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Walking, cycling and the urban form: A Heckman selection model of active travel mode and distance by young adolescents

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ABSTRACT

Physical inactivity of children and adolescents is a major public health challenge of the modern era but, when adequately promoted and nurtured, active travel offers immediate health benefits and forms future sustainable and healthy travel habits. This study explores jointly the choice and the extent of active travel of young adolescents while considering walking and cycling as distinct travel forms, controlling for objective urban form measures, and taking both a "street-buffer" looking at the immediate home surroundings and a "transport-zone" looking at wider neighborhoods. A Heckman selection model represents the distance covered while cycling (walking) given the mode choice being bicycle (walk) for a representative sample of 10–15 year-olds from the Capital Region of Denmark extracted from the Danish national travel survey. Results illustrate the necessity of different urban environments for walking and cycling, as the former relates to "street-buffer" urban form measures and the latter also to "transport-zone " ones. Results also show that lessening the amount and the density of car traffic, diminishing the movement of heavy vehicles in local streets, reducing the conflict points with the density of intersections, and intervening on crash frequency and severity, would increase the probability and the amount of active travel by young adolescents. Last, results indicate that zones in rural areas and at a higher percentage of immigrants are likely to have lower probability and amount of active travel by young adolescents.

Introduction

Physical inactivity of children is a major health challenge, and coping with ever growing urban environment is a challenge for children due to their physical fragility, required mental strength, autonomy traits, spatial skills, hazard detection and conflict mitigation skills (Mackett, 2013). The challenge is even greater considering the increase in parental chauffeuring to school trips in several European countries (Fyhri and Hjorthol, 2009), the development of high car-dependence due to parental chauffeuring (Carver et al., 2013), and the relationship between high car-dependence during childhood and car use intentions as future adults (Sigurdardottir et al., 2013, 2014). In contrast to child chauffeuring and car-dependence, active travel carries huge advantages in terms of providing health benefits (Lubans et al., 2011; Mackett et al., 2005; Santos et al., 2009; Wake and Reeves, 2012) and forming future sustainable travel habits (Sigurdardottir et al., 2013, 2014).

The choice of active travel and its amount are joint choices that shape the active travel pattern of children to counter their physical inactivity and their intentions to choose non-sustainable travel options as future adults. Understanding the

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relationship of active travel mode and distance with objective measures of urban form is essential for meeting the challenge of encouraging children to use non-motorized modes to school and leisure activities. Urban form relates to the active travel of children directly through motivators and barriers to non-motorized mobility and accessibility, and indirectly through support of parental perceptions about the children's ability to maneuver the urban environment given their spatial and cognitive skills. Hence, understanding the relationship between active travel and urban form is a necessary pre-requisite for evaluating the effectiveness of policy measures such as adding pedestrian pathways and school crossing guards in major roads near schools, designing neighborhoods in which residences, retail outlets and sport facilities are located in close proximity, and improving parental perceptions regarding the safety of non-motorized modes.

In the literature about active travel of children, most studies focused on the probability of choosing active travel while using the distance traveled as an exogenous explanatory variable (e.g., Christiansen et al., 2014a). The choice of active travel distance has been scarcely investigated (Seraj et al., 2012; Villanueva et al., 2012) and previous studies have not dealt with the simultaneity of the choice of active travel and the choice of active travel distance. However, using one choice as an exogenous variable to the other choice leads to potential estimation problems deriving from neglecting the simultaneity in the two choices (Bhat, 1997). Moreover, it also impedes understanding the linkage between urban form and the amount of active travel.

While previous research on the choice of active travel, and also the limited research on active travel distance, has primarily focused on school trips (e.g., Christiansen et al., 2014a,b; Easton and Ferrari, 2015), travel made by children to leisure and other non-mandatory activities has attracted much less consideration (Fyhri and Hjorthol, 2009). Due to the growing role of such activities in the daily travel patterns of children, and the role of the car in such trips (Fyhri and Hjorthol, 2009; Fyhri et al., 2011), including such leisure and non-mandatory travel as an integral part of the analysis of active travel patterns of children is increasingly important.

