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An Overview of How the Built Environment Relates to Children's Health

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Abstract

Purpose of Review Explore the varied pathways between the built environment and children's health. The review begins by describing how the built environment and transport infrastructure relate to conditions that lead to health outcomes. The review examines emissions, noise, and traffic dangers in relation to children's physical, mental, and social health.

Recent Findings Evidence is increasing for walkable neighborhoods and health-related behavior such as physical activity. However, diverse land uses (often supporting walkability) were also found to increase traffic injuries. Cognitive impacts of motorways on children at schools were found. Finally, the relationships between social activities and built environment are beginning.

Summary The built environment's influence on various physical health outcomes is increasingly clear and is often through a transport pathway. However, the links with mental and social health are less developed, though recent findings show significant results. Having accessible child-relevant destinations is an important consideration for children's health.

Keywords Built environment · Children's health · Travel behavior · Exposure · Emissions · Noise · Traffic danger

Introduction

This chapter will give a general overview of how the built environment relates to children's health. The built environment refers to any man-made change to the natural environment including buildings and transport infrastructure. In our review of the literature, we primarily considered studies that examined people aged under 18 [1, 2], though the age of majority varies up to 21. The Convention on the Rights of the Child uses 18 [1], though adolescence is defined as up to 19 by the WHO [3]. Finally, for health, we will take the World Health Organization's definition that includes physical, psychological, and social health outcomes [4].

Several characteristics of the built environment influence children's health. A major influence on the impacts of the built environment relate to transport as a source of pollution and danger, but also children's travel options and activity patterns [5••]. It is important to remember that a child's physical environment can affect their health in a number of ways [6, 7•, 8, 91).

The built environment can impact children's health indirectly in a number of ways (Fig. 1—built environment). The two main components are land use and transport infrastructure. Some authors distinguish pedestrian environments and greenspaces separately [5••], but we consider those as part of transport infrastructure and land use, respectively. Land use will determine not only what activities are possible through diversity which can relate to what children can do, but also whether there are sources of local pollution or environments that reduce pollutants. As density increases, it is possible to support a greater diversity of activities, but it also increases development intensity that could limit certain activities including natural spaces. Design can influence not only whether air pollutants and noise are dissipated, but also a number of social determinants of health. Transport infrastructure will play a strong role in what modes are possible

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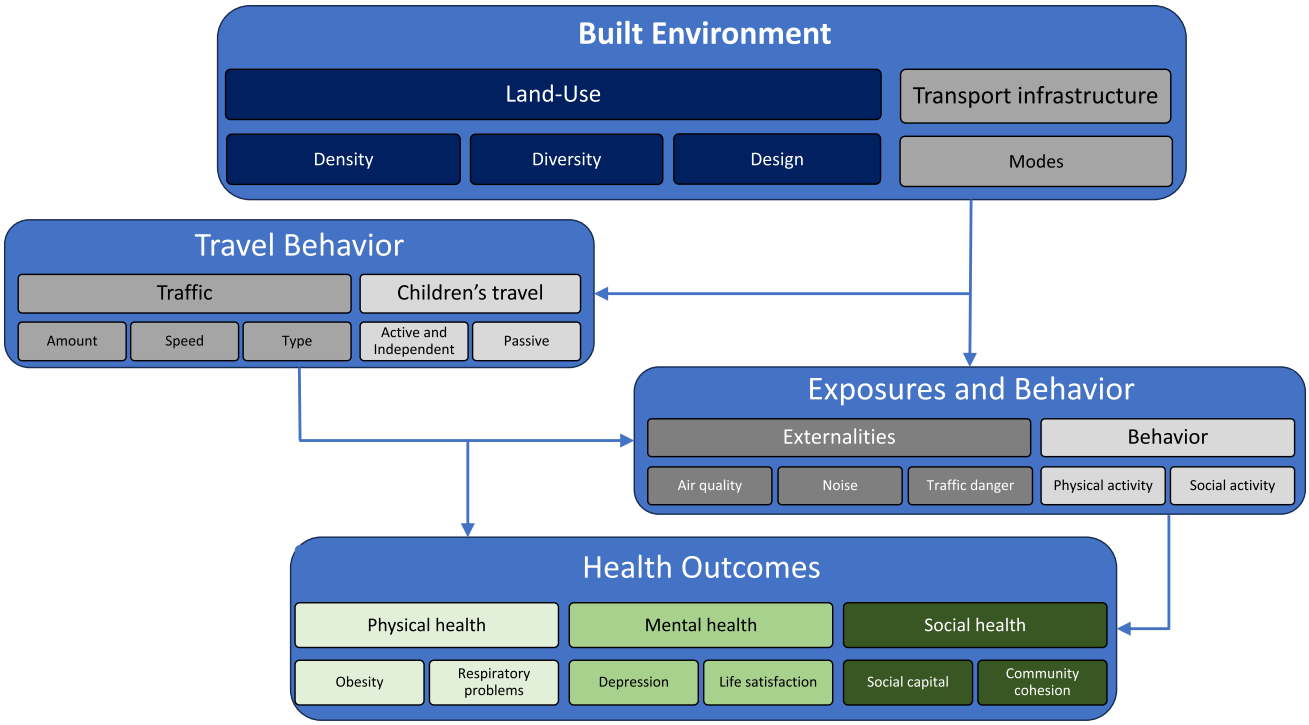

