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Examining the impact of cycle lanes on cyclist-motor vehicle collisions in the city of Toronto

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ABSTRACT

Objectives: To examine whether implementation of painted cycle lanes in Toronto, Canada is associated with a reduction in cycle-motor vehicle collisions (CMVCs).
Methods: A pre-post design was used to evaluate the frequency of CMVCs pre- and post-installation of 7 cycle lanes in Toronto, Canada. Study data was obtained from Toronto Police Service reports for collisions occurring between 1991 and 2010. A zero-inflated Poisson model was used to determine the effect of cycle lane installation on CMVC frequency.
Results: Over the study period (January 1, 1991–December 31, 2010), a total of 23,959 collisions between cyclists and motor vehicles were reported in Toronto. Of these collisions, 329 occurred on the 7 lane segments included in this analysis. There was no statistically significant change, pre to post implementation of painted cycle lanes; however, a 19% reduction in the frequency of collisions per segment-month (IRR=0.82, 95% CI: 0.65, 1.03) was observed. There were also no statistically significant differences in the frequency of collisions that resulted in minimal/minor injuries (IRR=0.84, 95% CI: 0.59, 1.20) or in major/fatal injuries (IRR=0.72, 95% CI: 0.51, 1.01). There was a statistically significant increase in collisions that resulted in no injuries (IRR=5.00, 95% CI: 1.44, 17.28).
Conclusion: The implementation of painted cycle lanes had a non-significant effect in reducing collisions between cyclists and motor vehicles. Cycle lanes could be considered as a means to facilitate active transportation while reducing risk for cyclists, given the conservative nature of our estimate. Further research is needed on intersection treatments, cycle tracks, and bike volumes.

1. Introduction

Cycling is a popular form of active transportation that can reduce congestion, air pollution, and commuting time (Statistics Canada, 2014). According to the Canadian Census, the proportion of commuters who cycled to work in the City of Toronto increased from 1.3% to 1.7% from 2001 to 2006 (Statistics Canada, 2013a, 2014). Despite the environmental, financial, and health benefits of cycling, cyclists are at a greater risk of injury and/or death per kilometer (km) traveled and per person-trip traveled than motor vehicle occupants (Aultman-Hall and Kaltenecker, 1999; Beck et al., 2007). In Toronto, Ontario, over 23,000 collisions between cyclists and motor vehicles were reported to the Toronto Police Service between 1991 and 2010; approximately 1100 collisions per year. A total of 53, or 0.2% of those collisions resulted in fatal injuries.

Besides user-oriented measures such as the use of helmets, modifying the built environment can have a profound effect on the risk and severity of cycling injuries (Haworth, 2011; Thompson et al., 2000). Built environment characteristics are associated with changes in risk of injury, collision, and death for cyclists. For example, on-street parking has been associated with a higher collision risk, while protected cycle tracks have been associated with a lower collision risk (Teschke et al., 2012). The installation of painted cycle lanes is a commonly

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Table 1
Cycle infrastructure types in the City of Toronto.

	Signed routes	Cycle lanes	Sharrow Lanes	Cycle tracks	Multi-use trails
Network length in Toronto	302 km	207 km	21.3 km	6.3 km	294.1 km
On-road	✓	✓	✓	✓	✓
Visual separation		✓		✓	
Spatial separation				✓	✓
Reserved cyclists		✓		✓	

employed measure to visually separate motor vehicle traffic from bicycle traffic. In Toronto, cycle lanes are marked by a solid white or yellow line, and/or the use of a bicycle symbol and diamond markings within the lane (City of Toronto, 2014b; Table 1). Painted cycle lanes are not physically separated from motor vehicle traffic, but exist as a dedicated, same grade lane. Since 2001, over 70 km of cycle lanes have been built in the City of Toronto (personal communications, Christina Bouchard). Painted cycle lanes differ from other cycling infrastructure, such as sharrows, mixed-use trails, and cycle tracks. Sharrows are sections of roadways marked by a chevron and a bicycle symbol, and demonstrate the appropriate cyclist position within the lane (Table 1). Mixed-use trails are intended for the use of pedestrians, cyclists, and other users and are physically and visually separated from motor vehicle traffic. Cycle tracks are both physically and visually separated from motor vehicle traffic (City of Toronto, 2012); Table 1. Motor vehicles (except for emergency, public works, transit, and taxis) are prohibited from using a cycle lane or a cycle track (City of Toronto, 2012).

