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Critical Review

Association between the built environment and children's independent mobility: A meta-analytic review

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ABSTRACT

Children's independent mobility (CIM) is considered as a determining criterion of child-friendly built environment (BE). Researchers have made a substantial effort to identify the characteristics of the BE that affect CIM and thereby to inform city policy to promote CIM. Although the findings from these studies are useful to inform context specific CIM policy, together they provide inconclusive results. This study made a first attempt to draw a generalised conclusion through a meta-analysis of existing knowledge base. The analysis was conducted using primary studies reporting 13 BE-CIM links and published between 1980 and 2016. Overall effect size (ES), directions, and consistency of each link were calculated, also stratified by contexts, using the reported results from the primary studies and based on a random effect model. The results show that four BE factors (dead-end street, % of residential land, % of commercial land, and residential location type) have a positive association with CIM; traffic volume has a neutral association; and the remaining eight factors (vehicular street width, road density, intersection density, major road proportion, land use mix, availability of recreational facilities, residential density, and distance to destination) have a negative association. Living in a dead end street was found to have the strongest positive ES (0.352), with moderate level of consistency across the primary studies. In contrast, land use mix has the strongest negative ES (− 0.212) but with the highest level of inconsistency. Both ESs and consistencies, however, vary between developing and developed country contexts. Diversity in contexts, research design, and measurement instruments across the primary studies contributed to the heterogeneous results. The findings of this research serve as a guide for practitioners and researcher alike to make an informed decision about the BE factors that consistently foster or hinder CIM in different contexts.

1. Introduction

Child-friendly built environment is an important prerequisite for children's physical, mental, spiritual and social development (UNICEF, United Nations International Children's Emergency Fund, 1989). However, what constitutes a child-friendly built environment is debated in the literature (Kyttä, 2004; Nordström, 2010). Within this context, Broberg et al. (2013a) have provided an operational definition of child-friendly built environment using two criteria: children's possibilities for independent mobility, and their opportunities to actualize environmental affordances. This study focuses on the former criterion and aims to review the characteristics of the built environment that promote/hinder children's independent mobility. The findings from this research, therefore, contribute to the spatial dynamics – mobility nexus in the literature – i.e. how children independent mobility changes with respect to changes in the built environment (Priemus et al., 2001).

Children's independent mobility (CIM) is defined as the freedom and/or ability of children to travel around their neighbourhood without adult supervision (Carver et al., 2010b; Tranter and Whitelegg, 1994). It has been measured using various indicators in the literature such as home range (how far a child can travel from their home), independent time outside (how many minutes a child can stay outside of home independently), independent journey to destinations (child's independent movement to specific destinations), and parental license for children (whether a child is allowed to travel independently by parents) (Kyttä, 2004; Loebach and Gilliland, 2014; Villanueva et al., 2012a; Villanueva et al., 2012b). In this paper, these indicators are respectively referred to as CIM Range, CIM Time, CIM Destination, and CIM license. Built environment (BE) is referred to the human made features in a city and is often characterised by '5Ds' in the literature: density, diversity, design, distance and destination accessibility (Cervero and Kockelman, 1997; Ewing and Cervero, 2001). Each 'D' again is measured using a number of indicators. For example, density can be measured by: population density, residential density, floor area ratio etc. See

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Cervero et al. (2009) for a detailed description of the '5Ds' and their indicators.

Research on the link between BE and CIM has been popularised recently for two reasons. First, an increasing evidence shows that the level of CIM dropped significantly over the last few decades. This decline led to childhood obesity (Whitzman et al., 2010); sense of loneliness and fear (Prezza and Pacilli, 2007); physical (Rushovich et al., 2006), social (Groves, 1997), and cognitive (Christensen and O'Brien, 2003) incompetencies; poor environmental knowledge (Rissotto and Tonucci, 2002); reduced social and recreational opportunities (Prezza et al., 2001); and car dependency (Lopes et al., 2014; Mackett, 2002). For example, in Australia, the overall proportion of unaccompanied children travelling to school had dropped from 61% to 32% from 1991 to 2012, arguably this figure may vary between different geographical contexts in Australia (Schoeppe et al., 2015). In contrast, the number of children with obesity increased from 21% to 26% between 1995 and 2012 (ANPHA, Australian National Preventive Health Agency, 2014). Second, the topic attracts research attention from multiple research disciplines (public health, urban planning, and psychology) due to its multiple policy benefits as outlined above.

Built environmental and socio-cultural transformations caused by growing pressure of urbanization are on the rise and are argued to have altered children's mobility pattern worldwide (Fyhri et al., 2011; Lopes et al., 2014; Malone and Rudner, 2011; Tranter and Sharpe, 2012). Consequently, research on the complex relationship between BE and CIM has increased since the first reported study in the early 1980s by Van Vliet (1983). These studies have investigated a range of built environment factors (e.g. availability and proximity of destinations, land use diversity and density, street connectivity) and assessed their impacts on CIM to inform policies (De Meester et al., 2014; Kyttä, 2004; Loebach and Gilliland, 2014; Monsur and Islam, 2011; Prezza et al., 2001; Villanueva et al., 2012a; Villanueva et al., 2012b; Villanueva et al., 2013).