Fig. 1 General framework of how the built environment affects children's health (source: authors' own work)

which will impact local air pollution, noise, and traffic danger. Greater detail on transport is discussed next.

Transport can influence children's health and well-being in many ways [10••]. The two primary components here are externalities from traffic and how children travel (Fig. 1—travel behavior). For traffic, the amount (or volume) of traffic can influence the quantity of air borne pollutants. Speed relates strongly to not only traffic danger, but also traffic noise. The type of traffic is also important as differences exist between public transport (rail and road), private vehicles (size and motor type), and active modes such as walking, cycling, and scooting, and how children travel (e.g., the mode used) can impact their health. Active and independent travel is not only associated with physical activity during travel, but also relate to different psychological and social measures of health. It should be noted however that children's independence varies by age and culture (e.g., [11]).

The built environment and travel behavior thus create various conditions that relate to health (Fig. 1—exposures and behavior). The primary conditions that have been examined in the literature that examine the built environment and transport's influence on health can be grouped into externalities and behavior. Externalities include air quality, noise, and traffic danger mentioned above [12, 13]. Behavior relates to what types of behavior are associated with different built environments and transport systems. These include physical activities and social activities that impact a child's physical, social, and psychological health.

Finally, many health outcomes are associated with those exposures and behavior (Fig. 1—health outcomes), and those outcomes can be grouped as measures of physical, mental, or social health. Too many outcomes exist to list them all here, but examples of physical health include obesity and respiratory problems. Mental health measures examined in the literature include stress and life satisfaction. For social health, examples include social capital and community cohesion [14].

This chapter will give a general overview of how the built environment affects children's health. While the built environment and transport play an important role in health, studies have primarily examined the built environments' impacts on adults, but less frequently on children. There is an obvious research gap in this area because built environment measures are linked to children's health via different pathways. Moreover, it is important to note that strategies to promote health along one pathway may have adverse consequences on the other [5••]. In order to develop more effective health promotion strategies and to avoid unintended adverse health consequences, it is necessary to understand how they interact. As an example, travelling by active means can reduce traffic and air pollution at a regional level [15], but if adequate walking and cycling infrastructure is lacking, active forms of transportation may increase the risk of injury.

Our focus in this chapter is on the relationship between the built environment's determinants and children's health. As the built environment influences travel behavior, much focus will be on the negative health outcomes of transport

externalities—traffic danger, noise pollution, and air pollution—along with the positive health outcomes, such as physical activity, social interaction, and well-being. Then, on the basis of recent studies, we consider a few changes to the built environment that can improve the health of children.

Literature Review

Several searches were conducted primarily with Web of Science Core Collection during the month of January 2023. The search protocol included variations of the terms "child" (e.g., child*, adolescent, youth), "built environment" (e.g., "physical environment," "urban environment"), and the primary health dimensions (e.g., "mental health," "physical health," "social health"). The objective of this overview is not a systematic review, and as such, some relationships may be missed. The results reported focus on summarizing findings from various reviews and supplementing where new results exist or where gaps in those reviews are evident. The full search logic can be found in the Appendix.

The Built Environment and Behavior

This section examines how the built environment relates to physical and social behavior (Fig. 1—exposures and behavior). It can affect what options children have in terms of where to go and whether they can get there by themselves. Accessibility to child-relevant destinations is variously linked to physical activity and active travel, but is also linked to various measures of health outcomes [6••]. The presence of parks within 250 m, walkability, and intersection density have been linked to lower obesity [16•], likely through their capacity to facilitate physical activity including active travel. However, the evidence of a direct link between active travel with obesity is unclear [17]. Access to nature and open space are positively linked to mental health in early childhood [9•], and for children aged 6–12 [18], one other systematic review on children aged 0–18 found positive associations [19]. However, a more in-depth review found that the results were mixed depending on the measure of mental health [20••] and another on adolescents found inconclusive results for causal associations [21••]. One review [20••] suggested that it was not only important to consider the type of mental health measure, but also the type of interaction: accessibility, exposure, or engagement. That recommendation makes a distinction between the indirect effect of land use and the behavior. However, all reviews suggest that on the whole, natural spaces are correlated with some better mental health outcomes such as stress reduction. Ye et al. [22] proposed that greenspaces can help promote health by facilitating physical and social activities and also through restorative experiences and stress reduction.