In the city of Toronto, people are more likely to ride their bicycles for utilitarian purposes compared to other places in Ontario (Share the Road Coalition, 2010). This increases the level of interaction with motor vehicles compared to recreational cycling, which can be done on mixed-use trails separated from the direction and presence of traffic (Share the Road Coalition, 2010). The evidence supporting the use of separated cycle tracks as a protective measure against collisions is stronger than the evidence for cycle lanes (Thomas and DeRobertis, 2013).

A recent review on the effect of cycling infrastructure demonstrated a decrease in collisions and falls with the implementation of painted cycle lanes. (Reynolds et al., 2009). One study specific to cycle infrastructure in the city of Toronto demonstrated a 25% reduction in collisions after the installation of a cycle lane on Jarvis Street, after adjusting for cycling volume (Egan, 2012). A case-crossover study by Teschke et al. (2012) conducted in Vancouver and Toronto demonstrated a non-significant reduction in collisions with painted cycle lanes (OR=0.69, 95%CI: 0.32, 1.48). A cross-sectional study by Helak et al. (2013) compared collisions occurring on cycle lanes to collisions occurring on roads without cycle lanes and found there were no statistically significant differences in injury severity (Helak et al., 2013).

Despite the mixed evidence on protectiveness, there has been a rapid increase in the implementation of painted cycle lanes in parallel with the increase in commuter cycling in Canadian cities such as Toronto. This knowledge gap limits the efforts to prevent collisions and serious or fatal injuries. This study examines rates of collisions before and after installation of seven painted cycle lanes in the city of Toronto from 1991 to 2010. It was hypothesized that implementation of a painted cycle lane was not associated with a change in cyclist-motor-vehicle collisions.

2. Material and methods

A pre-post design was used to evaluate whether the frequency of cycle-motor vehicle collisions per month changed after the installation of painted cycle lanes (also referred to as "cycle lanes" throughout this study). Study data were publicly available and obtained through collation of Toronto Police Service collision reports. The data included all collisions between bicycles and motor vehicles reported to and filed by the Toronto Police Service between 1991 and 2010, inclusive. Cycle lane segments were included if: 1) the lane segment was located within the city of Toronto, 2) the roadway contained a known painted cycle lane implemented between 1991 and 2010; 3) the lane segment was considered a higher collision cycle lane (i.e., a minimum of 100 cycle-motor vehicle collisions between 1991 and 2010). Lane segments were excluded if: 1) the cycle lane was located outside of the city of Toronto; 2) the segment implementation date was unknown or outside of the inclusion dates; 3) the lane segment had fewer than 100 cycle-motor vehicle collisions between 1991 and 2010 4) Collision data 2 years pre implementation of the lane and 2 years post implementation of the lane were not available. The dataset included the following information: age of the cyclist; location of collision; time and date of collision; injury severity; and collision type.

2.1. Variables

The outcome of interest was the frequency of cycle-motor vehicle collisions per lane segment per month. Age categories were considered for analyses; however, almost 100% of collisions occurred in adults (ages 16–59 years); therefore, age was not considered for sub analysis. Injury severity was categorized using Toronto Police Service injury coding: no injury, minimal injury (i.e., no medical attention required), minor injury (i.e., emergency room visit required), major injury (i.e., hospital admission required), and fatal injury. Due to frequent misclassification of minor injuries, minimal and minor injuries were collapsed into one category (minor) for use in this study (Agran et al., 1990; Richmond et al., 2014a, 2014b; Rosman and Knuiman, 1994; Sciortino et al., 2005).

The location and installation dates of all cycle lanes were obtained from the city of Toronto and archived issues of the city of Toronto Cycling Magazine (Cyclometer) (Table 2). Lane segments were defined as segments of roadways where a cycle lane was installed within the period of analysis (i.e., 1991–2010). Since only month and year of the installation dates were available, we used the first day of the