Designing and building healthy places for children

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Abstract: The design and construction of the built environment have broad implications for the health of children. Healthy places should protect children from injury, pollutants and disease, provide children with a place to be physically active, play and experience nature, and promote a sustainable future. Health promotion can occur at all scales of the built environment, including buildings, communities and global infrastructure. The disabled, poor and other disadvantaged groups may benefit from built environment improvements. These improvements require partnerships among urban planners, engineers, architects, developers, public health practitioners and communities.

Keywords: built environment; children; public health.

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1 Introduction

Healthy places for children supplement and magnify positive parental and community influences, supporting the development of children to become healthy, caring and well-adjusted citizens. The built environment, those places that humans have created or modified, comprises almost all the places in which children live, grow, learn and play (Frumkin and Dannenberg, 2007).

The built environment includes objects, such as homes and roads, as well as activities intrinsically linked to physical infrastructure, such as transportation and energy consumption. The scale of the built environment, impacting children, ranges from a crib in a child's room to the world in which that child resides; the scale and elements important to a child change as that child grows. Healthy places for children incorporate understanding of the development of children, creating spaces and opportunities ranging from the supervised play of infants to healthy places for teenagers to congregate and define themselves.

Children's health faces some troubling challenges that may be influenced by the built environment. Worldwide, transport-related injuries are a leading cause of childhood mortality and the incidence of these injuries is increasing (Krug et al., 2000). Childhood obesity is increasing (Kaur et al., 2003; Krassas and Tzotzas, 2004; Ogden et al., 2006; Rigby and Baillie, 2006); diminishing opportunities to play or exercise may contribute to this trend (Larkin, 2003). In a worldwide study of asthma symptom prevalence, 11.6% of the 6–7 years age group and 13.7% of the 13–14 years age group reported wheezing in the past 12 months (Pearce et al., 2007); the burden of asthma may be exacerbated by automobile-associated air pollution (Friedman et al., 2001; Gent et al., 2003). Children's mental health might be impacted by too little exposure to nature (Louv, 2005). Many of these children's health issues have worsened despite traditional interventions such as provider and patient education.

Concern about the quality of children's health has spurred interest in the role the built environment has on children's health. Research has demonstrated links between the built environment and health outcomes such as childhood obesity, injury and asthma (Ewing et al., 2003; Levy et al., 2004; Ewing et al., 2006).

A health-promoting built environment for children can be distilled to a few themes. It provides children with protection from injury risk and protection from exposure to pollutants and disease. It gives children opportunities for physical activity, play and contact with nature. It also incorporates sustainable practices, helping to prevent catastrophic environmental changes.

Table 1 lists desired health outcomes and identifies key built environment components that support these outcomes. While Table 1 is organised by desired outcome to highlight the effect of the built environment on health and wellness, design and

planning of the built environment usually occur at different scales of the built environment. This paper describes how features of the built environment that promote health for children can be incorporated into the design and construction of buildings, communities and global systems.

Table 1 Built environment components that promote health for children, by desired outcome, scale and sector

Desired outcome	*Scale*	*Sector*	*Examples of built environment components*
Protection from injury	Building	Home design	Smoke alarms
			Fall preventive design
		Education	Safe school playground design
	Community	Transportation	Bicycle and pedestrian infrastructure
			Traffic calming
			Increased connectivity
		Education	Safe routes to schools
Protection from exposure to pollutants and disease	Building	Home design	Lead paint abatement
			Smoke alarms
			Carbon monoxide alarms
		Education	School indoor air quality improvements
			Noise reduction and mitigation
			Appropriate chemical storage or disposal
	Community	Transportation	Bicycle and pedestrian infrastructure
			Transit improvements
		Utilities	Water protection
			Effective waste management infrastructure
Opportunities for physical activity, play and experiences in nature	Community	Transportation	Bicycle and pedestrian infrastructure
			Improved connectivity
			Travel distance reduction
		Land use	Increased density and mixed-use neighbourhoods
			Increased parks and greenspace
		School design	Locating schools within communities
			Safe routes to school
Sustainable future	Building	Building design	Energy efficient design
	Community	Transportation	Decreased auto-oriented design
	Global	Energy	Reduced fossil fuel dependence
		Transportation	Efficient transportation

2 Buildings

Buildings are a prominent component of the built environment, where many children spend much of their time. The design, physical conditions and use of schools and homes may promote children's health through injury prevention and protection from pollutants and disease.

