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Pedestrians risk perception of traffic crash and built environment features – Delhi, India

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ABSTRACT

Traffic crash fatalities from 2006 to 09 in Delhi, India show that pedestrians have the largest share in total road fatalities. Perception of risk provides important information to identify potential crash risk. Thus, the main objective of this paper is to explore the pedestrian perception of risk in getting involved in a traffic crash in different locations and the role of built environment features in risk perception of pedestrians. Locations having a high number of pedestrian fatal crashes were identified using GIS map of Delhi. Pedestrian perceptions of risk at forty-five actual crash sites were collected through questionnaire survey. Risk perception of pedestrians of built environment features were analyzed based on pedestrian demographic characteristics. Ordered logit model was used to examine the influence of these variables on risk perception of respondent's neighborhood and of the location where the survey was conducted. Seventy percent respondents perceive the neighborhoods where they reside having higher risk than the actual crash locations. Several factors such as gender, number of lanes, sidewalk width, sidewalk maintenance, traffic speed and traffic volume were significantly associated with perceived risk. Survey sites were further categorized into four groups i.e. foot of flyover, four-way junctions below flyover, midblocks and intersections to find the impact of characteristics of locations on pedestrians' risk perception of different locations. Four-way junctions below flyover were found to have higher perceived risk compared to other locations.

1. Introduction

Pedestrian safety is an important issue in most cities. In developing countries like India, pedestrians are involved in the largest number of fatal crashes (Mohan et al., 2009). An estimated 14,924 traffic crashes in Delhi from 2006 to 2009 (Delhi Police, 2009) involved pedestrians. These crashes resulted in 4276 pedestrian fatalities. Fig. 1 shows the proportion of road traffic victims in fatal crashes in Delhi from 2006 to 09. It shows that pedestrians have the largest share in total traffic fatalities. The traffic stream in Delhi includes pedestrians, bicycles, animal and human drawn vehicles along with modern cars, trucks, buses, two-wheeler and three-wheelers. Nearly 35% of all commuter trips in Delhi are walking trips (RITES, 2010). Often pedestrians have to share the road space in the absence of infrastructure specifically designed for pedestrians and generally the existing pedestrian infrastructure is in the very poor state of maintenance, therefore pedestrians are exposed to high risk of being involved in a road traffic crash. Hence, it becomes crucial to provide pedestrians with safe, accessible and comprehensive facilities to reduce pedestrian crashes (Zegeer and Bushell, 2012).

Pedestrians are mainly exposed to risk when crossing a road in urban areas (Lassarre et al., 2007). Pedestrian overpass or underpass is provided at some locations for crossing the road, but their usage is very low. Studies by Tanaboriboon and Jing (1994) and Räsänen et al. (2007) has confirmed this that pedestrians prefer at grade signalized crossings than overpass or underpass crossing. Construction of grade separators to reduce the delay of motorized vehicles and to make arterial roads in Delhi signal free has increased the risk faced by pedestrians while crossing the road (Khatoon et al., 2013).

Planning pedestrian environments require assumptions about how pedestrians will respond to the characteristics of the environment as they choose their routes (Zacharias, 2001). Meyer (2005) states that relativistic new concepts of safety planning such as safety conscious planning or context sensitive solution emphasize the need to account for comprehensive aspects of transportation. Kononov et al. (2007) remarked that safety planning should bring the perception of roadway safety in line with the reality of safety. Schneider et al. (2004) also proposed that a proactive approach

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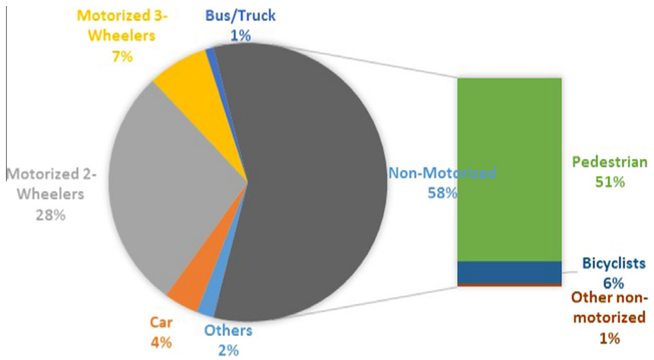

Fig. 1. Fatal accidents in Delhi.

should be taken that avoids an accident “waiting to happen” by considering perceived crash risk.

Pedestrian attitude toward risk has been studied and it has been found that pedestrian perceptions and preference toward facilities are very important factors to be taken care of during planning (Holland and Hill, 2007). Perceived safety plays an important role in proactive safety planning, because it provides critical information for understanding individual travel behavior and identifying potentially high crash risk areas (Schneider et al., 2004). This study proposes to analyze the pedestrian’s perception of risk while walking along or crossing the road in Delhi.