Among the various studies, only a few of them have reported a consistent relationship between several BE factors and CIM. Despite their consistency (in terms of direction), the strength of association, however, varies substantially among the studies. For example, Broberg and Sarjala (2015) have reported that a strong negative correlation exists between CIM and land use mix in Finland, whereas the relationship was found to be moderately negative in Bangladesh (Islam et al., 2014). A number of studies have, however, identified that such a correlation does not exist at all - i.e. land use mix has no impact on boy's IM (Carver et al., 2014b). Further adding to this complexity, an opposite relationship has also been reported in the literature for several BE factors. For example, most studies have reported that a positive association exists between well-connected street networks and CIM (Braza et al., 2004; Kerr et al., 2006). Monsur and Islam (2011), in contrast, found that less-connected road networks (e.g. dead end streets) are more likely to increase CIM. These contradictions and ambiguity in research findings raise the question about the true effect of the BE on CIM; and despite decades-long exploration on this topic, there is clearly a dearth of studies that systematically and statistically investigated these inconsistencies.

Previously, four studies have conducted a systematic review of the CIM literature (Bates and Stone, 2015; Malone and Rudner, 2017; Moghtaderi et al., 2012; Schoeppe et al., 2013). These studies have mainly focused on the link between CIM and health benefits. This means that CIM has been used as an explanatory factor of health outcomes. However, Malone and Rudner (2017) have provided a descriptive summary of CIM in relation to different socio-cultural and ecological contexts. This current study draws on the relationship between BE factors and CIM measured by systematically reviewing effects of the former on the latter, considering cultural and geographic determinants, which may affect the expression of both variables. In particular, this research aims to answer the following four research questions: a) What are the different BE factors that significantly affect CIM?; b) What are the magnitudes and directions of the associations?; c) Which BE factors have more consistent relationships with CIM?; and d) What are the plausible causes of variations of the reported results in prior studies?

The paper employs a meta-analysis technique to answer the above research questions. A meta-analysis is a form of a structured review of the literature on a particular topic of interest. Previously, researchers have used a range of review techniques which can broadly be categorised as traditional or narrative literature review and systematic literature review. A detailed description of these methods is outlined in Jesson et al. (2011). Briefly, a narrative review examines a body of the literature and draws a conclusion about a topic in question. It aims to provide the readers with a comprehensive background for understanding existing knowledge and thereby to identify gaps for new research. In contrast, a systemic review uses more rigorous and well-defined criteria to select and review the literature to answer a well-developed research question in order to allow the readers to assess the reliability and validity of the review (Torgerson, 2003). In addition to meta-analysis, another form of systematic review includes meta-synthesis. A meta-analysis is different from a meta-synthesis in that the former is based on statistical analysis of findings reported in previous studies whereas the latter is a non-statistical technique used to integrate, evaluate and interpret the findings of multiple qualitative research studies (Borenstein and Wiley, 2009). Therefore, a meta-analysis permits to extract the strength and direction of associations between dependent and independent variables, and thereby allows a more objective assessment of the evidence and may clarify heterogeneity or similarities (Egger and Smith, 1997).

The objective of this meta-analytic review is to statistically summarize the current body of knowledge on the association between BE and CIM in an attempt to estimate the average impact of different BE characteristics on CIM. It first combines the effect size (ES) of the studies reporting an association between BE and CIM for generalizability, and then compares the average effect sizes across different variables to rank their relative strengths and validity. These findings would serve as a policy guide to design urban areas that promote travelling autonomy for children; ensuring them with greater freedom to explore their surroundings, which is one of the fundamental premises for a child-friendly city.

2. Research methods

2.1. Search strategy

An extensive search procedure was employed comprised of six stages in order to identify relevant studies for meta-analysis. First, a comprehensive search was performed within all major electronic databases including Scopus, Tailor & Francis online, BioMed Central and Science Direct. The search range was specified from January 1980 to May 2016. The 1980 was selected as the starting period because an initial search result indicated that the first study on this topic was published in 1983 by Van Vliet (1983). Search terms included, but not limited to, "*urban environment", "built environment", physical environment of neighbourhood, neighbourhood character, neighbourhood, land use, proximity, distance to destination, walkability, street connection, street network, accessibility* in combination with *"children's independent mobility"*, or *"children's autonomous mobility"*, or *children's*: *free movement"*, or *children's independent journey"*, or *"free play"*. Second, a selective search was performed, for the same time period, within the following journal titles: *Health and Place, Transportation Planning and Technology, Environment and Behaviour, Children's Geographies, Journal of Urban design, Journal of Transport Geography, Journal of Transport and Health, Transport Policy, and Journal of Science and Medicine in Sport.* The initial research showed that these journals published a majority of studies on this topic. Third, reference lists of the selected publications from the above steps were checked in order to identify additional studies not