Transportation Research Part A 53 (2013) 10–21

Contents lists available at SciVerse ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Statistical analysis of pedestrian perceptions of sidewalk level of service in the presence of bicycles

Lei Kang *, Yingge Xiong, Fred L. Mannering

Purdue University, 550 Stadium Mall Drive, West Lafayette, IN 47907-2051, United States

ARTICLE INFO

Article history:
Received 21 May 2012
Received in revised form 17 May 2013
Accepted 23 May 2013

Keywords:
Pedestrian level of service
Pedestrian attitudes
Bicycles
Random parameters ordered probit

ABSTRACT

Gaining a better understanding of pedestrian perceptions of level of service (LOS) in urban areas can be useful in developing strategies for providing a comfortable and safe walking environment. Using a sample of 114 respondents, this research studies how pedestrians perceive LOS on sidewalks shared with bicycles under various urban-street conditions. To do this, 15 carefully constructed video clips of Chinese urban sidewalks are presented to respondents and, after each 60-s video clip, respondents were asked to assess the pedestrian level of service in the video on a scale from LOS A (the most comfortable pedestrian environment) to LOS F (the least comfortable pedestrian environment). By estimating random parameters ordered probability models of respondents' LOS assessments (to account for unobserved heterogeneity across respondents) we found, as expected, that pedestrian perceptions of LOS are strongly influenced by the pedestrian flow rate. However, many other factors were found to significantly affect LOS perceptions including sidewalk width, the presence of a barrier separating the sidewalk from motor-vehicle traffic, the presence of parking next to the sidewalk, the presence of businesses along the sidewalk, the bicycle flow rate, the speed of bicyclist, whether or not bicycles were riding against the flow of pedestrians, weather conditions, time of day, and age of the respondent. The specific impacts of the wide variety of factors that affect pedestrian perceptions of LOS suggest that a number of important tradeoffs need to be considered when planning pedestrian facilities.

1. Introduction

In recent years there has been a renewed emphasis toward improving pedestrian facilities and operational characteristics to help reduce congestion, improve safety and improve the populous' general quality of life (Lawlor et al., 2003; Sisiopiku et al., 2002; Lo, 2009; Elias and Shiftan, 2012). With regard to this quality of life, Mehta (2008) found that, given a safe and comfortable walking environment, people have a sense of belonging that has a significant effect on the overall satisfaction of the urban populous. There has also been progress toward measuring the quality-of-life benefits of pedestrian facilities and what can be generally termed as walkability. For example, Saelens et al. (2003) addressed this from the perspective of individuals' walking decisions, finding that neighborhood-environment characteristics, such as population density, street connectivity, and land-use patterns were influential determinants. In other work, Ewing et al. (2006) found five design qualities (human scale, transparency, tidiness, enclosure, imageability) that were statistically related to walkability.

In contrast to the more global perspective of walkability, engineers have used traditional measurement techniques in an attempt to establish some quantitative assessment of what might constitute a pedestrian-friendly walking environment in terms of pedestrian comfort and measures of congestion. In the Highway Capacity Manual (2010), this is primarily done with

* Corresponding author. Tel.: +1 (765) 337 1267.
E-mail addresses: lkang119@gmail.com (L. Kang), xiong0@purdue.edu (Y. Xiong), flm@ecn.purdue.edu (F.L. Mannering).

0965-8564/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.tra.2013.05.002

a level of service (LOS) concept which is defined as "a quantitative stratification of a performance measure or measures that represent quality of service". As with measures of vehicle LOS on highways, the Highway Capacity Manual (HCM) uses in a six-level scale for pedestrian LOS ranging from A to F in which A represents the "best" and F represents the "worst" level of service. In determining pedestrian LOS on a sidewalk facility, the HCM considers two variables: pedestrian LOS score (a linear combination of vehicle exposure and segment configuration) and average pedestrian space on the sidewalk. However, the HCM's view of pedestrian LOS is understandably limited so that one can arrive at an LOS measure that can be readily determined with the limited data that practitioners are likely to have available. Clearly one would expect a variety of other factors relating to comfort, security, safety, and the possible presence of bicycles on the pedestrian facility, to affect LOS (Sarkar, 2003; Kroll, 2006). With regard to the possible presence of bicycles in the pedestrian stream, bicycles have been found to have an important impact on pedestrian level of service on sidewalks (Jensen, 2007; Bian et al., 2007), at intersections (Bian et al., 2009), and on shared-use trials (Hummer et al., 2005; Patten et al., 2006). There is a general consensus that having pedestrians and bicyclists share the same facility is not optimal, yet it is often tolerated due to the cost of constructing separate facilities and concerns relating to bicycle safety on roadways (Cyclists Touring Club, 2000). Complicating the pedestrian-bicyclist LOS measurement issue is that there are many cultural differences within the same country as well as across countries. For example, across the US, regulations regarding the use of bicycles on urban sidewalks vary considerably from being illegal to being fully permitted. In other parts of the world, bicycle riding on sidewalks is more uniformly accepted such as in China, where riding on sidewalks is widely permitted and is common practice. Thus the pedestrian-bicycle culture that is established based on past behavior clearly influences what individuals may consider a tolerable LOS and this may limit the broad applicability of LOS measurement procedures.

