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Neighborhood-based differences in walkability, physical activity, and weight status in India

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ABSTRACT

Introduction: Data on built environment (BE) and physical activity (PA) in low- and middle- income countries is sparse. This study compared BE features, PA levels, and weight status among adults living in neighborhoods stratified by walkability and socio-economic status (SES) in the city of Chennai, India.
Methods: This cross sectional study design surveyed 370 adults ($\geq$ 18 years) from four neighborhoods with differing walkability and socio-economic status. Participants were asked to complete a survey on their neighborhood environment, leisure and travel PA, height, weight, and demographic characteristics. One-way analysis of variance tests were used to examine differences across neighborhoods.
Results: Residents of high-walkability/high-SES neighborhoods reported higher land use mix diversity, land use mix access, street connectivity, aesthetics, and safety from crime. Residential density and walking/bicycling infrastructure were highest in the high-walkability/low-SES neighborhood. Transport PA was the maximum contributor to total PA in low-SES neighborhoods, while residents of high-SES neighborhoods reported greater levels of leisure-time PA. Sitting time and BMI were greater among high-SES participants. Patterns of PA, sedentary time, and weight status varied significantly by neighborhood walkability and SES.
Conclusions: An understanding of BE correlates of domain-specific PA can support the development of contextually tailored interventions to promote physical activity and reverse the determinants of inactivity occurring through patterns of urbanization and sedentary behaviors in India.

1. Introduction

India, with a population of 1.2 billion people and will soon be the world's most populous country (UNFPA, 2015). India is experiencing a non-communicable disease (NCD) epidemic (Ranasinghe et al., 2013; Jonas et al., 2010; Mohan and Pradeepa, 2009; Pradeepa and Mohan, 2002). Rapid rates of increase of obesity, diabetes mellitus, and associated chronic and co-morbid NCDs (e.g., cardiovascular diseases and some cancers) are being documented in India, yet in-country evidence-based research is lacking.2, 6 Currently, India has the largest diabetic population with 33 million, projected to reach 100 million by 2020 (World Health Organization, 2010). Cardiovascular disease is the leading cause of death in India, and its contribution to mortality is rising; deaths due to cardiovascular disease are projected to double between 1985 and 2015 (World Health Organization, 2010; Pearson, 1999, 1996). Morbid obesity is currently affecting 5% of Indians (approximately 61 million people) (Woodcock et al., 2007). Despite such alarming statics, there is minimal research examining the rising prevalence and risk factors causing NCDs in the general population of India.

Calls to reduce global epidemics of NCDs by the United Nations and the World Health Organization have recommended increasing physical activity (PA) as a key strategy (World Health Organization, 2010, 2000, 2011; United Nations Organization,

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2011). Environmental and policy supports for increasing PA (e.g., walking, bicycling) represent promising modifiable strategies to curb the rise in NCDs at a population level (Sallis et al., 2012). Understanding the associations between PA and the neighborhood built environment (BE) where the activity occurs has been the subject of recent international interest (Kerr et al., 2013; Sallis et al., 2016). This interest reflects a social ecological view of health (Stokols, 1992; Sallis et al., 2006) and recognition of the interaction between individuals and their environment.

In the developed countries of North America, Australia, and Europe, consistent findings have emerged that BE features can facilitate or constrain PA (Sallis et al., 2008; Saelens et al., 2003; Papas et al., 2007; Sallis and Glanz, 2006; Hipp et al., 2013; Adlakha et al., 2014; Brownson et al., 2009; Brownson et al., 2006; Committee on physical activity, 2005; Sallis et al., 2009). For example, measures of land-use mix, residential density, and street intersection density have been positively related to minutes of moderate PA per day. Presence of sidewalks, bicycle lanes, bus shelters, and access to public transportation (e.g., bus rapid transit, light rail) has been linked to increased levels of transport PA (Hipp et al., 2013; Adlakha et al., 2014). Studies have demonstrated that individuals in more walkable, mixed-use, and transit accessible neighborhoods tend to walk or bicycle more and have a lower likelihood of obesity compared with those in automobile-dependent neighborhoods (Adlakha et al., 2014; Handy et al., 2002; Badland et al., 2008; Yang et al., 2015). In addition to walking, other exercise activities, BMI, and overall health ratings, neighborhood design can also influence air pollution emissions and exposures, thus impacting several chronic disease outcomes (e.g., cardiovascular disease, asthma and other respiratory ailments) (Marshall et al., 2009; Ewing et al., 2003). However, these relationships established in developed countries may not generalize to other parts of the world, particularly in low-and-middle-income countries (LMICs) like India that are collectively home to 80% of the world's population and are at particularly higher risk for developing NCDs (Hallal et al., 2012; Prentice, 2006; Milton et al., 2014). Questions also remain about the applicability of surveys constructed in developed countries to the local contexts in LMICs. To address this issue, there have been recent calls for investigators to collaborate on a regional basis to adapt BE measures that are tailored to the LMIC contexts (Sallis, 2011; Oyeyemi et al., 2013).