2.1 Protection from injury risk

Improvements in the built environment can reduce childhood injuries at home. Fires, suffocation, poisoning and falls cause the highest number of childhood deaths in homes (Nagaraja et al., 2005); designs to reduce these risks could improve children's health. Children are at risk for falling out of open windows, off railings, out of bunk-beds, down stairs and off roofs (Barlow et al., 1983; Lehman and Schonfeld, 1993; Vish et al., 2005; Khambalia et al., 2006). Window guards, closely spaced vertically slatted railings and limited access to roofs and other elevations can reduce these risks (Lehman and Schonfeld, 1993; American Academy of Pediatrics (AAP), 2001). Childhood burns can be reduced through installing smoke detectors and sprinkler systems and reducing the temperature setting on hot water heaters (Feldman et al., 1978; Pichoff et al., 1994; Runyan et al., 2005).

School design can protect children from injury by incorporating the protection offered in home design as well as taking additional steps. Health-conscious design of specialised classrooms, such as shop or physical education classes, can help prevent injuries (Frumkin et al., 2006). The design of school playgrounds can incorporate safety considerations in addition to the requirement that they encourage fun (Frumkin et al., 2006). Schools can be designed using principles to reduce crime-related violence which would help protect children from intentional injuries. School design to reduce children's injuries requires consideration of the unique aspects of the school environment, including their specialised classrooms, playgrounds and potential to host crime.

2.2 Protection from pollutants and disease

Home design and component choice help protect children from pollutants. For example in the USA, many homes still contain lead paint. In these homes, degradation of the home environment creates opportunity to expose children to a substance linked to reduced intelligence and substantial medical costs (Needleman et al., 1979; Landrigan et al., 2002; Canfield et al., 2003; Woolf et al., 2007). Targeted home improvements, in addition to specific maintenance and cleaning practices, can reduce sources of lead exposure (Farfel et al., 1994).

School design can reduce children's exposure to pollutants through steps such as modifying indoor air quality and reducing toxic exposures. Indoor air quality might affect children even more than outdoor air quality as children spend much of their time indoors (Anderson and Bogdan, 2007). Heating, Ventilation and Air Conditioning (HVAC) systems control act as the lungs of the building, bringing in fresh air and expelling waste air (Environmental Protection Agency (EPA), 2007a). A well-designed HVAC system efficiently provides a comfortable temperature, controls humidity levels and expels potential airborne hazards from building materials, combustion and organic sources (Frumkin et al., 2006; Anderson and Bogdan, 2007). Toxic exposures can occur

from contact with chemicals present in cleaning supplies and in science, art and shop classrooms. Proper storage, controlled access and timely disposal of hazardous chemicals could reduce potentially adverse exposures. Another strategy to reduce children's exposure to hazardous chemicals is to schedule construction and cleaning work to avoid times when children are present (Frumkin et al., 2006).

Crowding and noise are environmental hazards that may affect children both at home and at school. Crowding is measured subjectively, in terms of privacy and stimulation, and objectively, the number of people per unit area. Crowding at home and in classrooms is associated with lower academic achievement, withdrawal from classroom participation, adverse health effects and less cooperative behaviour (Saegert, 1984; Maxwell, 1996; Evans et al., 1998). Additionally, crowded indoor environments may increase the risk of infectious disease transmission and worsen environmental conditions. Noise reduction strategies might improve children's health and learning ability. Noise in the home may increase stress (Evans, 2003). Classrooms with intrusive noise are linked to reduced reading comprehension (Stansfeld et al., 2005; Clark et al., 2006).

3 Communities

The design of communities affects children's health (Lee, 1970; Cummins and Jackson, 2001; Evans, 2006). Communities vary in size; they might be an area where a small child might play and roam or a large metropolitan region. Community design can provide protection from injury risks, exposure to disease and pollutants and opportunities for physical activity, play and experiences in nature.

