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Natural and built environmental exposures on children's active school travel: A Dutch global positioning system-based cross-sectional study

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ABSTRACT

Physical inactivity among children is on the rise. Active transport to school (ATS), namely walking and cycling there, adds to children's activity level. Little is known about how exposures along actual routes influence children's transport behavior. This study examined how natural and built environments influence mode choice among Dutch children aged 6–11 years. 623 school trips were tracked with global positioning system. Natural and built environmental exposures were determined by means of a geographic information system and their associations with children's active/passive mode choice were analyzed using mixed models. The actual commuted distance is inversely associated with ATS when only personal, traffic safety, and weather features are considered. When the model is adjusted for urban environments, the results are reversed and distance is no longer significant, whereas well-connected streets and cycling lanes are positively associated with ATS. Neither green space nor weather is significant. As distance is not apparent as a constraining travel determinant when moving through urban landscapes, planning authorities should support children's ATS by providing well-designed cities.

1. Background

Physical activity is a major public health asset decreasing the risk of adverse health effects (Lee et al., 2012). For children, the World Health Organization (WHO, 2015) recommends 60 min of moderate to vigorous physical activity every day to prevent disease in later life (Faulkner et al., 2009; Janssen and Leblanc, 2010). However, as a consequence of sedentary lifestyles, the number of children following this recommendation is constantly decreasing across Europe (Fyhri et al., 2011). Only 18% of Dutch children currently do so (Hildebrandt et al., 2013).

In that respect, active transport to school (ATS) – that is, walking or cycling to school – seems to be a valuable source for energy expenditure in children's daily lives (Steinbach et al., 2012; Schoeppe et al., 2013; Dessing et al., 2014). This is particularly true for Europe, where schools are well integrated in residential neighborhoods (Aarts et al., 2013). There is empirical evidence that ATS results in increased physical activity levels in children compared to those who are chauffeured by their parents (Van Sluijs et al., 2009; Cooper et al., 2010; Owen et al., 2012). ATS also mitigates adverse environmental effects around schools, such as greenhouse gas emissions and traffic congestion during peak times (Maibach et al., 2009).

A crucial first step toward comprehensive policy strategies promoting ATS is to understand the factors that stimulate and hinder ATS. Children's travel decisions are highly complex; they are driven by, for example, personal characteristics, distance between home and school, safety issues due to traffic, and stranger-danger (Sirard and Slater, 2008; Schoeppe et al., 2013; Mitra, 2013). In addition, natural and urban environmental determinants are suggested to be influential (Pont et al., 2009; Panter et al.,

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2010; Wong et al., 2011a; Sallis et al., 2015). Despite the significance of greenness and weather conditions for active transport among adults (Helbich et al., 2014; Fishman et al., 2015; Böcker et al., 2016), little is known about how these natural environmental factors shape children's mobility. Most studies either regard weather as non-modifiable or consider weather conditions (e.g., precipitation) only on a daily (or even seasonal) basis (Børrestad et al., 2011; Van Goeverden and de Boer, 2013), inappropriately reflecting their instant effects on mode choice.

More research has been conducted on urban environmental effects on children's ATS (Ewing and Cervero, 2010; Van Loon and Frank, 2011). The built environment – subsuming urban morphology, land-use, and street layout – is frequently operationalized by means of density, diversity, and design measures (Saelens and Handy, 2008; Ewing and Cervero, 2010). It is assumed that neighborhoods with, for example, a higher density and a more mixed land-use bring destinations (e.g., shops) closer together, thereby shortening trip distances (Van Loon and Frank, 2011). This increases the destination accessibility and promotes walking and cycling. Neighborhoods with pronounced land-use diversity make trip chaining via active transport modes more convenient (Saelens and Handy, 2008). Regarding the design of the street layout, more intersections yield a higher street connectivity, which increases route opportunities (Giles-Corti et al., 2011). In contrast, well-connected streets potentially attract more traffic which raises the risk of pedestrian injury (Sirard and Slater, 2008). Even though there is considerable knowledge about the impacts of built environmental features on adults, knowledge about the ATS of children is still fragmented and inconclusive (Pont et al., 2009; Wong et al., 2011a).