Built Environment on Physical Activity and Active Travel

The importance of physical activity for the well-being and health of humans cannot be overstated [23]. A number of previous studies have demonstrated that regular physical activity can reduce the health risks associated with childhood obesity and chronic diseases [24]. Childhood obesity increases the risk of diabetes, cardiovascular disease, and metabolic syndrome as an adult [25]. Furthermore, there has been increased research on physical activity and children's mental health, including depression, self-esteem, and cognitive development. Depression and cognitive functioning appear to be causally related to outdoor physical activity in children [26]. A recent study conducted in the USA with over 35,000 children aged 6–17 [27] found that a few built environment measures such as having a recreational center or library were positively associated with a lower mental health index (higher means more problems reported), but the key finding was related more to participation in activities. A similar result was found in Norway with a study of over 23,000 8-year-olds, where participation in activities (leisure PA, organized activities) were positively associated with positive mood and feelings, but that the built environment measures of nearby parks and playgrounds were negatively associated. However, those same built environment variables were positively associated with the activities. Such results imply that it is not just enough to have the locations nearby (indirect effect of land use), but to conduct activities (behavior).

The relationships between the built environment and physical activity (Table 1) can be explained in part by land use and transportation [5••]. The land use pattern influences one's activity spaces, as well as the quality and availability of transportation options [28•]. Various reviews have examined how the built environment relates to children's physical activity (PA) [7•, 8, 29••, 30]. McGrath et al. [8•] conducted a review of objective built environment measures with moderate-to-vigorous physical activity and found either trivial or small associations. They also found that most activities were conducted in urban space and streets rather than green spaces. Gascon et al. [7•] found that the links of PA with green spaces were mixed, though leaning to the positive side. No clear relationship with housing density, street connectivity, or walkability was found in that review. However, a more recent review [29••] using a broader approach found ten different relationships between the built environment and total physical activity, including active travel. In that review, positive relationships were found for numerous built environment components: residential density, land use diversity, walkability, pedestrian infrastructure, access and proximity to facilities, and availability and proximity to green or public open spaces. Traffic danger was found to have a negative influence, while social environment considerations such as

Table 1 Summary of relationships between the built environment and physical activity and health outcomes

Built environment		Behaviors	Health outcomes		
	Articles	Physical	Physical	Mental	Social
Walkability	[8*, 16•*, 29••*, 30*, 32*]	Incr. PA			
Safe AT infrastructure	[6*, 29••*, 30*, 107*, 108]	Incr. PA			
Connectivity	[29••*, 40+, 41*]	Incr. PA			
Green space	[6*, 19*, 20••*, 40+]	Incr. PA		Mental health	
Streets	[8*]	Incr. PA			
Child-relevant destinations	[6*, 10••, 40+]		Better	Better	Better
Parks close-by	[8*, 16•*]		Obesity		
Dense, mixed environments	[6*, 29••*, 30*, 32*]	AT	Incr. PA	Some evd	Some evd

+Overview.

*Review.

personal safety and social support had positive relationships. One new avenue of study is examining how streets can be used again for places of play. A systematic review of Play Streets, where traffic is forbidden for a period of time, found that evidence is limited but suggests an increase in physical activity [31•]. Finally, a review of interventions [32], which helps determine causality, found that improving walkability, the quality of parks and playgrounds, and active travel infrastructure were all associated with better PA outcomes.

Street connectivity was a built environment measure that was found to be inconsistently associated with physical activity in a couple of reviews [7•, 29••]. However, in [29••], they highlight that objective measures of PA were associated with greater connectivity while self-reported PA was associated with lower connectivity. Higher connectivity was associated with more active travel, but the lower connectivity is often related to controlling traffic through cul-de-sacs or traffic calming. As such, intersection density's influence may be moderated by levels of traffic volume.