3.1 Protection from injury risks

The built environment can help protect children from injury risk. Injuries are a leading cause of death and, in the USA, motor vehicle crashes are the leading cause of injury mortality for children aged 3 years and older (Minino et al., 2006). Responses to this threat have included creating safety features for occupants of vehicles, such as car seats and booster seats for young children, and laws, such as speed limits and graduated licensing, to support safe driving behaviour. Despite these interventions, the absolute toll on children's health from automobile crashes remains high and will likely increase if appropriate interventions are not implemented. Current worldwide projections predict that motor vehicle collisions will be the leading cause of death for people ages 1–40 years by the year 2020 (Dalvi, 2004).

A built environment that supports children would need to support the transportation modalities that they use such as foot and bicycle travel. Children need the freedom to explore their surroundings; choices in the design of their built environment influence how safely and how far they can travel. Automobile-oriented design restricts children's independent travel and increases the danger to child pedestrians and cyclists. During 2003 in the USA, motor vehicle collisions killed 390 pedestrians and 130 cyclists under the age of 15 years (National Highway Traffic Safety Adminitration (NHTSA), 2004). Paradoxically, the number of pedestrian and bicycle injuries is declining despite auto-oriented built environment design; however, this relationship is likely due to a reduction in walking and biking rather than improved safety of these activities (Pucher and Dijkstra, 2003; NHTSA, 2004). Trips taken to school highlight the decline of active

transportation rates, as children are driven more and walk or bike less (McDonald, 2007). In the USA, 13% of trips to school are made on foot or bicycle; 55% use a private vehicle and 30% use a school bus (McDonald, 2007). Even for those children living close to school, fewer than half walk or bike to school (Martin et al., 2007). Leading barriers to walking or biking to school were distance and concern about traffic (Dellinger and Staunton, 2002). Finally, because children often use the built environment differently than adults, children may be faulted for injuries that occur in the built environment without accounting for the role of the built environment as a contributing factor. For example, a child hit by a car while darting across a busy street may be held responsible, rather than accounting for the structural factors leading to the collision (Roberts and Coggan, 1994).

The built environment in automobile-oriented development may increase the risk to automobile passengers and drivers as well as to pedestrians and cyclists. The design of commercial suburban streets adds to the risk, when wide, high speed and volume roads are combined with frequent 'curb cuts' where drivers enter and exit store parking lots (Ossenbruggen et al., 2001). Additionally, typical suburban design often entails large distances between destinations, such as grocery stores, homes and schools, likely resulting in more time that children spend in automobiles and more kilometres travelled, increasing their risk of being in a crash.

Individuals often recognise the safety concerns of a poorly designed built environment, but the design of the environment may offer them few alternatives. The suburban built environment creates difficult decisions for individual parents wanting to minimise motor vehicle risks. Pedestrian and bicycle trips are more likely than automobile trips to result in injury (Beck et al., 2007). Should parents concerned about the dangers of traffic in their neighbourhood drive their children to school, adding yet another vehicle passing through the school parking lot, rather than having their children gain the physical activity and social benefits of walking? Should the fear of motor vehicle crashes inspire parents to purchase larger vehicles for protection in a collision with another motor vehicle, knowing that light trucks and vans, should they collide with a child pedestrian, are more likely than sedans to kill that child (Holland et al., 2000; Ballesteros et al., 2004; Fenton et al., 2005; DiMaggio et al., 2006)? The solution requires a coordinated community effort rather than individual decisions. In a cross-sectional study of the largest 101 metropolitan areas in the USA, less sprawl was associated with both fewer traffic fatalities and lower pedestrian fatality rates (Ewing et al., 2003). Under the right conditions, higher levels of walking and biking may be associated with lower rates of injuries and fatalities to pedestrians and cyclists. In Germany and The Netherlands, where walking and biking are much more common, pedestrians and cyclists are killed at lower rates than in the USA (Pucher and Dijkstra, 2003). Other studies have confirmed the relationship of heavier pedestrian and bicycle traffic with lower rates of collisions with automobiles (Leden, 2002; Jacobsen, 2003). Communities have the opportunity to implement built environment modifications that support all transportation modes and reduce injury rates for pedestrians and bicyclists. A built environment minimising automobile use and optimising safe pedestrian and bicycle facilities is a primary prevention strategy against motor-vehicle-related childhood injuries and has the added benefit of increasing physical activity opportunities for children.

