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Exploring road design factors influencing tram road safety – Melbourne tram driver focus groups

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ABSTRACT

Melbourne, Australia has the largest tram/streetcar network in the world including the largest mixed traffic tram operating environment. Therefore, Melbourne tram drivers are responsible for controlling one of the heaviest vehicles on road ranging from shared tram lanes to exclusive tram lanes. In addition to different tram lane configurations, tram drivers need to follow different traffic signal phases at intersections including tram priority signals as well as need to serve passengers at various types of closely spaced tram stops. Despite all these challenges, no research has explored tram driver perceptions of the risk factors on different tram route road design configurations. Therefore, the aim of this study is to investigate how tram drivers' safety perceptions alter along various tram route sections, signal settings and stop configurations. A tram driver focus group approach was adopted for this research involving thirty tram drivers (4 female and 26 male drivers). The tram drivers' age ranged from 29 to 63 years, with an average age of 47.6 years (standard deviation of 10.1 years), and their experience of tram driving ranged from 1.17 to 31 years, with an average experience of 12.5 years (standard deviation of 10.2 years). The participating tram drivers perceived that the raised tram tracks and tramways with raised yellow curbing beside tracks are safer lane priority features on the Melbourne tram network compared to full-time, part-time and mixed traffic tram lanes. They regarded 'hook turns' as a safe form of tram signal priority treatment at intersections and platform tram stops as the safest tram stop design for all passengers among all other tram stop designs in Melbourne. Findings of this research could enhance the understanding of crash risk factors for different tram route features and thus can offer effective planning strategies for transit agencies to improve tram road safety.

1. Introduction

Trams are defined as the light rail transit vehicles which run on fixed rail tracks on roads and mostly share the road space with other traffic and pedestrians. Melbourne has the largest tram network in the World with a track length of 250 km, including the largest mixed traffic tram track (167 km) (Currie and Shalaby, 2007). The term 'streetcar' used in North America can describe much of the Melbourne tram system.

Trams sharing the road with general road traffic is often known as 'mixed traffic tram operation' and is the least desirable tram operational type due to the impact of road traffic on tram travel time and reliability (Vuchic, 2007). Therefore, tram priority measures are often implemented on road corridors, at intersections and at stops to improve tram travel time and service reliability (Yarra Trams, 2010). The aim of these priority features is to transform an older tram or streetcar system to a light rail comparable service 'as far as practical' by providing more protected and prioritized right of way to trams from other road traffic. Tram priority can be divided into 'space priority' and 'time priority'. Space priority generally involves providing a separate right of way (ROW) to trams, termed as 'tram lane priority' (VicRoads, 2012; Vuchic, 2007). Another form of space priority is known as 'stop priority'. Stop priority is typically provided to tram vehicles and passengers by installing platforms beside tram tracks to offer a safe waiting area for tram passengers and to facilitate faster boarding and alighting to low floor trams (Currie and Smith, 2006; Toronto Transit Commission, 2003; Currie and Reynolds, 2010). Time-based tram priority facilitates the movement of trams through traffic signal controlled intersections and is often termed as 'tram signal priority' (Nash, 2003; Currie and Shalaby, 2008; Yarra Trams, 2010; Association of German Transport 2000). The positive impacts of tram priority treatments on increased ridership, reliability and efficiency have been explored widely (Currie et al., 2012a,b; Yarra Trams, 2010; Zhang and Garoni, 2013; Currie and Shalaby, 2007). A detail description of the common types of tram

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Table 1
Summary of tram priority measures in Melbourne.

Location	Priority type	Description
Lane	Part-time tram lane	Yellow demarcation line is painted beside tram tracks and overhead signs indicate the time of tram lane operation (Fig. 1(a)).
	Full-time tram lane	Yellow demarcation line is painted beside tram tracks and demarked by an overhead 'tram only' sign. General motorists are not allowed to use these lanes (Fig. 1(b)).
	Tramways with raised yellow curbing	Raised yellow curbs are provided beside tram tracks for tramways as opposed to painted yellow lines for part- and full-time tram lanes. Motorists are not permitted to use these tramways (Fig. 1(c)).
	Raised Tram tracks	Tram tracks are raised from other traffic lanes to prevent other traffic using this tram tracks (Fig. 1(d)).
Intersection	Hook turns	Melbourne has a special intersection treatment called 'hook turns' to give priority to trams, which relocate opposing-turning traffic at intersections. Vehicles intending to turn right use the left lane to enter the intersection, wait at the far side of the road in front of, and parallel to the side road stop-line. These hook-turning queuing vehicles complete their turn once the side road traffic receives the green light (Fig. 1(e)).
	Tram only 'T' light and white arrow	White 'T' lights and white arrow signals at intersection are part of the active signal priority system provided for Melbourne trams to cross the intersection separated from other traffic (Fig. 1(f)).
	Right turn bans	Right turns are banned at many intersections to provide uninterrupted movement of trams through intersections (Fig. 1(g)).
Stop	Platform stops	Platform tram stops include wide waiting areas for passengers in the middle of the road to allow level entry of passengers into low floor trams (Fig. 1(h)).
	Easy access stops	The easy access stops are located in the curbside traffic lane where the road pavement is raised to allow passengers level access from the footpath to the tram door (Fig. 1(i)).

priority treatments in Melbourne is provided in Table 1 and the illustrations of the treatment features are shown in Fig. 1.