India is experiencing dramatic urban growth with implications for social, economic, and ecological sustainability (Guha, 2011; Goenka, 2007). Urbanization has outpaced the development of basic public health services and regional infrastructure, compounding health threats from NCDs (Goenka, 2007; Gupta, 2014). Along with poor chronic health outcomes, issues of pedestrian safety, air pollution, and increasing carbon emissions are especially challenging to adapt to in urban environments already facing disparities across religious and socio-economic lines (World Health Organization, 2013a, 2013b, 2013c; Sahni and Aulakh, 2014). While the consequences of urban living may be exposed through a population's health, the underlying causes or amplifications of health problems are often rooted in conditions best addressed through non-public health pathways such as neighborhood design and planning, as explored in this study.

To our knowledge, there is no literature that documents relations between neighborhood walkability, BE variables, and PA in India (Ranasinghe et al., 2013). Studies on active transportation in India are minimal, and do not provide definitive explanations. From a PA and public health perspective, these transportation studies have numerous shortcomings: the contribution of community design to overall PA is unknown, neighborhood environment variables have not been studied, and reliable and valid measures of environmental variables tailored to the Indian context have not been used in these studies. Further investigation of the environmental correlates of PA is needed and could lead to improved interventions for Indian contexts.

This paper probes the question of how the BE, including density, land-use mix, and elements of design (e.g. pedestrian and bicycling facilities), pedestrian safety, and crime influence walking, bicycling, and PA behaviors. We use a self-report measure of neighborhood environment adapted for India—Neighborhood Environment Walkability Scale (Saelens and Sallis, 2002; Saelens et al., 2003) (hereafter called NEWS-India)—and its variables hypothesized to be important contributors to PA. We compare PA and weight status among adult residents living in neighborhoods stratified by walkability and socio-economic status (SES).

2. Methods and analysis

2.1. Study setting

This study recruited a diverse sample of participants from the metropolitan area of the city of Chennai, India (164.5 sq. miles). Chennai is the capital city of the state of Tamil Nadu, a major commercial and industrial hub in southern India (Vēṅkatācalapati and Aravindan, 2006; Hancock, 2008). It is the fourth most populous city (8.9 million residents) in India and the 31st most populous city in the world (Ministry of Home Affairs, 2011). Within India, the state of Tamil Nadu is the most urbanized state with 48.4 percent of the population living in urban areas (Ministry of Urban Development, 2013) and has the highest number of diabetic cases, a majority of them being reported in the city of Chennai (Gupta et al., 2010). For administrative purposes, the Chennai metropolitan area is divided into 155 smaller subdivisions called wards. Wards are the smallest geographic areas for which the Census Bureau of India publishes demographic information. Due to the lack of consensus on what constitutes a neighborhood (Foster and Hipp, 2011), wards were used as the primary definition and unit for sampling purposes.

2.2. Sampling

This study adopted a stratified two-stage cluster sampling strategy. Study participants were selected from neighborhoods chosen to maximize the variance in neighborhood walkability and SES (Frank et al., 2010). This type of stratification by SES was used to enhance the representativeness of the sample because low-SES populations tend to be underrepresented in studies of this nature (Turrell, 2000; Cerin et al., 2009). The goal of this study design was to select participants from neighborhoods stratified into