3.2 Protection from pollutants and disease

The built environment can protect children from air pollution, water pollution and other hazardous chemicals. For example, automobile-dependent transportation systems create air pollution and impervious surfaces, such as roadways, contribute to water pollution and waterway degradation. Hazardous chemical clean-up, as might occur in redevelopment of a formerly industrialised area, can decrease exposure to pollutants. Pollution and disease impair children's health; the design of the built environment offers an opportunity for reducing exposure to pollutants and decreasing disease.

Built environment changes that reduce automobile travel and reduce exposure to air pollution can reduce the health consequences of air pollution. Motor vehicles create a substantial portion of local air pollutants, including carbon monoxide, particulate matter, oxides of nitrogen (NO_x), and volatile organic compounds, and contribute to the formation of ozone (Hao et al., 2001; EPA, 2007b). Ozone and particulate matter irritate airways and are associated with respiratory symptoms, reduced lung function, increased emergency room visits and hospitalisations, and more frequent school absenteeism (Gilliland et al., 2001; Hruba et al., 2001; Park et al., 2002; Gauderman, 2006). Traffic-related pollution impairs children's lung development (Gauderman et al., 2007). Children with asthma or other chronic lung diseases are especially susceptible to air pollution (Gent et al., 2003). Strategies designed to reduce automobile travel can decrease air pollution and its associated health effects (Friedman et al., 2001). In addition to improving community-wide transportation systems, design strategies at the neighbourhood level of a community may help reduce exposure to air pollution. Higher concentrations of traffic-related pollution occur in the immediate vicinity of heavily trafficked roads (Lena et al., 2002). Asthma and asthma symptoms may be increased with residential proximity to major roads (McConnell et al., 2006). Designing neighbourhoods, so that schools and homes are buffered from busy streets, could help reduce children's exposure to traffic exhaust.

The built environment impacts drinking and recreational waters. In developing countries, diarrhoeal diseases are a major cause of childhood morbidity and mortality; clean drinking water access could lead to substantial reductions in mortality (Thapar and Sanderson, 2004). Similar problems can occur in developed countries. Less dense, exurban communities may be served by well water and septic systems rather than a municipal water supply and sewage treatment system. As increasing development occurs, well water may become contaminated by sewage as the amount of waste overwhelms the soil's accommodative ability; increases in childhood diarrhoeal illness has been linked in the USA to increasing density of septic systems and wells (Borchardt et al., 2003). Heavy rains are also linked to infectious disease outbreaks (Curriero et al., 2001). Municipal sewage and water treatment systems capable of handling heavy rains could reduce infectious disease transmission and improve health. The built environment may also minimise adverse environmental effects. Well water is not universally tested and may contain contaminants, some of which are related to the built environment (Tabbot and Robson, 2006). The built environment can alter the natural cleansing processes. In a natural environment, rainwater filters and is cleansed as it percolates through the earth into groundwater. As natural areas, especially trees, are cleared, surface runoff and river discharge increase (Sahin and Hall, 1996). Impervious surfaces, such as asphalt, concrete and roofs, further accentuate runoff by preventing water from entering the ground (Dietz and Clausen, 2007). Built environment modifications that protect

watersheds, reduce reliance on well water and reduce runoff could reduce pollutant exposure. A health-promoting built environment ensures that drinking and recreational waters are safe and clean.

Reducing hazardous chemicals through built environment changes can improve children's health. Hazardous chemicals directly harm children as well as create restrictive environments. These hazards can range from pesticides applied to a lawn or playground to a contamination from an abandoned industrial site in a community; they can modify a vacant lot, where children are allowed to play, into a no-man's land. Abandoned industrial sites not only create eyesores, but also their waste may leach into the water and soil, creating an opportunity for children to become exposed. Clean-up and redevelopment of abandoned industrial sites, particularly if incorporating principles of sustainable redevelopment, may change these areas for the betterment (McAvoy et al., 2004).

