919. <https://doi.org/10.3390/land12101919>

Lidbe, A., Li, X., Adanu, E. K., Nambisan, S., & Jones, S. (2020). Exploratory analysis of recent trends in school travel mode choices in the U.S. *Transportation Research*

- Interdisciplinary Perspectives*, 6, Article 100146. <https://doi.org/10.1016/j.trip.2020.100146>
- Loebach, J., Sanches, M., Jaffe, J., & Elton-Marshall, T. (2021). Paving the way for outdoor play: Examining socio-environmental barriers to community-based outdoor play. *International Journal of Environmental Research and Public Health*, 18(7), Article 3617. <https://doi.org/10.3390/ijerph18073617>
- Long, Y., Ao, Y., Li, H., Bahmani, H., & Li, M. (2024). Non-linear effects of children's daily travel distance on their travel mode choice considering different destinations. *Journal of Transport Geography*, 118, Article 103921. <https://doi.org/10.1016/j.jtrangeo.2024.103921>
- Loureiro, K. S., Grecu, A., de Moll, F., & Hadjar, A. (2020). Analyzing drawings to explore children's concepts of an ideal school: Implications for the improvement of children's well-being at school. *Child Indicators Research*, 13(4), 1387–1411. <https://doi.org/10.1007/s12187-019-09705-8>
- Lu, C., Yu, C., & Liu, X. (2024). Evaluating the quality of children's active school travel spaces and the mechanisms of school district friendliness impact based on multi-source big data. *Land*, 13(8), Article 1319. <https://doi.org/10.3390/land13081319>
- Malone, K. (2001). Children, youth and sustainable cities. *Local Environment*, 6(1), 5–12.
- Manouchehri, B., & Burns, E. A. (2023). Perception, concern, competency: children's understanding of physical and non-physical aspects of urban environment in Iran. *Children's Geographies*, 21(1), 147–162. <https://doi.org/10.1080/14733285.2021.2011836>
- Maslow, A. (1943). A theory of human motivation. *Psychological Review*, 2, 21–28. google schola.
- Masoumi, H. E. (2017). Associations of built environment and children's physical activity: A narrative review. *Reviews on Environmental Health*, 32(4), 315–331.
- McDaniel, C. E., Hall, M., Markham, J. L., Bettenhausen, J. L., & Berry, J. G. (2023). Urban-rural hospitalization rates for pediatric mental health. *Pediatrics*, 151(6).
- McDonald, N. C. (2007). Active transportation to school: Trends among US schoolchildren, 1969–2001. *American Journal of Preventive Medicine*, 32(6), 509–516.
- McDonald, N. C. (2008). Children's mode choice for the school trip: The role of distance and school location in walking to school. *Transportation*, 35, 23–35.
- McKendrick, J. H., Bradford, M. G., & Fielder, A. V. (2000). Kid customer? Commercialization of playspace and the commodification of childhood. *Childhood*, 7(3), 295–314.
- Meng, Y., Wang, J., Xi, C., Han, L., Feng, Z., & Cao, S.-J. (2023). Investigation of heat stress on urban roadways for commuting children and mitigation strategies from the perspective of urban design. *Urban Climate*, 49, Article 101564. <https://doi.org/10.1016/j.uclim.2023.101564>
- Michail, N., & Torun, A. O. (2024). Walking to school: What streets do children prefer? *Urban Planning*, 9, Article 8460. <https://doi.org/10.17645/up.8460>
- Miller, P., & Votruba-Drzal, E. (2013). Early academic skills and childhood experiences across the urban-rural continuum. *Early Childhood Research Quarterly*, 28(2), 234–248. <https://doi.org/10.1016/j.jecresq.2012.12.005>
- Mishra, A., Zhou, B., Rodriguez-Martinez, A., Bixby, H., Singleton, R. K., Carrillo-Larco, R. M., ... Savin, S., & Collaboration, N. C. D. R. F. (2023). Diminishing benefits of urban living for children and adolescents' growth and development. *Nature*, 615(7954), 874–883. <https://doi.org/10.1038/s41586-023-05772-8>
- Mitra, R., & Buliung, R. N. (2012). Built environment correlates of active school transportation: Neighborhood and the modifiable areal unit problem. *Journal of Transport Geography*, 20(1), 51–61.