Numerous research studies have examined the relationship between children's transportation behavior, physical activity levels, and physical health [30, 33, 34]. Walking, cycling, and scooting are all forms of active travel where children move themselves by using their muscles, though most research has focused on walking and less on cycling. According to studies, children who use active travel (predominantly walking) are more active than those who use other transportation modes [17]. For example, previous research has shown that walking or biking to school can increase children's physical activity, even after school and in the evening [35]. It appears that active travel does not substitute for other physical activities and is generally in addition to other PA [36]. Further, active and independent travel has been found to help children develop their physical, psychological, and social health, as well as their cognitive skills as they accumulate physical activity, interact with friends, and explore their surroundings [37]. Finally, most active travel is walking, though some evidence suggests that those who cycle are more likely to meet health guidelines [38] and reduce psychosomatic complaints [39].

Moreover, better transport infrastructure can encourage active transportation by improving convenience and comfort for pedestrians and cyclists. For example, a systematic review of the literature has indicated that environments that are more walkable (e.g., those that facilitate walking by improving destination accessibility, street connectivity, active transportation infrastructure availability) are associated with greater physical activity for children [40]. When it comes to density, it is positively correlated to active transport since in dense cities, housing is closer to a range of destinations, increasing children's accessibility and active transport rates [41]. In addition, a positive association between safe active transport infrastructure and physical activity was also observed for children [42].

Conversely, environments can also discourage physical activity. Based on a review by Frank et al. [5••], sprawling development patterns are often car-oriented because key destinations are difficult to reach on foot. The level of active transportation for children was lower in neighborhoods with fewer recreational open spaces, lower residential density, lower traffic density, and fewer sidewalks [43].

Built Environment on Social Activity

Physical activity is more often studied, and various reviews exist. The majority of the results in this section on children are not based on reviews and require further research to build support or refute. Social activity is related to social well-being measures such as social cohesion and social networks [14]. Along with being important for well-being [44, 45] and mortality risk [46], various social conditions of one's living environment relate to children's PA and AT [29••]. As

such, social activities relate to social well-being which influences health outcomes and resilience. Participating in social activities was found to be positively associated with mood and feelings in a study of over 23,000 8-year-olds in Norway [47], but the built environment measure of having nearby playgrounds was negatively associated to the mental health measure, but positively with the social activity. As above, this implies that doing the activity (behavior) is essential, though facilitating (indirect land use) is an important part.

Child development is a consequence of a variety of influences, such as those of immediate family members, neighbors, and larger cultural and societal influences [48]. Studies have shown that built environment features such as residential density and the presence of playgrounds are positively associated with social and emotional domains of early childhood development [49]. In addition, a child's ability to socialize is influenced by the physical form of the environment in which they live [50••]. It may be the case that children who live in the same family structure, but who live in completely different locations (such as rural and inner city areas) will have different social experiences [50••]. In some studies, having child-relevant destinations, neighborhood safety measures (from traffic and crime), and parental perceptions of safety affect children's social development [6••]. Similarly, parents' perceptions of neighborhood cleanliness were associated with prosocial behavior [51]. There is also evidence that traffic risk, stranger danger, and car dependency restrict children's autonomy and social skills development [52, 53].

The built environment can impact children's social health in a number of ways (Table 2), though many are through its relationship with transport. The built environment relates to what destinations are available within a reasonable walking distance for children. Other research has shown that children are more likely to meet at friends' homes who live nearby [54], highlighting the importance of proximity. This is important as other research has shown that children meet up with friends most often on foot [55] so destinations that are within walking distance influence the likelihood of social interaction.

As children are generally found to use more active and independent travel in denser, mixed environments, the built environment indirectly influences outcomes such as higher occurrences of incidental social interaction [56, 57], knowing and interacting with neighbors [55], social activities with friends [54, 58], and a sense of community [58]. Those in turn are related to mental health measures such as decreased loneliness [58] and well-being [44]. In various studies (e.g., [, 5960

Social exclusion has been found to be a better explanatory factor for children's subjective well-being than measures of material well-being [45]. However, the relationship between social exclusion and the built environment for children does not appear to have been studied. The measure of social exclusion used contains factors which relate to the built environment through accessibility and activity participation. This is another avenue for future research.

The Built Environment and Externalities

Children's health is indirectly affected by the built environment through individual transport choices and environmental exposures resulting from different built environment patterns [5••]. Pathways of how greenspace in particular can affect children's health are described here [22]. They include mostly positive pathways affecting both mental (e.g., psychological restoration) and physical health (e.g., physical activity, mitigating air pollution and noise). That paper discusses various other potentially positive impacts of greenspace, but the studies are too limited in number.