Protection from air pollution, water pollution and hazardous chemicals requires considering the interaction of children with their environment at all stages of life. An older child who runs across a pesticide-treated lawn or playground may have limited exposure, but a crawling baby might have a higher level of exposure. Similarly, as hazardous chemicals leach into a nearby stream, the baby who never ventures into the water would likely not be exposed, but older children cavorting in the stream may swallow or have skin exposure to the substances. Children do not follow the same behaviour patterns as adults; their exposure to environmental chemical hazards may vary substantially from adults and their ability to recognise and avoid hazards may be limited. Children's environments require special attention to ensure that dangerous chemical exposures are identified and controlled.

Built environment changes designed to protect children from pollutants and diseases are often synergistic with injury prevention. For example, promoting facilities for active transportation, such as bicycle paths and sidewalks, can reduce injuries and decrease air pollution. Cleaning up an abandoned industrial site could remove old equipment that might injure children in addition to removing environmental contaminants. Built environment changes can affect more than one area of children's health.

3.3 Opportunities for physical activity, play and experiences in nature

Children need places to lead active, playful lives and the opportunity to experience nature; the built environment can provide these places. Sedentary lives lead to obesity and associated chronic diseases (Flegal, 2005). The United Nations (UN) has declared play and recreation as a basic right of every child; the UN charges public authorities to support this right (UN, 1959). A well-designed built environment of a community can facilitate children's physical activity and play, and provide them with experiences in nature.

The built environment offers a mechanism to promote physical activity (de Vries et al., 2007). Children's physical activity habits may have impacts on their longevity and mortality (Haslam and James, 2005; Hills et al., 2007). Sedentary lifestyles increase the risk of cardiovascular disease, diabetes, stroke, some cancers and all-cause mortality (Erikssen, 2001; Bianchini et al., 2002; Hills et al., 2007). In some school systems, children are only provided a barren yard for a few minutes of recess (Hackett, 2007; Loupe, 2007), despite the evidence that school physical activity policy can improve physical activity levels (Ferreira et al., 2007). Organised children's sports can provide an

outlet for physical activity, but they do not supplant the need for children's communities to provide places for them to obtain physical activity through other mechanisms. Children can be active by walking to each other's homes, playing on a playground, yard or street, riding a bike to school and exploring nature. Active transportation corridors, playgrounds, open spaces and woods permit the opportunity for children to exercise. Ensuring that areas are free from crime and the perception of crime can help encourage use (Jutras, 2003). The UN Basic Principles for the Treatment of Prisoners state that every prisoner should have at least 1 hour of outdoor exercise and that installations and equipment be provided for their physical and recreational training (UN, 1990). The built environment provided to children should offer at least these provisions.

Schools affect children's health not only through the building design, as previously discussed, but also through the transportation options available for children to get to school and the site chosen for the school. Developing safe routes to schools is an efficient mechanism to provide children with the ability to increase their activity level. As mentioned previously, the largest barriers to active transportation to school are traffic and distance (Dellinger and Staunton, 2002). Decreasing distances by offering walking paths that provide a direct route to school and designing roads and intersections that improve safety for pedestrians could reduce these barriers. The site chosen for a school also can affect children's health. Building and maintaining schools in neighbourhoods close to where children live, rather than in land at the periphery of communities, facilitates active transportation (EPA, 2003). Additionally, when built in neighbourhoods, the amenities of the school, such as its playgrounds, auditoriums and fields, can become resources for the community during non-school hours.

The built environment can support unstructured play by providing spaces for children. Unstructured play facilitates development by providing children the opportunity to create their own rules, manage their own projects and spend time learning in a self-directed manner about the world around them (Ginsburg, 2007). Community design could promote unstructured play by incorporating play areas such as natural spaces, which are well suited for supporting unstructured play (Louv, 2005), and ensuring that the built environment optimises children's safety from environmental hazards while they are playing (Ginsburg, 2007).

The design of the built environment can help children experience nature more fully. Children have become isolated from the natural world as increasing development, rules and lack of ability to get to a natural setting inhibit – or prohibit – contact with nature; the combination of these effects may have adverse health consequences (Louv, 2005). Nature deprivation may increase asthma and attention deficit hyperactivity disorder symptoms (Kuo and Taylor, 2004; Maziak, 2005). Lack of contact with nature may worsen children's ability to handle childhood stressors (Wells and Evans, 2003). Nature deprivation may lead to further adverse consequences for the preservation of the natural world as children without contact with nature may not care about it as adults (Lohr, 2007).