- Mitra, R., & Manaugh, K. (2020). A social-ecological conceptualization of children's mobility. <https://doi.org/10.1016/b978-0-12-814694-1.00005-1>
- Nam, H., & Nam, S. I. (2018). Child-friendly city policies in the Republic of Korea. *Children and Youth Services Review*, 94, 545–556.
- Nichols, A., & Ryan, J. (2023). How accessibility to schools is not (just) a transport problem: The case of public school choice in the city of Malmö, Sweden. *European Transport Research Review*, 15(1), Article 41. <https://doi.org/10.1186/s12544-023-00617-x>
- Ningsih, T. (2020). Mental revolution education strategy in realizing child-friendly schools based on character education strengthening. *Akademika*, 90(1), 113–122. <https://doi.org/10.15756/akad-2020-9001-10>
- No, W., Choi, J., & Kim, Y. (2024). How do children move and behave on streets? Vision-based movement behavior analysis using children's trajectories in urban surveillance systems. *Applied Geography*, 162, Article 103170. <https://doi.org/10.1016/j.apgeog.2023.103170>
- Noverman, D., Novita, T., & Rahmah Dianti, P. (2018). Acceleration model of child-friendly city/district in Lampung Province. *Jurnal Bina Praja*, 10(1), 147–157. <https://doi.org/10.21787/jbp.10.2018.147-157>
- Oh, H., Kim, S., & Jeon, Y. (2015). A study of Youth Happiness Community's Index and Construction Project III: The pilot project and developing strategies for establishing the youth happiness community. National Youth Policy Institute.
- Ortiz-Hernández, L., Vega-López, A. V., & Ayala-Hilario, C. (2019). Commuting to school among Mexican schoolchildren and adolescents. *Boletín médico del Hospital Infantil de México*, 76(5), 225–236.
- Peng, J., Qi, J., Cui, C., Yan, J., Dai, Q., & Yang, H. (2021). Research on the impact of the built environment on the characteristics of metropolis rail transit school commuting-Take Wuhan as an example. *International Journal of Environmental Research and Public Health*, 18(18), Article 9885. <https://doi.org/10.3390/ijerph18189885>
- Petticrew, M., & Roberts, H. (2008). *Systematic reviews in the social sciences: A practical guide*. John Wiley & Sons.
- Plevnik, A., Balant, M., & Mladenovic, L. (2017). Alarming changes in youth mobility: Primary school pupils in Novo Mesto. *Urbani Izvizi-Urban Challenge*, 28(2), 149–158. <https://doi.org/10.5379/urbani-izvizi-en-2017-28-02-006>
- Pont, K., Wadley, D., Ziviani, J., & Khan, A. (2013). The influence of urban form and family decision making on children's travel to school. *Journal of Urban Design*, 18(3), 363–382.
- Rachel, C., Roman, N. V., Vickerman, S. A., & Donga, G. T. (2022). Parents' perspectives on children's independent mobility in selected rural towns in South Africa: A human capabilities perspective. *Social Sciences-Basel*, 11(12), Article 540. <https://doi.org/10.3390/socsci11120540>
- Riazi, N. A., Wunderlich, K., Yun, L., Paterson, D. C., & Faulkner, G. (2022). Social-ecological correlates of children's independent mobility: A systematic review. *International Journal of Environmental Research and Public Health*, 19(3), Article 1604.
- Ross, C. E. (2000). Walking, exercising, and smoking: does neighborhood matter? *Social Science & Medicine*, 51(2), 265–274.
- Ross, N. J. (2007). 'My journey to school...': Foregrounding the meaning of school journeys and children's engagements and interactions in their everyday localities. *Children's Geographies*, 5(4), 373–391.