While the built environment can provide positive health outcomes, particularly for physical activity and active transportation, it can also pose significant health risks. In addition to road crashes, transportation-related air pollution is conservatively estimated to result in nearly 200,000 premature deaths each year, and transportation noise is associated with a burden of disease similar to second-hand smoke [12••]. Several epidemiological studies have linked air pollution exposure to children's respiratory health [61], lung function [62], and childhood cancer risk [63]. It has been found that children under 5 years old living within 100 m of highways are more at risk of leukemia due to high levels of emissions

Table 2 Summary of relationships between the built environment and social activities and health outcomes

Built environment		Behaviors	Health outcomes		
	Articles	Social	Physical	Mental	Social
Higher density, mixed	[53–59]	Local social interactions			Sense of community
Child-relevant destinations	[6*]		Development	Development	Development
Control/limit motor vehicles	[50••, 51, 57]	Local social interactions			Social skills development
Residential density; playgrounds	[47]	Social activities		Emotional	

*Review

[63]. In addition to its effects on physical health, traffic exposure can also have a negative impact on mental health. Children's mental health can be directly affected by environmental properties such as spatial layout, traffic intensity, noise, and pollution [64], with positive correlations found for quality urban environments and green spaces, though questions remain [21••]. In urban areas, traffic noise and traffic danger are the most significant factors affecting the mental health of children negatively, but traffic emissions are also a concern [65]. Among children exposed to traffic, sleep disturbance, cognitive development problems, and behavioral problems are some of the most common mental health problems [66, 67].

Throughout this chapter, we aim mainly to synthesize literature linking the built environment determinants to health via exposure pathways. Most research has focused on air quality, noise, and traffic danger. However, other pathways with the adult population have been identified such as urban heat islands, contamination, climate change, limitations on access to natural environments, and electromagnetic fields [12••]. To begin, research on natural environments will be summarized as a component of the living environment (i.e., both natural and built environments).

Built Environment and Air Quality

Children are especially susceptible to health problems related to air quality due to various reasons including their developing lungs. A detailed discussion of this topic can be found in [68••]. Air quality can relate to traffic, home heating, and cooking. The focus here will be on traffic as a major source of ambient air quality, particularly ultrafine particles [69]. Pollutants created by traffic can be attributed to three main mechanisms: tailpipe *exhaust*, *abrasion* of tires, brakes, and pavement, and *resuspension* of particles [10••]. Among the many pollutants emitted by road traffic, particulates with a diameter under 10 m (PM10) and 2.5 m (PM2.5), ozone (O3), and nitrogen oxides (NOx) are considered to be the key indicators for health effects [70]. Other considerations include carbon monoxide and volatile organic components (VOCs) [68••]. Air quality is more commonly associated with respiratory problems such as asthma [68••], but Malacarne et al.'s [16•] review of the link between the built environment and childhood obesity found strong evidence that traffic-related air pollutants (NO_2 and NO_x) were related to obesity. Other areas of research have demonstrated links with childhood cancers, autism, and adverse birth outcomes [68••].

The built environment can affect how people travel, which impacts transport emissions [5••] and the impacts on children's health (Table 3). Several studies have directly examined the relationship between the built environment and traffic emissions. These studies have indicated that sprawling development results in more vehicles being used for transportation, leading to higher levels of emissions and air pollution [68••, 70–72] and multimodal streets such as complete streets support the use of alternative modes, such as walking and cycling, and traffic calming reduces car use and emission levels [73].

When focusing on children's exposure to traffic emissions, it is important to take into account their lifestyle, particularly the time they spend at different locations. The results of a Dutch study found that children attending schools near motorways were significantly more exposed to soot and PM2.5 than children attending schools in urban settings [74]. In a review of the impact of ultrafine particles on children's health, da Costa e Oliveira et al. [69] found that children attending schools with high exposure had substantially smaller growth in all cognitive measures. It has been suggested that active transport such as biking and walking could significantly reduce vehicle miles traveled (VMT) and traffic-related pollution emissions [75]. However, while cycling or walking children may be closer to vehicle emissions and ventilate more, this may cause them to be more exposed to traffic-related pollution [76].

Table 3 Summary of relationships between the built environment and emissions and health outcomes

Built environment		Exposure	Health outcomes	
	Articles	Emissions	Physical	Mental
Low density, sprawl, motorways	[70*, 106••]	Air pollution	Respiratory problems; cancer; obesity	
Motorways near schools	[63, 74, 76]	Air pollution		Smaller growth in cognitive measures
Proximity to traffic	[74, 75]	Air pollution		
Presence of green space	[22*, 98, 106••]	Air pollution		
Mixed land use	[102, 103]	Air pollution		
AT infrastructure	[106••*]	Air pollution		

*Review

Built Environment and Traffic Danger

Traffic danger is one critical direct negative effect of transportation on human health [77••]. There are risks associated with cars both inside and outside the vehicle with the majority of children in wealthy countries being killed as passengers [78•]. Traffic crashes kill about 1.4 million people every year, making them the eighth leading cause of death worldwide [79]. Since school-aged children are among the most vulnerable groups to traffic injuries, many efforts have been made to enhance traffic safety for them. A summary of the findings is shown in Table 4.