With the above discussion in mind, the intent of the current paper is to provide a rigorous statistical analysis of individuals' perceptions of pedestrian comfort in the presence of bicycles using a sample of pedestrians form China. We do not distinguish between the concept of comfort and perceived LOS – the perceived LOS is a discrete choice made by individuals after accounting for various factors and their own perception of comfort. Within this context (details of which will be provided later), the hope is that our work will add to the growing body of literature on pedestrian LOS analysis and encourage its further exploration.

2. Literature review

Past work has studied pedestrian level of service (LOS) by focusing on either the conditions along sidewalk segments or at intersections because the operational characteristics of these two can be quite different (a summary of methodologies of analyzing pedestrian LOS could be found in Byrd and Sisiopiku, 2006). While a wide-variety LOS-rating systems have been developed by researchers over the years, most approaches consider how safe, operationally efficient, aesthetically pleasing, and/or comfortable a sidewalk segment or intersection is for pedestrians. For example, Dixon (1996) developed a scoring system to evaluate pedestrian LOS by using variables that were weighted and scored with an emphasis on pedestrian safety and traffic operations. Miller et al. (2000) followed a similar idea – designing a scaling system to evaluate pedestrian LOS at intersections by developing a 3-dimensional visualization technique for intersection simulation. In other work, Lee et al. (2005) redefined the LOS boundaries for signalized crosswalks in Hong Kong commercial areas in terms of pedestrian density, pedestrian flow rate, and walking speed.

Another approach to pedestrian LOS determination is to use pedestrian perceptions directly (some studies have considered LOS at intersections from the driver's perspective, such as Pecheux et al., 2000, but viewing LOS from the pedestrian perspective is much more common). For pedestrian LOS perceptions, Landis et al. (2001) used an ordinary least squares regression to find variables that significantly influenced pedestrian perceptions with a focus on safety. Their study collected real-time data by letting 75 volunteers walk on a designed course, which contained 24 road segments, and then evaluated each condition. In addition to safety, traffic volume on the adjacent roadways has also been identified as a primary factor influencing pedestrian perceptions of LOS (Petritsch et al., 2006).

Other research efforts have used less direct measurements of pedestrian LOS perceptions. For example, Muraleetharan et al. (2005) studied pedestrian LOS at intersections with survey respondents providing ratings based on their experiences and memories at actual sites (a similar modeling approach has been used by Bian et al., 2007, 2009). Finally, Jensen (2007) used respondent ratings of video clips to estimate a cumulative logit model (to account for the ordinal nature of the responses considered – with respondents rating level of service on a 1–6 scale – with 1 being very satisfied to 6 being very dissatisfied) to capture various factors affecting pedestrian satisfaction on sidewalks. A list and summary of some relevant past research efforts is presented in Table 1.

The focus of our paper will be to consider pedestrian LOS along urban sidewalk segments (the reader is referred to a variety of other sources that specifically deal with pedestrian LOS considerations at intersections such as Keegan and O'Mahony, 2003; Li et al., 2005; Lee and Lam, 2008; Hubbard et al., 2009). As the review of past literature suggests (see Table 1), a wide variety of factors need to be considered to adequately capture the full spectrum of the pedestrian-walking experience and thus LOS. Given the number of factors involved, it is difficult to assess LOS for pedestrian facilities in general, and even more difficult to generalize LOS definitions under different contexts and pedestrian populations. However, our intention in this paper is not to precisely define the thresholds for LOS boundaries or to establish generalized pedestrian LOS functions, but instead, using the findings of past work as a basis, we seek to consider a wide range of factors and quantify their effect of pedestrians' perceived level of service for a specific pedestrian population. By identifying significant factors influencing