While walking was investigated as a sole active travel mode in several studies (e.g., Bejleri et al., 2011; Kerr et al., 2007; Lee et al., 2013; Mitra et al., 2010a,b; Pont et al., 2013; Su et al., 2013; Yarlagadda and Srinivasan, 2008), other studies considered jointly walking and cycling as a single active travel mode without differentiation (e.g., Carver et al., 2014; Dalton et al., 2011; Johansson, 2006; Leslie et al., 2010; Seraj et al., 2012; Sidharthan et al., 2011), possibly because of the scarcity of cycling versus walking in car-oriented countries (e.g., Easton and Ferrari, 2015). Consequently, cycling received very little attention (Christiansen et al., 2014a,b) and, while the relationship between walking and urban form is clear, the relationship between cycling and urban form needs to be further explored.

Several studies addressed a narrow range of urban form variables focusing mainly on a linear effect of home-to-school distance and a limited number of infrastructure and land-use characteristics, measured within a distance band from the home or the school location, thus neglecting non-linear effects and the possibility of effects of urban form variables at different aggregation levels. The most recurrent factors were travel distance (e.g., Christiansen et al., 2014a,b; Lee et al., 2013; McMillan, 2007; Pont et al., 2013; Yarlagadda and Srinivasan, 2008), road infrastructure in terms of intersection density and road hierarchy (e.g., Bejleri et al., 2011; Kemperman and Timmermans, 2014; Kerr et al., 2007; McMillan, 2007; Seraj et al., 2012; Su et al., 2013), availability of pedestrian infrastructure (i.e., sidewalks, curbs) and walkability (e.g., Bejleri et al., 2011; Carver et al., 2014; Christiansen et al., 2014a,b; Easton and Ferrari, 2015; Villanueva et al., 2012), land-use mixture (e.g., Carver et al., 2014; Kemperman and Timmermans, 2014; Mitra et al., 2010b; Pont et al., 2013; Seraj et al., 2012; Su et al., 2013), residential and population density (e.g., Dalton et al., 2011; Kemperman and Timmermans, 2014), and number of activity opportunities within distance bands (e.g., Dalton et al., 2011; Kerr et al., 2007; Sidharthan et al., 2011; Villanueva et al., 2012). Most studies did not base their analysis on detailed GIS databases and thus used approximate urban form measures such as home-school aerial distance (e.g., Bejleri et al., 2011).

Most studies focused on primary and middle school 8–13 year-old children who are at the early stages of developing their travel independence (e.g., Carver et al., 2014; Johansson, 2006; Mitra et al., 2010a,b; Pont et al., 2013; Villanueva et al., 2012) or on younger children (e.g., Bejleri et al., 2011; Kerr et al., 2007; Lee et al., 2013; McMillan, 2007; Seraj et al., 2012; Yarlagadda and Srinivasan, 2008). The results of these studies cannot be readily extended to older adolescents because, as the child age increases, parental attitudes and perceptions change toward viewing active and independent travel more positively (e.g., Johansson, 2006; Seraj et al., 2012).Very little attention has been posed exclusively on adolescents (e.g., Dalton et al., 2011; Leslie et al., 2010; Sigurdardottir et al., 2013, 2014), leading to knowledge gaps with respect to their active travel patterns.

Geographically, most studies analyzed car-oriented countries (e.g., Dalton et al., 2011; Kerr et al., 2007; McMillan, 2007; Mitra et al., 2010a,b; Seraj et al., 2012; Sidharthan et al., 2011; Su et al., 2013; Villanueva et al., 2012). Cycling rates of children and the general population are generally low and cycling infrastructure is relatively scarce in these countries, which poses severe infrastructure and social barriers for cycling as an active travel mode. The active travel of children in countries with a high cycling share among travel modes, such as the Netherlands or Denmark, has received little attention (Christiansen et al., 2014a,b; Kemperman and Timmermans, 2014; Sigurdardottir et al., 2013, 2014).

This paper explores the relationship between objective "street-buffer" and "transport-zone" urban form measures and the combination of the odds and the amount of active travel to school and leisure activities by young adolescents between the age of 10 and 15, while considering walking and cycling as different modes. Exploring the joint choice of active travel and distance enables the accommodation of the simultaneous nature of these two choices by accounting for unobserved individual characteristics that affect both choices and recognizing that urban form may be associated differently with the odds and