Spatial clustering and the temporal mobility of walking school trips in the Greater Toronto Area, Canada

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ABSTRACT

Interest in utilitarian sources of physical activity, such as walking to school, has emerged in response to the increased prevalence of sedentary behavior in children and youth. Public health practitioners and urban planners need to be able to survey and monitor walking practices in space and time, with a view to developing appropriate interventions. This study explored the prevalence of walking to and from school of 11–13 year olds in the Greater Toronto Area (GTA), Canada. The Getis–Ord (G_i^*) local spatial statistic, Markov transition matrices, and logistic regressions were used to examine the spatial clustering of walking trips in the study area, and to document any temporal drift of places in and out of walking clusters. Findings demonstrate that walking tends to cluster within the urban and inner-suburban GTA, and in areas with low household income. Temporally persistent cluster membership was less likely within inner-suburban and outer-suburban places. The evidence suggests that interventions to increase active school transportation need to acknowledge spatial and temporal differences in walking behavior.

1. Introduction

Walking and cycling for school travel may make an important contribution to overall daily energy expenditure for children and youth (Faulkner et al., 2009). Engaging in active school transportation (AST: walking and cycling) may also develop into persistent environmentally sustainable travel practices through time (Black et al., 2001), improve psychological well being (Frumkin et al., 2004), and give rise to greater participation in physical activity later in life (Frank et al., 2003). Policy interest in AST, as a utilitarian source of physical activity, has materialized in response to the increasing prevalence of obesity and over-weight in children and youth (Frumkin et al., 2004; Tudor-Locke et al., 2001). In response, urban planners have emphasized built environment interventions to increase AST among children (Ontario Professional Planners Institute, 2009; Transportation Alternatives, 2002).

The interest of practice in AST has been matched with the development of transdisciplinary research focused on the relationship between the built environment, school transportation, and the level of physical activity among children and youth. Several recent studies have reviewed and summarized this emerging urban planning and physical activity literature (Pont et al., 2009; Sirard and Slater, 2008). Perhaps the largest consensus among the researchers concerns the effect of distance on school travel mode choice; longer school travel distances tend to associate with auto-oriented outcomes (Ewing et al., 2004; McDonald, 2008; Nelson et al., 2008; Timperio et al., 2006). With regard to other built environment characteristics, the empirical results have been less conclusive. Some studies indicate that density (Kerr et al., 2006; McDonald, 2008), land use mix (Larsen et al., 2009; McMillan, 2007), and neighborhood design characteristics (e.g., street facing houses) (McMillan, 2007) statistically associate with the likelihood of taking an active mode to school. In contrast, others have reported no statistically significant association between density and/or land use mix, and school travel mode choice (Ewing et al., 2004; Yarlagadda and Srinivasan, 2008). A few researchers have examined differences in school transport between urban and rural places; not surprisingly, urban children tend to walk more for school purposes than others (Martin et al., 2007; Robertson-Wilson et al., 2007).

With regard to transportation connectivity, the presence of sidewalks appears to positively associate with AST (Boarnet et al., 2005; Ewing et al., 2004), while other design characteristics such as intersection density tend to negatively correlate with the likelihood of walking (Mitra et al., 2010; Schlossberg et al., 2006; Timperio et al., 2006). These findings support conclusions

regarding the central role of safety concerns in the school travel debate. Not only do objective measures of the pedestrian experience appear to correlate with AST, but research has also shown that perceptions of risk regarding traffic and personal safety in general may act as key barriers to AST (Kerr et al., 2006; Schlossberg et al., 2006). Parental attitudes toward travel may also mediate school transport decisions. For example, the *car-centeredness* of a household (Black et al., 2001; McMillan, 2007), and lack of confidence about a child's capabilities for autonomous mobility (Martin et al., 2007; Wen et al., 2008) likely reduce the odds of walking to/from school.

Despite current thinking that the built environment may facilitate healthy and sustainable school travel mode choice decisions, there remains two important conceptual issues, that are not addressed in current AST literature (e.g., Pont et al., 2009; Sirard and Slater, 2008), requiring closer attention. First, while most empirical research has studied travel behavior of an *individual* child or youth, and explored built environment qualities of *neighborhoods*, patterns of AST practices at the regional scale, an increasingly relevant planning unit, have received less attention. If the built environment does influence AST, then it is reasonable to assume that AST should vary systematically across an urban region, where characteristics of the built environment also vary. For example, in Western nations, walking school trips are expected to be more common in "traditional" urban areas, developed prior to World War Two (WW2), where development densities, land use mix, street connectivity, and the availability of pedestrian infrastructures combine to provide a built environment that is perceived to be comparably more *walkable* than what might be found in the typical post-war suburban context. At the scale of an urban region, particularly one like the Greater Toronto Area (GTA), Canada, which has a lengthy development history ranging from the colonial period to present day, a range of urban forms is expected to be present (see Sewell, 2009; White, 2007). This mixture of forms may associate with a diverse range of walkability outcomes, creating a formidable challenge for regional planners who may be attempting to influence walking in the absence of data that adequately describe how outcomes associated with school travel mode choice decisions potentially vary from place to place, in space, and in time.