- Russo, A., & Andreucci, M. B. (2023). Raising healthy children: Promoting the multiple benefits of green open spaces through biophilic design. *Sustainability*, 15(3), Article 1982. <https://doi.org/10.3390/su15031982>
- Sapsaglam, Ö., & Eryilmaz, A. (2024). Building child-friendly cities for sustainable child development: Child-Friendly City Scale-Child Form. *Sustainability*, 16(3), Article 1228. <https://doi.org/10.3390/su16031228>
- Sharmin, S., & Kamruzzaman, M. (2017). Association between the built environment and children's independent mobility: A meta-analytic review. *Journal of Transport Geography*, 61, 104–117. <https://doi.org/10.1016/j.jtrangeo.2017.04.004>
- Shaw, B., Watson, B., Frauendienst, B., Redecker, A., Jones, T., & Hillman, M. (2013). *Children's independent mobility: A comparative study in England and Germany (1971–2010)*. Policy Studies Institute.
- Shu, H., & Zheng, G. (2025). Bibliometric analysis of research on child-friendly cities from the Web of Science, 2004–2024. *Sustainability*, 17(2), Article 525. <https://doi.org/10.3390/su17020525>
- Simón-i-Mas, G., & Honey-Rosés, J. (2024). A global overview of Bike Bus: A journey toward a child-friendly city. *International Journal of Sustainable Transportation*, 18(12), 1012–1025. <https://doi.org/10.1080/15568318.2024.2432654>
- Smith, L. E., Gosselin, V., Collins, P., & Fröhlich, K. L. (2022). A tale of two cities: Unpacking the success and failure of school street interventions in two Canadian cities. *International Journal of Environmental Research and Public Health*, 19(18), Article 11555. <https://doi.org/10.3390/ijerph191811555>
- Tawodzera, M. C., Mabasa, L. T., & Themane, M. (2022). Contributions of social research methodologies to social change: Giving voice to the voiceless. *International Journal of Qualitative Methods*, 21. <https://doi.org/10.1177/16094069211072417>
- Tori, S., Pappers, J., Martinez Ramirez, L., & Kesperu, I. (2024). 'There is a lot of traffic at the school gate in the morning which makes me nervous': Exploring children's current and desired school commutes. *Children's Geographies*, 22(6), 926–943. <https://doi.org/10.1080/14733285.2024.2401500>
- Torres, M. A., Oh, H. W., & Lee, J. (2022). The built environment and children's active commuting to school: A case study of San Pedro de Macoris, the Dominican Republic. *Land*, 11(9), Article 1454. <https://doi.org/10.3390/land11091454>
- Tranter, P., & Sharpe, S. (2008). Escaping Monstropolis: Child-friendly cities, peak oil and Monsters. *Children's Geographies*, 6(3), 295–308. <https://search.ebscohost.com/login.aspx?direct=true&AuthType=shib&db=edsbl&AN=RN234090031&site=eds-live&custid=s8370378>
- Unicef. (1989). *Convention on the rights of the child*.
- United Nations Children's Fund. (2001). *Partnerships to create child-friendly cities: Programming for child rights with local authorities*. New York: UNICEF/IULA.
- United Nations Children's Fund. (2018). *Child friendly cities and communities handbook*. U. N. C. S. F. (UNICEF). <https://www.unicef.org/reports/child-friendly-cities-and-communities-handbook>
- Urinboyev, R., Wickenberg, P., & Leo, U. (2016). Child rights, classroom and school management: A systematic literature review. *International Journal of Children's Rights*, 24(3), 522–547. <https://doi.org/10.1163/15718182-02403002>
- Valentine, G. (1997). "Oh Yes I Can." "Oh no you can't": Children and parents' understandings of kids' competence to negotiate public space safely. *Antipode*, 29(1), 65–89.