The design and quality of the built environment – road and infrastructure, streetscape – influences the levels of pedestrian crashes as shown by Dai (2012). Several studies (Brude and Larsson, 2000; Retting et al., 2003) have focused the impact of built environment features that increase or decrease crash risk in urban areas. Traffic volumes, parked vehicles, traffic speed and lack of pedestrian facilities were the most frequently mentioned sources of danger by Salter et al. (1993). Research indicates that the width of the street (Lightstone et al., 2001), the number of lanes (Gårder, 2004) and roadway light (Lee and Abdel-Aty, 2005) have much influence on pedestrian crashes. Koepsell et al. (2002) reported higher risk of collisions between older pedestrians and vehicles in marked crosswalks.

In contrast to the studies examining actual crashes, the research focusing on the association between built environments and perceived crash risk are few. Kononov et al. (2007) showed that actual crash data only provide accident frequency and severity comparison, but does not provide any information related to the nature of the safety problem itself. Cho et al. (2009) examined how perceived and actual crash risks are related to each other and with respect to built environment characteristics for pedestrian and bicycle safety.

The main objective of this paper is to explore the pedestrian perceptions about risk of getting involved in a traffic crash while walking and the role of built environment factors that influence the risk perception. The present study aims at examining the impact of variables such as pedestrian age and gender, road-characteristics, traffic characteristics and sidewalk characteristics on risk perception. This study followed these steps to achieve the objective: (i) investigate actual high crash risk areas for pedestrians in Delhi (ii) find a pedestrian’s risk perception of the high crash risk location and the location where respondent resides (iii) determine the built environment features and traffic features which affect the pedestrian risk perception and (iv) investigate perceived risks based on location characteristics.

The relationship between risk perception and built environment features can provide useful insights to policy makers and planners to improve pedestrian safety in urban areas. Although the study focused on pedestrian crashes and risk perception in Delhi, the results can be applied to other metropolitan cities where similar infrastructure exists.

2. Method

The aim of the study is to explore the risk perception of pedestrians of getting involved in a traffic crash while walking with respect to various infrastructure and traffic features at the locations with actual high crash risk. The actual high crash risk in this paper refers to reported fatal pedestrian crashes during 2006 to 09. Actual high crash risk locations have been identified on the basis of clustering of fatal crashes. Fatal crash locations risk areas were analyzed using GIS to find if crashes are clustered at any specific location. A questionnaire survey was administered at these locations to know the risk perception of pedestrians. Risk perception of pedestrians was documented for two categories of locations – (1) of the location where the person who is being surveyed resides (neighborhood), and (2) of the location where the survey is conducted. The main reason for this was to compare the pedestrians’ perceptions at two different locations. Pedestrians were asked to rank the built environment features based on risk perception at these two location categories.

2.1. Data collection

2.1.1. Spatial data

To identify locations where pedestrian crash problems exist in Delhi, we used GIS tools to create the pedestrian fatal crash density maps. The digital road map of Delhi was imported in the data frame of the Arc Map window. The imported digital map and the data frame were given the common ‘projected co-ordinate’ system to bring them to the same scale. The co-ordinate system used throughout this study is WGS 1980 UCS. The pedestrian fatal accident data in Delhi from 2006 to 09 was collected from Delhi police. Only fatal accidents were analyzed as it has been well documented that lower severity level crashes are often under reported (Elvik and Mysen, 1999; Tsui et al., 2009). Few studies on underreporting issues associated with crash data revealed that crashes were unreported in all industrialized countries, but the unreported rate was worse in developing countries (Ye and Lord, 2011).

Excel sheet with accident details’ given by the police was imported into GIS by giving *X* and *Y* coordinates of each accident (considering all as points) by searching the accident locations in Google Map. Further analysis was done using Kernel Density which is a spatial analysis tool. There are dozens of analysis methods for spatial point pattern analysis in general and hot spot identification with specific (Everitt, 1974). Flahaut et al. (2003) compared two methods of spatial data analysis – local spatial autocorrelation indices and kernel estimation and found that both provided quite similar results under specific parameters. Furthermore, Lu (2000) compared kernel density to other spatial analysis techniques and found out that kernel density is more reliable and desirable for identification of locations with unusual high concentrations of occurrence.

Locations having clusters of crashes can be identified using the density feature available in widely used commercial GIS software. Density is a measure of the quantity of an item per unit of area. In a GIS environment; density can be calculated using kernel method (ESRI, 2002). The kernel method divides the entire study area to a pre-determined number of cells and applies a circular neighborhood around each crash. Cell size chosen was 1 m $\times$ 1 m and radius was 50 m. Cell size impacts the visual appearance of the output. Larger cell sizes generate blocky pixilation of the output (Chainey, 2013). The output of the kernel density function is a raster file displaying the areas of high and low clusters of crash occurrence (Prasannakumar et al., 2011). The radius of the circular