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Environmental supports for walking/biking and traffic safety: Income and ethnicity disparities

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ABSTRACT

Objective. The present study investigates the influence of income, ethnicity, and built environmental characteristics on the percentages of workers who walk/bike as well as on pedestrian/cyclist crash rates. Furthermore, income and ethnicity disparities are also explored.

Methods. This study chose 162 census tracts in Austin as the unit of analysis. To explore income and ethnicity differences in built environments, this study examined the associations of the poverty rate, the percentage of white population, and the percentage of Hispanic population to each built environmental variable. Path models were applied to examine environmental supports of walking/biking and pedestrian/cyclist safety.

Results. Areas with high poverty rates had more biking trips and experienced more cyclist crashes, while areas with a high percentage of white population generated more walking trips and fewer pedestrian crashes. Sidewalk completeness and mixed land uses promoted walking to work but increased the crash risk for pedestrians as well. In terms of biking behaviors, road density and transit stop density both increased biking trips and cyclist crashes.

Conclusions. Environmental designs that both encourage walking/biking trips and generate more safety threats should attract more attention from policy makers. Policies should also be more devoted to enhancing the mobility and health for areas with high poverty rates.

Introduction

Regular physical activity provides several health benefits such as the prevention of obesity (McCormack and Shiell, 2011; Pucher and Buehler, 2006), cardiovascular disease (Ahmed et al., 2012; Pucher and Dijkstra, 2005), and mental health disorders (Dunn and Jewell, 2010; Strohle, 2009). Based on the 2008 Physical Activity Guidelines for Americans, adults who engage in at least 150 min of moderate-intensity aerobic activity such as brisk walking a week are more likely to obtain greater health benefits than individuals who do not engage in physical activity. A growing body of studies have utilized the socio-ecological framework to examine the impacts of personal, social, and built environmental factors on physical activity (Giles-Corti and Donovan, 2002; Giles-Corti et al., 2005; Glanz et al., 2008). The 3Ds of built environments – density, diversity, and design – have been extensively applied to examine this relationship (Cervero and Kockelman, 1997). Areas with high population densities, mixed land uses, connected streets, complete non-motorized infrastructure, high transit access, and short trip distances produced more walking/biking trips (McCormack and Shiell, 2011; Pucher and Buehler, 2006; Pucher and Dijkstra, 2005; Saelens and Handy, 2008; Saelens et al., 2003).

Meanwhile, traffic safety is also identified as an important barrier to active travel (Davison and Lawson, 2006; Saelens and Handy, 2008). Traffic-related deaths and injuries have become a growing public health issue because of the enormous economic losses and social stress they bring (Ernst and Shoup, 2011). Previous studies reported that areas with high street connectivity, high traffic volume, and high population densities experienced more crashes (Clifton and Kreamer-Fults, 2007; Dumbaugh and Rae, 2009; Graham and Glaister, 2003; LaScala et al., 2000).

Few studies, however, simultaneously examined the influences of built environments on walking/biking behaviors and traffic safety. It should be noted that some built environmental designs (i.e., population density, street connectivity, etc.) not only promote active travel but also increase the risk of collisions. The effectiveness of walkable/bikeable neighborhoods should work under the premise of providing safe environments for people to walk/bike. If the designs of environments cannot ensure the safety for pedestrians and cyclists, the effort to encourage walking/biking may impose safety threats for pedestrians and cyclists and increase traffic-related deaths and injuries (Sleet et al., 2010). Thus, the neglect of pedestrian and cyclist safety made walking and biking dangerous (Pucher and Dijkstra, 2005).

Moreover, environmental supports for active travel and traffic safety may differ by neighborhoods' economic statuses and ethnic compositions. Prior research separately identified that deprived areas (i.e., low

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income, minority population) experienced more pedestrian crashes (Graham and Glaister, 2003; Loukaitou-Sideris et al., 2007; Noland et al., 2013) and had more active travel (Besser and Dannenberg, 2005; Freeland et al., 2013). The distribution of walkable/bikeable and safe environments is inequitable across neighborhoods with different income statuses and ethnicity compositions (Sallis et al., 2011; Zhu and Lee, 2008). Current empirical evidence is limited in exploring economic and ethnic disparities in environmental supports for active travel and traffic safety. It is necessary to detect the areas that suffer the most from health disparities.

Most disparity studies on walkability identified activity-supportive environmental attributes according to previous research rather than based on empirical testing from their own studies (Abercrombie et al., 2008; Sallis et al., 2011; Zhu and Lee, 2008). The inconsistent relationships between built environments and physical activity in varying study settings raise questions about the appropriateness of this approach. The present study empirically identifies significant factors related to active travel and traffic safety in order to explore income and ethnicity disparities.

The purpose of the present study is to concurrently examine the relationships of income, ethnicity, and environmental characteristics to active transportation and traffic safety. Moreover, income and ethnicity disparities in active travel and traffic safety are also explored.