- Vitale, M., Millward, H., & Spinney, J. (2019). School siting and mode choices for school travel: Rural-urban contrasts in Halifax, Nova Scotia, Canada. *Case Studies on Transport Policy*, 7(1), 64–72. <https://doi.org/10.1016/j.cstp.2018.11.008>
- Wang, X., Liu, Y., Yao, Y., Zhou, S., Zhu, Q., Liu, M., & Helbich, M. (2023). Adolescents' Environmental perceptions mediate associations between streetscape environments and active school travel. *Transportation Research Part D-Transport and Environment*, 114, Article 103549. <https://doi.org/10.1016/j.trd.2022.103549>
- Wang, X., Liu, Y., Zhu, C., Yao, Y., & Helbich, M. (2022). Associations between the streetscape built environment and walking to school among primary schoolchildren in Beijing, China. *Journal of Transport Geography*, 99, Article 103303. <https://doi.org/10.1016/j.jtrangeo.2022.103303>
- Weir, H. (2023). Spaces for children's play and travel close to home: The importance of threshold spaces. *Children's Geographies*, 21(6), 1071–1086. <https://doi.org/10.1080/14733285.2023.2192338>
- Weir, H., Khan, M. K., & Marmot, A. (2023). Displaced children's experience of places and play: A scoping review. *Children's Geographies*, 21(3), 502–517. <https://doi.org/10.1080/14733285.2022.2078656>
- Wenyue, D., & Ke, C. (2022). Reflections on children's participation in the construction of child friendly community. *Modern Management*, 12(12), 1642–1648. <https://doi.org/10.12677/MM.2022.1212212>
- Williams, T., Ward, K., Egli, V., Mandic, S., Pocock, T., Clark, T. C., & Smith, M. (2022). More-than-human: A cross-sectional study exploring children's perceptions of health and health-promoting neighbourhoods in Aotearoa New Zealand. *International*

- Journal of Environmental Research and Public Health*, 19(24), Article 16968. <https://doi.org/10.3390/ijerph192416968>
- World Bank. (2024). World Bank country classifications by income level for 2024–2025. Retrieved March 4, 2025 from. World Bank. [HTTPS://BLOGS.WORLDBANK.ORG/OPENDATA/WORLD-BANK-COUNTRY-CLASSIFICATIONS-BY-INCOME-LEVEL-FOR-2024-2025](https://blogs.worldbank.org/opendata/world-bank-country-classifications-by-income-level-for-2024-2025).
- Wu, Y., Hu, X., Ji, X., & Wu, K. (2023). Exploring associations between built environment and crash risk of children in school commuting. *Accident Analysis and Prevention*, 193, Article 107287. <https://doi.org/10.1016/j.aap.2023.107287>
- Yang, F., Li, J., Zhang, C., Chang, F., & Xiong, S. (2025). Exploring the impact of built environment on traffic risk perception of school-aged children: A case study of old residential neighborhoods in Changsha City, Hunan Province, China. *Accident Analysis and Prevention*, 212, Article 107920. <https://doi.org/10.1016/j.aap.2025.107920>
- Yang, Y., Wang, Q., Wu, D., Hang, T., Ding, H., Wu, Y., & Liu, Q. (2024). Constructing child-friendly cities: Comprehensive evaluation of street-level child-friendliness using the method of empathy-based stories, street view images, and deep learning. *Cities*, 154, Article 105385. <https://doi.org/10.1016/j.cities.2024.105385>
- Zannat, K. E., Naim, M. N. H., Islam, K. A., Das, S., Adnan, M. S. G., & Dewan, A. (2023). Does children's independent mobility matter? Insights into escorting practices in a developing country. *Children's Geographies*, 21(4), 677–692. <https://doi.org/10.1080/14733285.2022.2106119>
- Zhao, J., Su, W., Luo, J., & Zuo, J. (2022). Evaluation and optimization of walkability of children's school travel road for accessibility and safety improvement. *International Journal of Environmental Research and Public Health*, 19(1), Article 71. <https://doi.org/10.3390/ijerph19010071>
- Zhou, Y., Wang, M., Lin, S., & Qian, C. (2022). Relationship between children's independent activities and the built environment of outdoor activity space in residential neighborhoods: A case study of Nanjing. *International Journal of Environmental Research and Public Health*, 19(16), Article 9860. <https://doi.org/10.3390/ijerph19169860>