Closely tied to the health implications of the built environment is the connection between the built environment and social capital (Kawachi, 1999). For example, developing neighbourhood programmes, such as a walking school bus, could make active transportation a social experience and increase social capital (Rossi et al., 2004). Increased social capital is correlated with lower chronic disease rates in adults (Ahern and Hendryx, 2005); children might benefit as well.

While the built environment of communities offers opportunities to improve the lives of children, other factors are needed as well. Behaviour changes are necessary to take full advantage of built environment modifications; people will have to choose to walk or ride a bike. Educational and experiential programmes, such as the US Forest Service's More Kids in the Woods programme, may help encourage more children to experience nature (USFS, 2007). Built environment changes to improve health might be more effective if accompanied by educational interventions.

4 Global systems

While many decisions about the built environment are local, the combined effects may have global impacts on the health of children. On a global scale, automobile-dependent built environments may encourage more automobile-dependent development because of automobile users' expectations, the perception of automobiles as a status symbol, the effects of economies of scale and shared transportation structures. National and international transportation and energy policies affect the built environment by supporting certain energy and transportation infrastructure options and by helping to define normal use.

Climate change is a key example of a global process, influenced by the built environment, with global heath effects. Climate change will likely impact the health of children (Shea, 2007), but built environment changes, including those enacted by children, could help lessen adverse impacts from climate change. Strong scientific evidence and consensus among experts has identified that Earth is undergoing climate change and climate change is contributed by human activity (Solomon et al., 2007). Fossil fuel consumption and changes in land use contribute to increased atmospheric concentrations of carbon dioxide, a greenhouse gas (Solomon et al., 2007). How the built environment is designed and constructed can help to mitigate or exacerbate humanity's impact on climate change. Climate change has become a worry for children, as reflected in their drawings (Barraza, 1999), but opportunities could be created within the built environment for children to become empowered by making positive changes. For children at earlier stages of development, a concrete task, such as planting trees in their neighbourhood, allows them to see that they can help. Older children might begin to perceive how reductions in their fossil fuel consumption help to ensure a habitable planet. A built environment designed to reduce energy consumption through efficient buildings and transportation systems, provides a mechanism to reduce carbon dioxide and other emissions contributing to global climate change.

The global impact of today's built environment decisions will likely affect children more than the other populations. Children have their life ahead of them, so they may experience either the consequences of poor planning or the benefits of long-term strategies to improve the built environment. Current trends suggest that children may have lower life expectancies than their parents due to growing rates of obesity (Olshansky et al., 2005); this trend is likely contributed to by aspects of the built environment that discourage physical activity. Parents have a responsibility for the health and well-being of their children. Harnessing the collective motivation of caring adults could lead to improvements in the built environment, so children inherit a healthier world.

5 Discussion

Children are particularly sensitive to effects of the built environment. Their higher respiratory and metabolic rates create more exposure to contaminants than adults. They spend more time as 'alternative users' of roads, bicycling or walking instead of driving, so the degree of accommodation that the design of the built environment provides these users has a heightened effect on children. Accommodating children's transportation modes in the built environment should improve transportation resources for those who are restricted from driving or who are unable to own an automobile such as the poor, elderly or disabled. A built environment that accommodates children will improve transportation equity for other disadvantaged groups. Finally, because children have more years of life ahead of them and are in the formative stages of creating habits and behaviours that may last a lifetime, creating built environments that shield children from harmful exposures, creating spaces and transportation systems that are safe for active users and promote healthy habits and ensuring that the built environment supports a sustainable future will have long-lasting effects.

Children use and perceive the built environment differently than do adults, and when children use public aspects of the built environment, they are often perceived as not using the built environment 'properly' (Matthews and Limb, 1999). Because of the incongruity of the adult design with the child's use, the children are particularly vulnerable to problems arising from their use of the built environment. An example is a road that separates a school from a neighbourhood. Children may play in or along the road, depending on the traffic patterns, or cross the road to get into the neighbourhood. However, the road is usually designed for adult users of the road, predominantly drivers. While there may be some concessions to children's use of the road, such as crosswalks and decreased speed limits, these provisions typically do not include extensive modifications to the basic road design. Children may also perceive changes to the built environment differently than do adults. For example, adults might view the infill development of a vacant lot as an improvement to their neighbourhood, even though it may steal from children an opportunity to play in the outdoors (Moore, 1986). Creating a healthy built environment for children requires consideration of how children will perceive and use the environment.