There have been a number of studies investigating the impact of the built environment on children's traffic collisions [77••, 80]. In terms of diverse land use, a positive relationship was found between mixed and diverse land use and injuries among children [80]. Generally, mixed land use includes all types of land usage, including residential, commercial, institutional, and industrial [77••]. In one study, mixed and non-residential land use effects on children's traffic safety at intersections and mid-block crossings were examined. At intersections, mixed land use negatively affected children's traffic safety, but at mid-block crossings, it did not appear to have a substantial effect [81]. Regarding children's destinations, school location plays an important role in child safety since schools are the center of daily activities for school-aged children (5 to 12 years old). It has been found that schools are high-risk crash locations [81], likely because they are convergence points for children and traffic (including parents driving their children). However, many child-friendly destinations remain unexplored with respect to traffic safety. For instance, the result of one study confirmed that child pedestrians are at greater risk of collision in areas near parks and schools [82].

Regarding design characteristics, how streets are designed have important health impacts as they influence traffic speed and volumes [77••, 81]. In previous research, a variety of aspects related to road infrastructure and design were considered, such as the type of road, the road class, the number of lanes, the street width, walking, and cycling infrastructure. In a review of children's traffic collisions, traffic volume was found to be positively correlated with child collision frequency and injury rate [83•]. Other results have shown that child pedestrian collisions are more likely on large and straight roads with high traffic volumes [84•]. Related to controlling speed, several studies [77••, 80, 81] have found that speed humps reduced the number of pedestrian collisions and pedestrian injuries. Moreover, a study found that children within their neighborhoods and in front of their schools were less likely to be injured when speed bumps were present [85]. According to a systematic review, sidewalks around schools are associated with fewer collisions with children than roads without sidewalks [86]. Another study indicated that there is a greater likelihood of school-aged children being involved in pedestrian collisions on streets with a high proportion of missing sidewalks [81].

Children's traffic safety is highly influenced by population density and multi-dwelling density based on previous research. Rothman et al. [86] found that high multifamily density decreases the risk of child pedestrian collisions. In addition, children's injuries are negatively correlated with population density in several studies [81]. However, high population density may increase walking proportions in areas around elementary schools, and such areas were found to be linked to high-risk exposure [83•].

Built Environment and Noise

Noise pollution occurs from a variety of sources, such as industrialization, social events, transportation, construction activities, and household activities [66]. In recent years, noise pollution from road traffic has increasingly been shown to be a threat to urban residents' health [87]. The term noise pollution refers to any sound that is unwelcome, unwanted, or too loud to cause or be capable of causing disturbance or irritation [67]. According to the WHO's published guideline on the burden of disease caused by environmental noise [88],

Table 4 Summary of relationships between the built environment and traffic danger and health outcomes

Built environment	Articles	Exposure Traffic danger	Health outcomes Physical
Schools, parks	[77••*]	More collisions	More injuries
Wide roads	[78, 83•*]	Incr. speed	Incr. death
Many lanes	[83•*]	Incr. traffic	Injury rate
Speed bumps	[83•*]	Reduce collisions	Reduce ped. injury
Sidewalks	[77••*]	Fewer collisions	
Multi-family dwellings	[77••*, 83•*]	Fewer collisions	
Traffic calming	[77••*, 83•*]	Reduce collisions	
Lighting	[79]	Visibility	

*Review

Table 5 Summary of relationships between the built environment and noise and health outcomes

Built environment		Exposure	Health outcomes
	Articles	Noise	Mental
Spatial layout, facilitate traffic	[91]	More noise	Sleep disturbance, cognitive development, behavioral problems
Mixed land use	[94]	More noise	
Traffic density	[90, 93]	More noise	Stress (blood pressure)
Green space	[22*, 98, 104]	Less noise	
Presence of noise barrier	[104]	Less noise	

*Review

future epidemiological noise research must focus on vulnerable groups, of which children are one [66, 89–91].

In comparison with air pollution emitted by motor vehicles, the relationship between urban environment and traffic noise (Table 5) is likely more complicated. Based on previous studies, traffic, population density, urban form elements, and urban morphology, including open space, building facades, shapes, and positions, can have significant impacts on urban noise levels [5••, 92]. Urban sprawl, for instance, increases total noise emissions since the number of vehicle KMs driven (VKM) and speed increases; however, noise sources are distributed over a larger area, so they are generally located at greater distance from people [93] until they enter more urbanized spaces. Transportation noise (including from airplanes) has been linked to sleep problems in various studies [66, 90], but have also been linked to behavioral and emotional problems [91].