Second, the temporal consistency of mode choice for school travel (i.e., between morning and afternoon period trips), or lack thereof, has received relatively less attention in the literature. Although most studies have focused on trips *to* school (e.g., Ewing et al., 2004; McDonald, 2008; McMillan, 2007); and while others have explored school travel in general, pooling the responses across the a.m. and p.m. periods (e.g., Kerr et al., 2006; Timperio et al., 2006; Wen et al., 2008), recent exploratory research has found more parentally escorted car trips to school, than parentally escorted car trips from school to home at the end of the day (Buliung et al., 2009; Schlossberg et al., 2006; van der Ploeg et al., 2008). This third group of studies is particularly relevant because they begin to suggest that the strength and possibly the direction of the relationship between AST and the built environment may change through time, as the spatial, temporal, and institutional constraints (e.g., hours of paid work, suburbanization of employment) facing households intensify and/or subside throughout the day. Also, and regardless of the cause, changes in individual mode choice decisions over time, when aggregated to the neighborhood or some other areal unit, could produce places that generate above average AST rates some of the time, and below average rates at other times. In other words, the relationship between place and AST is likely to be spatially and temporally heterogeneous.

This study contributes to the literature on active school travel, and pedestrian behavior, by exploring this spatial and temporal variability in school travel mode share in the GTA. For public health practitioners and urban planners, to be able to identify places where healthy behaviors are either commonly or rarely practiced, may have important implications with regard to developing appropriate interventions. Certainly, the potential spatial and temporal variation of AST outcomes, described previously, could moderate the impact of a policy intervention (e.g., sidewalks development) on the use of active modes. Nesting the school travel mode choice problem within a quantitative spatial analytic framework provides an opportunity to demonstrate the utility of spatial analysis for broadening current thinking about the relationship between active school travel and place.

The study addresses three research questions: first, to what extent are high rates of walking geographically clustered? Second, to what extent do places change in time, i.e., between the a.m. (trips to school) and p.m. (trips from school) time periods, with regard to the clustering of walking trips? And third, what spatial characteristics may explain the likelihood of being part of a cluster? The Getis–Ord (G_i^*) local spatial statistic, Markov transition matrices, and logistic regressions were used to explore this "idealized" travel behavior (i.e., walking to and/or from school) in space and time. The remainder of the paper is organized into three sections. The following section establishes the scope of the study and outlines the empirical research design. Observations regarding the spatial clustering of AST outcomes, temporal variability of the spatial clusters, and the correlates of cluster membership are described next. The paper concludes with a summary of the major findings, and a brief discussion of their implications for advancing knowledge and policy that are focused on the promotion of AST.

2. Research design

2.1. Data and study area

Data from the 2001 Transportation Tomorrow Survey (TTS) were used to explore patterns of walking school trips across space and time. The decision to exclude the other common active mode, cycling, was informed by previous research which found that, for the study area, cycling captured no more than 1% of all school trips (Buliung et al., 2009). The TTS is a repeat cross-sectional travel survey that covers 21 cities and regional municipalities in the province of Ontario, Canada; it has been conducted, once, every five years, since 1986 (Data Management Group, 2008). The TTS data are collected using a computer assisted telephone interview (CATI) method, in the Fall or the Spring; a direct data entry (DDE) instrument is used to record self-reported weekday travel data (e.g., origin and destination of a trip, trip purpose, travel mode). Travel information for all household members aged 11 years and older, for trips made on the day prior to the interview date, is proxy reported by an adult household member. The 2001 TTS collected data from 5% of the households in the study area; this sample produced approximately 817,000 trip records (Data Management Group, 2008).

The study area for this research is limited to the City of Toronto, and the four surrounding regional municipalities: Durham, York, Peel, and Halton. These places collectively represent the GTA, which is Canada's largest urban region with regard to both population and geographic area. Travel data are reported at the level of 1548 traffic analysis zones (TAZs)—small geographical areas that are commonly used for transportation planning and engineering purposes. The TAZs for the 2001 TTS are largely similar in size to census tracts (CT). However, within the suburban GTA where CTs are typically larger, a CT may contain