Methods

Study area and the unit of analysis

The city of Austin was chosen as the study area according to (1) the variability in development patterns, with resident density ranging from 3 to 423 persons per acre and street intersection density from 0.02 to 0.66 intersections per acre; (2) the diversity of income and ethnicity compositions across neighborhoods, with the percentage of Hispanic population ranging from 3% to 92% and the poverty rate from 1% to 87% in the 2010 Census; and (3) the availability of rich and updated GIS datasets, including parcel-level land use data, street centerline data, sidewalk data, bike lane data, etc.

To obtain accurate socio-demographic information and have enough variations in environmental attributes, two neighborhood-level geographic units were considered — census tracts and census block groups. Because census tracts provided comprehensive income information in the 2010 Census data, this study selected census tracts as the unit of analysis. To ensure that all census tracts were covered by the data, this study used those were complete within the boundary of Austin city limit. In total, 162 census tracts in the city of Austin were chosen.

Variables and measurements

For dependent variables, two domains – active transportation and traffic safety – were considered. In terms of the active transportation, this study used the percentages of workers (aged 16 years or older) who walked and biked from the 2010 Census data (Table 1). With respect to traffic safety, this study included yearly pedestrian and cyclist crash rates. The ideal way to capture yearly crash rates would be to normalize number of pedestrian and cyclist crashes to the unit of exposure (pedestrian/cyclist volumes) per year. However, the information regarding pedestrian/cyclist volumes was not available in each census tract in the city of Austin. Because pedestrian and cyclist crashes occurred on or near roads (vehicles travel on streets and pedestrians/cyclists also move along at the sides of these streets), this study measured yearly crash rates per street mile. The crash data came from the Texas Department of Transportation (TxDOT) from 2008 to 2012.

In terms of independent variables, three domains – income, ethnicity, and built environments – were included. The poverty rate was used as the income variable, and the percentage of non-Hispanic white population and Hispanic population (from the 2010 Census data) were used as ethnicity variables. All of this information came from the 2010 Census data.

For built environmental variables, the 3Ds of built environments were used to guide the selection of variables: density (resident density, road density, street intersection density, and transit stop density), diversity (land use mix), and design (sidewalk completeness and bike lane completeness). Land use mix indicates the composition of various uses (residential, commercial, and office) within a given geographic area (Cervero, 1988). All activities derived from various uses intermix with each other (Cervero, 1988). All data for built environmental variables were collected from the Austin GIS Datasets except transit stops (from the Capital Metro–Austin Public Transit).

Normalized measurements were applied to most built environmental variables due to varying sizes of census tracts. The measurement of land use mix was obtained from the Strategies for Metropolitan Atlanta's Regional Transportation and Air Quality Study (Frank et al., 2005). It ranges from 0 to 1. A higher value means more even distributions of residential, commercial, and office land uses in census tracts.

Data analysis

This is a cross-sectional study. Because the two dependent variables – the percentages of workers who walked and biked – were positively skewed, log-transformation was used to approximate them into a Gaussian distribution.

In order to explore income and ethnicity differences in environments, this study examined the relationships of the poverty rate, the percentage of white population, and the percentage of Hispanic population to each built environmental variable.

Furthermore, the present study used M-Plus 6.11 to develop two path models: the walking model (including the percentage of workers who walked and pedestrian safety) and the biking model (the percentage of workers who biked and cyclist safety). These two path models allowed for a concurrent examination of the relationships between environmental variables and active transportation and traffic safety and an exploration of income and ethnicity disparities in active travel and traffic safety.

Results

Table 2 presents the standardized coefficients for the associations between the poverty rate, the percentage of white population, the percentage of Hispanic population, and each built environmental variable. Although the three independent variables were significantly correlated with each other at the 5% level according to correlation coefficients, no multicollinearity issue was recognized from the regressions (the highest variance inflation factor was 2.21).

The poverty rate showed positive associations with resident density, road density, street intersection density, transit stop density, and land use mix. The percentage of white population was positively related to street intersection density and negatively associated with land use mix. The percentage of Hispanic population was not significantly related to any built environmental variables.

For the examination of active transportation and traffic safety, two path models (the walking model and the biking model) illustrated a good mode fit as compared to the suggested values of indices (Brown, 2006). The root mean square error of approximation (RMSEA) was 0.02 for the walking model and 0.01 for the biking model. The comparative fit index (CFI) was 0.99 for the walking model and 0.98 for the biking model.

In terms of the walking model (Table 3), all income and ethnicity variables were significantly related to the percentage of workers who walked. Only the percentage of white population was significantly associated with pedestrian crash rates. Both sidewalk completeness and land use mix were simultaneously positively related to the percentage of workers who walked and pedestrian crash rates. Resident density, street intersection density, and transit stop density were related only to pedestrian crash rates. The coefficient between the percentage of workers who walked and pedestrian crash rate was 0.24, which was significant at the 1% level.

In regard to the biking model (Table 4), the poverty rate, road density, and transit stop density were positively related to the percentage of workers who biked and cyclist crash rates. Resident density and street intersection density were related only to the percentage of workers who biked, while land use mix was solely associated with cyclist crash rates. The coefficient between the percentage of workers who biked and cyclist crash rate was 0.46, which was significant at the 1% level.