The amount of noise in urban areas is also strongly influenced by land use [94, 95]. One study on urban land use and noise found that the level of noise is significantly higher in mixed land use areas as compared to residential neighborhoods [94], likely as a result of a concentration of activities. Furthermore, Zhou et al. [95] found that different types of residential blocks displayed different traffic noise distributions and generally, detached, semi-detached, and terraced houses experience low levels of noise. Similarly, Lam et al. [96] found that areas with high density of buildings and roads are more likely to suffer from noise pollution. The density of construction also plays a significant role in determining the level of noise pollution. Based on Guedes et al. [97], noise propagation from street and road traffic is attenuated in neighborhoods with more construction density because buildings act as obstructions to its free propagation. In urban settings, green spaces, especially vegetation, such as trees, plantings, and green belts, can also reduce noise effectively [98]. An important issue here is that (as mentioned above) low density suburban development styles are often a major source of traffic noise in urban settings. As such, there is a feedback problem where those who create more noise pollution are not suffering that pollution.

In terms of street design, Lee et al. [99] concluded that narrow roads, dense road networks, and complex intersections decreased traffic volumes, and therefore noise pollution. In a simulation of traffic noise, narrow roads (less than 10 m wide), complex road networks, and a high density of intersections all resulted in a lower volume of passenger cars and motorcycles. In general, as traffic volumes decrease, noise pollution decreases [100]. As such, built environments that limit traffic volumes or better control it should have lower noise pollution.

Potential Built Environment Interventions and Children's Health

A variety of literature exists regarding the use of the built environment to improve children's health [101–103], though most literature mainly focuses on adults. In general, the main objective is to reduce exposure and encourage people to use active transportation more often so as to reduce externalities related to transport and benefit from positive influences on health related to such daily activities. Overall, in the short term, reducing traffic-related pollutants and improving physical activity may be most effective by focusing on existing infrastructure and vehicles. In the long term, it is also crucial to consider land use planning to improve children's health by implementing built environment changes.

Among the key conclusions from previous studies in terms of reducing traffic emissions is the following: higher densities, a mix of uses, and walkable neighborhoods contribute to lower vehicle distances and less energy consumption [101, 102]. In addition, various built environment interventions have been proposed to reduce traffic noise, including platform barriers, green barriers, and land use zoning [104]. Sound barriers around high-speed roads are consistently used in countries such as Japan to limit noise pollution in urban areas. Often, it is not feasible or practical to control noise at its source, such as moving vehicles, so noise barriers are a highly effective solution [104].

Regarding children's traffic safety, the majority of safety measures have focused on traffic speed and volume as primary sources of danger [77••, 80, 105]. Several changes can be made as part of environmental and infrastructure interventions, such as speed management and enforcement, better visibility and lighting, road markings, sidewalk improvements, driver information alerts, traffic signs, and traffic calming systems [105]. Traffic calming measures aim to reduce traffic speed and volume and have consequently been found to reduce child collisions [80].

The second group of built environment changes focuses on improving physical activity, particularly active transportation. Due to the fact that both clean air and active transportation are functions of mobility, they overlap considerably [106••]. Even though previous studies have not focused enough on children, the built environment changes that can improve their physical health can be classified into three groups: (i) increasing accessibility and connectivity of an area or route; (ii) improving safety from traffic; and (iii) improving walking and cycling experiences [107]. For example, a study found that in a car-oriented environment or one with poor walking and cycling conditions, new infrastructure for safe active travel can encourage children to walk and cycle [108]. One meta-analysis found that increasing the connectivity of child-relevant destinations improved walking and cycling and where infrastructure was well utilized, walking and cycling increased [41].

Future Directions

First, as mentioned, the age of a child is different depending on what source is used. In general, the human brain does not stop developing until the mid to late 1920s [109•]. As such, future studies should consider expanding the age of a child. As well, as children's transport was an important influence, future research might consider relationships by age and level of independence. In a number of reviews on how the built environment impacts health [5••, 6, 6, 32], but the quality should be considered as well. As such, urban planning tools that measure quality of parks [110] and other important destinations will help improve cities for children. The study of transport and health is growing with reviews of the literature for the general population [12••] and children-specifically [37] existing. A previous review on transport and health pathways highlighted increasing evidence on climate change, contamination, and electromagnetic fields for adults [12••], though electromagnetic fields has also been linked to cognitive and behavioral development problems with boys [13].