Inconsistent findings in past research may be due to the various ways in which environmental context is delineated and contextual variables are derived (Kwan, 2012). Contextual areas for deriving environmental exposures (e.g., street intersection density) are often modeled with geographic information systems (GIS) as static areas around residential/school location (Larsen et al., 2009; Su et al., 2013), even though it is increasingly argued that not only the conditions of the origin and/or the destination, but also the traversed features of the taken route, are key (Badland et al., 2008; Duncan et al., 2009; Kwan, 2012). To substitute actual routes, Euclidean (Owen et al., 2012) or GIS-based shortest path analyses (Schlossberg et al., 2006) are employed. However, children rarely aim to minimize travel distance, and their route decisions are determined by safety issues, route attractiveness, and opportunities to meet classmates (Harrison et al., 2014). More importantly, Harrison et al. (2014) highlight significant differences in environmental exposures between the shortest and the actual paths. A promising solution is to track children with a global positioning system (GPS; Kerr et al., 2011), which is increasingly accepted as a reliable method to collect data on children's space–time mobility (Bohte and Maat, 2009; Dessing et al., 2014).

In addition to these exposure operationalization challenges, extra uncertainty about the validity of environmental correlates arises due to a North American and Australian centric research focus (McMillan, 2005; Pont et al., 2009; Su et al., 2013). Because of substantial differences in urban geographies, findings based on these regions may not be easily transferred and generalized to European areas (Panter et al., 2010; Lu et al., 2015). European cities have higher densities, distinctive land-use diversities, and lower levels of reliance on automobiles. Even within Europe, the Netherlands needs special attention as it has the world's highest level of bicycle usage (Pucher and Dijkstra, 2003) and cycling is embedded in people's daily lives not only for leisure but also for utilitarian trips (De Vries et al., 2010a).

Although there is a limited number of European studies (Bringolf-Isler et al., 2008; D'Haese et al., 2011; Broberg and Sarjala, 2015) and Dutch studies (De Vries et al., 2010a; Aarts et al., 2013; Van Goeverden and de Boer, 2013; Dessing et al., 2014), the present research addressed the aforementioned shortcomings and is among a few studies to consider the impact of not only built environmental exposures, but also natural environments (i.e., weather, green space) on children's actual commuting paths to and from school. The two research questions were:

a) Are weather conditions at the trip departure time a significant behavioral determinant influencing ATS?
b) Are the exposed natural and built environmental features en route significant determinates of ATS?

To answer these questions, we monitored children's commuting behavior by means of GPS and transport mode choice to and from six schools located in the Netherlands. The research outcomes dealing with the built environment are of fundamental importance for both urban planners and health policymakers who wish to develop strategies and interventions that will systematically promote active transport and thus a healthier urban living (Sallis et al., 2015).

2. Methods

2.1. Study design

This study was part of a project titled “SPACE: Spatial Planning and Children's Exercise” (De Vries et al., 2010a, 2010b) and focused on a subset of 97 children aged 6–11 years in six elementary schools located in five neighborhoods in mid- to large-sized Dutch cities (Amersfoort, Haarlem, Hengelo, Rotterdam, and Vlaardingen) for which GPS data was available. Children were only included when living in the neighborhood where the school was located. The schools are located in neighborhoods with similar demographic profiles (e.g., ethnicity, social status) but they varied in size and population density. Teachers invited children to participate, and their parents or legal guardians were asked for written consent.

The children’s daily movements were monitored between December 2008 and April 2009 for eight consecutive days during a regular school week. To record their spatiotemporal trajectories, each child was equipped with a GPS unit (Travel recorder X, BT-Q1000X, QStarz International Co) with a sampling interval of 5 s (Kerr et al., 2011). After distributing the GPS receivers during school hours, the children were briefed by a skilled researcher on how to wear and operate the device. A manual was handed to their parents/guardians. To guarantee uniform data collection, all children carried the GPS on an elasticated belt around their hips from the morning till bedtime. They removed the device temporarily only to perform activities that would otherwise damage the receiver (e.g., showering). The ethics committee of the Leiden University Medical Center has approved the present study.

2.2. GPS-based trip detection, transport mode classification

GPS loggers collect time–location data under free living conditions (Kerr et al., 2011). Neither individual trips nor selected modes are gathered directly and require data processing. As Wu et al. (2011) report no striking differences between rule-based and computational approaches, we applied the former (Sterkenburg et al., 2012), as it is more intuitive. First, we used the cluster detection algorithm of Maas et al. (2013) to distinguish between stationary activity places (e.g., residential and school locations) and conducted trips. For trip detection from home to school, we identified the first GPS data point within a 40 m radius of the