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## Pedestrians' Crossing Behavior at Marked Crosswalks on Channelized Right-Turn Lanes at Intersections

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### Abstract

Unsignalized marked crosswalks are problematic locations from pedestrians' safety perspective. Although the priority rule at such locations is clear; pedestrians have the absolute right of way over vehicles, driver often compete with pedestrians over the right of way which risks pedestrian safety and impose extra delays on pedestrians. In developing countries, as concluded in many previous studies, vehicles usually do not give right of way to pedestrians, leaving them with the only choice to wait until an accepted gap is available. In Gulf Cooperation Council (GCC) countries where vehicles are the predominant mode of travel, pedestrians are receiving lesser priority. Drivers usually hijack the right of way from pedestrians which often causes safety threats. Therefore, pedestrians lose the reason for crossing at these designed locations pushing them to cross at arbitrary locations increasing their safety risk. This paper investigates influencing factors on the crossing behavior of pedestrians at marked crosswalks located on dedicated right-turn lanes. A study site from Doha, Qatar was selected for video recording and data analysis. A sample of 235 pedestrian observations was used for waiting behavior, crossing speed, accepted gaps, and driver yielding behavior analysis. The results showed that the waiting behavior was independent of pedestrian characteristics and relied only on the traffic characteristics. In addition, the average crossing speed was 1.43m/s and the gender, distraction, and group significantly affected the crossing speed. Besides, the distracted pedestrians and pedestrians crossing in groups accepted significantly larger gaps compared to undistracted and individual pedestrians. Moreover, about 15% of drivers yielded for pedestrians, yielding was irrespective of gender and mainly affected by the crossing direction. Consequently, innovative strategies in terms of engineering measures and awareness are needed to improve pedestrian safety at these locations.

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## 1. Introduction

Marked crosswalks are common pedestrian crossing facilities at dedicated right-turn lanes at intersections. These crosswalks are rarely controlled by traffic signals. Generally, standard road markings (zebra marking) are used to define the pedestrian crossing area and warning signs are installed to alert drivers as they approach to designated crossing location. Globally, pedestrians have priority at these crosswalks and drivers are expected to yield to pedestrians. In the State of Qatar, drivers should stop before the crosswalk to allow safe crossing by the pedestrians as per Qatar Traffic Law<sup>1</sup>. The drivers may face a fine of 300 QAR if they do not yield to the waiting/crossing pedestrians<sup>2</sup>. However, in reality drivers compete with pedestrians over the right of way. Hence, pedestrians commonly have to wait for an appropriate gap to cross at these locations. Because of that, these marked crosswalks do not function properly and force pedestrians to cross at undesignated locations which impose more safety risks. In common with many rapidly growing countries, the State of Qatar is facing a high percentage of pedestrian fatalities. Between 2008 and 2010, around 33% of total road fatalities were pedestrians<sup>3</sup>. This paper aims at analyzing the crossing behavior of pedestrians at marked crosswalks located at channelized right-turn lanes. This study is part of a national research project to investigate pedestrian safety in the State of Qatar and to develop innovative control policies and recommendations for crosswalks to improve their safety.

Many studies address pedestrian crossing behavior at marked crosswalks including signalized<sup>4,5</sup> and unsignalized<sup>6,7</sup> ones. Alhajyaseen analyzed pedestrian crossing behavior at signalized crosswalks concentrating on crossing speed<sup>8</sup>. It was indicated that few studies have addressed the issue of pedestrian speed at crosswalks (signalized and unsignalized), which have significantly different operating and surrounding conditions compared to the others facilities like walkways and sidewalks. Therefore, this study is followed by other studies that analyze the impact of crosswalk geometry and signal timing parameters on pedestrian crossing decision and speed at signalized crosswalks<sup>4,9,10</sup>. It was concluded that pedestrian maneuvers are widely varying and they are significantly affected by control type (signal timing and indication), crosswalk length, presence of conflicting vehicles, and others. In a recent study, the pedestrian sudden behavioral changes while crossing at signalized crosswalks were analyzed<sup>11</sup>. They empirically found that the pedestrians do change their crossing behavior in terms of speed and direction due to combination of factors (long crossing distance, change in signal indication, etc.) without paying attention to the surrounding conditions. This may magnify safety risks since drivers cannot predict such behavioral changes. Various studies analyzed crossing behavior of pedestrians at signalized crosswalks, considering different parameters such as crossing choice, waiting time, initial reaction time, walking speed, violations and difference between individuals and groups<sup>12,13,14</sup>. Pedestrian safety, considering gap acceptance and speed profiles, was assessed with conflicting left turning vehicles at signalized intersections<sup>15,16</sup>. Koh and Wong studied violating behavior of pedestrians at various phases of signal cycle and relationship with pedestrians' personal characteristics, waiting time, number of lanes, and traffic volume at midblock and junctions<sup>17</sup>. Further, pedestrians' gap acceptance behavior at marked midblock crosswalks was studied<sup>18,19</sup>. The driver yielding behavior with pedestrians' gestures, smile, advance yield markings, and low cost engineering improvements were studied by Zhuang & Wu<sup>20</sup>, Gueguen et al.<sup>21</sup>, Samuel et al.<sup>22</sup> and Sandt et al.<sup>23</sup> respectively.

Many studies have assessed the crossing speed at marked crosswalks at junctions and midblock. However, to the best of our knowledge, there are few studies on pedestrian crossing behavior at crosswalks located at channelized right-turn lanes at intersections. Chen et al. presented a methodology to determine pedestrian delays for different vehicle arrival rate at exclusive right-turn lane at an intersection. Rules of conflict models were proposed for pedestrian delay and pedestrian capacity were proposed for two traffic conditions. Erlang distribution was fitted for vehicles' headway distribution for unsaturated and saturated release period using 213 continuous headways (108 saturated and 102 for unsaturated release period) observed for at an exclusive right-turn lane in China<sup>24</sup>.

This study explores the pedestrians crossing behavior at marked crosswalks on channelized right-turn lanes. The characteristics of pedestrians' crossing behavior, such as waiting time, crossing speed, and accepted gaps, are analyzed along with the driver yielding behavior.

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