Numerous reviews were found for topics such as physical activity, active travel, and traffic danger. However, the relationship between the built environment and children's mental health (though nature/greenspace and mental health is an exception, which was also noted by [29••]) and social lives appears to be less well studied. For behavior, in this review, we covered physical and social activities, but psychological activities are less evident. Conceptual frameworks for both practitioners and researchers were put forward [111••] where social and mental measures of health are evident. Further consideration on this is needed. Beyond walking in natural environments for restorative purposes [112], what might such behaviors be? Regarding social health, it should be noted that even though children's social health is related to built environment features, there is not enough evidence available to answer how much different such features can affect children's social health. It may be due to the lack of measures of social health among children. For example, physical health can be assessed based on body mass index (BMI) or respiratory problems, while mental health can be assessed based on stress or depression within the home environment for children. It is important to give more attention to social health measures such as social capital and social cohesion in order to improve our understanding of that relationship.

New research is connecting transport with various health-related conditions and outcomes. However, even though the built environment influences transport behavior, the influence of the built environment is not always examined. A recent study with nine mostly European countries found that active travel was more associated with psychological (e.g., depression, bad moods, problems sleeping) rather than somatic (e.g., headaches, back pain, dizziness) complaints. Although that study found differences between countries, the influence of the built environment was not directly examined. However, the study did mention that part of what might explain more cycling (which was the most associated with lower psychosomatic complaints) was that wealthier European countries had good bicycle infrastructure. As such, one recommendation is that in future studies of transport's impacts on health, the potential influence of the built environment should be examined.

Conclusion

This chapter gave an overview of relationships between the built environment and children's health. The topic is complex and evolving, and not all possible relationships are necessarily mentioned. This overview highlighted how the built environment indirectly affects children's health through its influences on transport and general health behaviors. Direct influences relate to what types of activities are possible at a local level. These can be positive such as spaces for play, restoration, and social interaction, but also negative if it allows for local pollution sources. A major source of local pollution can come from transport, which is influenced by the built environment through what transport infrastructure exists

(and thus what it permits), but also the density, diversity, and design of the built environment. The main negative influences that have been studied on children's health have been traffic danger, air quality, and noise. All three are intrinsically linked to transport externalities. Those externalities are associated with a vast array of negative health outcomes, but transport is also positively associated with better health outcomes through children's active and independent travel. Tension however exists between denser, mixed environments that facilitate such travel and a potential concentration of traffic conflicts, air quality, and noise if high-speed and high-volume traffic are prioritized. Fortunately, denser, mixed environments can also better support high-mobility alternatives to personal vehicle travel such as public transport with high service levels. The key message is that a built environment that limits motor-traffic and supports active travel will likely result in better health outcomes for children. Whether there is a threshold effect to this (e.g., too dense) is not clear. As well, it is likely important through the built environment and transport to facilitate access to nature, as various mental health benefits are evident. More research on psychological and social health impacts is especially needed.

Appendix. Search terms

The following search logic was used to identify literature. It was last conducted in January 2023 using Web of Science (Core Collection).

("built environment" OR "physical environment" OR "urban environment") AND ("children" OR "youth" OR "adolescents") AND ("mental health" OR "psychological well-being" OR "emotional well-being" OR "behavioral problems").

("built environment" OR "physical environment" OR "urban environment") AND ("transport" OR "transportation" OR "active transportation" OR "walking" OR "cycling" OR "public transportation") AND ("children" OR "child" OR "adolescent" OR "youth") AND ("physical health" OR "childhood obesity" OR "physical activity" OR "outdoor play").

("built environment" OR "physical environment" OR "urban environment") AND ("transport" OR "transportation" OR "active transportation" OR "walking" OR "cycling" OR "public transportation") AND ("children" OR "child" OR "adolescent" OR "youth") AND ("social health" OR "social well-being" OR "social interactions" OR "community engagement" OR "neighborhood cohesion").

Following comments from reviewers, "nature" was added to the built environment synonyms for each search and two additional relevant reviews on nature and green space were identified. That search was run on the 12th of June 2023.

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Declarations

Conflict of Interest Dr. Waygood reports grants from Social Sciences and Humanities Research Council of Canada (grant number 435–2020-1292), during the conduct of the study. Shabnam Abdollahi reports being in part funded by the above grant during the conduct of the study. Dr. Ali Yas has nothing to disclose.

Human and Animal Rights and Informed Consent. This article does not contain any studies with human or animal subjects performed by any of the authors.

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- • Of importance
- •• Of major importance

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