Previous studies have identified several inherent road safety concerns for trams, since they are large and heavy vehicles often operating in a complex road environment with multiple other road users (Grzebieta et al., 1999). A considerable number of tram-involved crashes has been recorded in many countries all over the world, especially in mixed traffic (Currie and Smith, 2006; Korve et al., 1996; Marti et al., 2016; Transport Safety Victoria, 2017; Blancheton and Fontaine, 2014). For instance, 5430 tram-involved incidents were recorded between 2009 and 2013 in Melbourne, of which 433 were fatal and serious incidents (Yarra Trams, 2014). Again, recently 1558 tram-involved incidents were reported by tram operators to Transport Safety Victoria (TSV) in year 2016, of which 61 were serious injuries (Transport Safety Victoria, 2017). Tram involved incidents are mostly categorized as tram to vehicle collisions, tram to pedestrian collisions, passenger falls on trams, and tram to tram collisions.

Although previous studies mostly investigated the safety concerns for mixed traffic tram operation, the implementation of tram priority measures adjusts the nature of road spaces and a handful of previous studies have evaluated the road safety impacts of tram priority measures. For instance, a study conducted by Shahla et al. (2009) revealed that the presence of transit signal priority treatments including tram signal priority had a positive correlation with transit-related collisions at intersections in Toronto, Canada. Whereas, a study in Melbourne conducted by Currie and Reynolds (2011) revealed that the intersections with hook turn had a lower crash rate compared to the intersections without hook turns. Previous studies also evaluated the overall road safety impacts of all forms of tram signal priority treatments in Melbourne and the results revealed that tram signal priority treatments can act to reduce crashes at intersections (Naznin et al., 2016d, 2015a).

A study by Richmond et al. (2014) explored the impacts of a dedicated streetcar (tram) right of way on pedestrian-motor vehicle collisions in Toronto, Canada. Their results suggested a 48% reduction in pedestrian-motor vehicle collisions after implementation of a streetcar ROW. Road safety impacts of tram lane priority treatments has been evaluated in Melbourne context and the results revealed that tram lane priority measures are effective for reducing total crashes involving all road users and tram-involved all injury crashes, whereas they also act to increase tram-involved serious injury crashes (Naznin et al., 2016a,d, 2015a). In addition to tram lane and signal priority measures, several studies have investigated the road safety impacts of tram stop designs. Currie and Reynolds (2010) investigated the road safety impacts of the platform and easy access tram stops replacing curbside and safety zone stops in Melbourne using simple before-after studies of crash data. The results indicated that car-pedestrian collisions reduced by 62% and car-tram collisions reduced by 12% after platform and easy access stops installation. Another study conducted by Naznin et al. (2015b) identified an 81% reduction in pedestrian-involved all injury crashe rates and 86% reduction in pedestrian-involved fatal and serious injury crashes per 10,000 passengers after installation of platform stops replacing safety zone stops in Melbourne.

However, the previous tram safety research is almost entirely based on an analysis of historical crash data which is known to have limitations in terms of lack of detailed crash risk factors (Elvik and Mysen, 1999; Alsop and Langley, 2001; Lopez et al., 2000; Giles, 2001). Therefore, while most previous studies have suggested potential causal factors on tram road safety outcomes, the exact reasons behind the findings are often not clear. Thus, the aim of this study is to enhance the understanding of crash risk factors on tram routes including tram priority treatments in Melbourne by exploring tram driver views.[1]

2. Research method

Researchers have identified several techniques to explore the detailed crash risk factors on roads. A common practice is to survey road users, primarily drivers adopting qualitative, quantitative or a combination of both approaches based on their research objectives (Morgan, 1996; Hennink et al., 2010; Bryman, 2015; Hox and Boeije, 2005; Ghauri and Grønhaug, 2005; Lecompte, 2000; Ulleberg and Rundmo, 2003; Castanier et al., 2012; Edquist et al., 2012). Quantitative survey data are measured and reported in numerical scales, and this approach can test and validate hypotheses and theories based on controlled processes (Connaway and Powell, 2010). Whereas, qualitative research is being adopted by researchers to examine people's experience in greater depth using several approaches such as focus groups, in-depth interviews, observation, content analysis, visual methods, and life histories or biographies (Hennink et al., 2010; Creswell and Clark, 2007). Among all qualitative research approaches, focus groups allow free discussion among participants on multiple issues to a greater extent and assist in obtaining insights in greater detail (ETR, 2013; Kenyon and Lyons, 2003). This approach brings a small group of people together to discuss an issue with structured questions, but with the flexibility to

[1] Results of this paper have been presented at the "Transportation Research Board 96th Annual Meeting, 2017" Naznin F, Currie G, Logan D "Key challenges in streetcar safety from the tram driver's perspective" Transportation Research Board, 96th Annual Meeting, 2017, Paper number: 17-05635. This paper has never been submitted for publication in a research journal prior to this submission. A related but separate paper discussing non-road design related aspects of road safety and trams is being considered for publication in the Journal Transportation Research Part F. This paper is the only paper being considered for publication about tram road safety and road design features.