Disabled children have the same needs to socialise and escape the indoor environment as other children; they may be more susceptible to a poorly designed built environment. Children with mobility impairments may not be able to cut through vegetation; well-maintained sidewalks are necessary to provide off-street transportation routes separated from traffic. Disabled children are at increased risk for collisions with motor vehicles (Xiang et al., 2006); creating environments where the speed and number of vehicles are minimised may have an even greater impact on disabled children's health.

The built environment affects all children, but the concerns vary by urban, suburban or rural status. Children growing up in urban areas may have greater exposure to pollution, from traffic and industrial sources, and may have increased exposure to a greater volume of traffic. However, older areas of cities designed prior to the age of the automobile may have more pedestrian accommodations and dense development, giving children more possible destinations. Suburban children often face less industrial pollution, but higher speed traffic and poor accommodations for pedestrians create dangers. Rural children may have greater access to nature, but they often live near high

speed rural roads, have greater exposure to other injury risks and may have untested drinking water (Cherry et al., 2007). Like suburban children, rural children may also be dependent on automobile transportation to get to destinations.

There is evidence that poor children and minority children are disproportionately impacted by poorly designed built environments (Powell and Stewart, 2001; Evans and Kantrowitz, 2002). Air pollution affects poor children and minority children more because of increased exposure to pollution and, because of higher prevalence of underlying disease, increased susceptibility (Litonjua et al., 1999; Woodruff et al., 2003; Maantay, 2007). Lead poisoning occurs more in poor, minority inner city neighbourhoods where housing has deteriorated (Centers for Disease Control and Prevention (CDC), 1997). Childhood death rates due to motor vehicle collisions vary by race and by age (Bernard et al., 2007). The built environment may have disparate health effects on specific subpopulations.

The quality of the built environment for children is affected by both the family's socioeconomic status as well as the status of their community. For example, children who come from poor families may live in housing with hazards, while children who grow up in poor neighbourhoods may have fewer resources such as safe parks and green space and may be exposed to additional environmental contaminants (Powell and Stewart, 2001; Evans and Kantrowitz, 2002). All children deserve to grow up in a safe and healthy built environment. Given the moral imperative of eliminating childhood health disparities based on class, race and ethnicity, associations among environmental problems, the built environment and vulnerable subpopulations deserve continued attention.

6 Conclusion

A safe and healthy built environment can help prevent some of the most prevalent health problems of childhood by protecting children from injury, reducing pollutant and illness exposure and providing children with places to play and be active. Consideration should be given to the intangible costs and benefits such as improved social capital and transportation equity when allocating resources to the built environment. Improving the built environment for children requires that communities and professionals from multiple fields work together towards a common goal. Architects design buildings, urban planners and developers create neighbourhoods, transportation planners and engineers design transportation systems and public health practitioners identify health concerns. Community groups are needed to help identify problems and provide the votes and grassroots support to create change. Even children, if provided education and resources, can become powerful advocates for their own behalf. Globally, cooperation among nations is required to protect all children (Guidotti and Gitterman, 2007).

Health professionals, community leaders and other concerned groups can act to promote healthy built environments by contributing to the planning and design of the built environment. Mechanisms to achieve built environment improvements include advocacy, participation in public planning meetings and volunteerism to build infrastructure. Rating systems for neighbourhood development, such as the Leadership for Energy and Environmental Design for Neighbourhood Development, can help to emphasise smart growth practices for a neighbourhood and identify areas of improvement (US Green Building Council (USGBC), 2007). Tools, such as health impact assessments, can help identify and improve the health impacts of proposed design changes in the built

environment (Dannenberg et al., 2006; CDC, 2007). Undertaking systematic analyses and drawing on health data from the community provides an opportunity to showcase the potential health effects of built environment changes to stakeholders. Children benefit when homes, schools, communities and global policies are designed to optimise health.

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