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Global bike share: What the data tells us about road safety

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ABSTRACT

Introduction: Bike share has emerged as a rapidly growing mode of transport in over 800 cities globally, up from just a handful in the 1990s. Some analysts had forecast a rise in the number of bicycle crashes after the introduction of bike share, but empirical research on bike share safety is rare. The goal of this study is to examine the impact of bike share programs on cycling safety. *Methods:* The paper has two substudies. Study 1 was a secondary analysis of longitudinal hospital injury data from the Graves et al. (2014) study. It compared cycling safety in cities that introduced bike share programs with cities that did not. Study 2 combined ridership data with crash data of selected North American and European cities to compare bike share users to other cyclists. *Results:* Study 1 indicated that the introduction of a bike share system was associated with a reduction in cycling injury risk. Study 2 found that bike share users were less likely than other cyclists to sustain fatal or severe injuries. *Conclusions:* On a per kilometer basis, bike share is associated with decreased risk of both fatal and non-fatal bicycle crashes when compared to private bike riding. *Practical Applications:* The results of this study suggest that concerns of decreased levels of cycling safety are unjustified and should not prevent decision makers from introducing public bike share schemes, especially if combined with other safety measures like traffic calming.

1. Introduction

Over a decade ago, Jacobsen (2003) published his landmark paper about 'Safety in Numbers' (SIN), showing that cyclists are less likely to be injured where volumes of cyclists are higher. This spurred a huge amount of research about SIN (Elvik & Bjørnskau, 2015; Elvik, 2009; Schepers et al., 2015). This paper aims to add to this branch of research by comparing crash risks of 'private bicycle riders' to those of bike share users that is interesting in relation SIN as volumes of cycling are (or become) typically higher where bike share programs are introduced.

Bike share safety has recently attracted a lot of attention (Bernstein, 2014). Prior to the introduction of North America's largest bike share program in New York City, a bicycle researcher was quoted in the *New York Times* predicting 'at least a doubling and possibly even a tripling in injuries and fatalities among cyclists and pedestrians during the first year' (Flegenheimer, 2013). This serves to highlight the safety concerns associated with bike share have been prominent at times, particularly around the launch of new programs. However, scientific research on the safety of bike share users is scarce (Fishman, 2015). The bike share literature, while all relatively recent, tackles a wide range of issues, from technological advancements (Ji, Cherry, Han, & Jordan, 2013), approaches to tracking bicycle movements and rebalancing (Luong, Parikh, & Ukkusuri, 2014), research on bike share barriers and facilitators (Fishman, Washington, & Haworth, 2012), and quantification of impacts (Fishman, Washington, & Haworth, 2014; Fishman, Washington, & Harworth, 2015; Fuller et al., 2013; Zhang & Huang, 2012). Even though bike share has rapidly emerged as a new transport option in over 800 cities, from less than a dozen little more than a decade ago (Fishman et al., 2014), research on crash risk of bike share users is scarce.

Safety issues that have been addressed in research are operational cycling speed and helmet use. A higher cycling speed may be related to more severe crashes (Hu, Lv, Zhu, & Fang, 2014; Schepers, Fishman, Den Hertog, Wolt, & Schwab, 2014). A study among bike share users in Lyon showed that average operational speed—in real conditions and for average users—was 13.5 km/h, with the lowest speeds recorded on weekends (10 km/h) and fastest average speeds (15 km/h) on weekday mornings (Jensen, Rouquier, Ovtracht, & Robardet, 2010). Studies on private bike operational speeds in other countries tend to vary between 15 and 25 km/h meaning that operational speeds for bike share users are low (Allen, Rouphail, Hummer, & Milazzo, 1998; Lin, He, Tan, & He, 2008). Bicycle helmets have been found to protect against head injuries (Bonander, Nilson, & Andersson, 2014; Elvik, 2011). Helmets and bike share has been a contentious issue, with cities having to weigh the benefits of helmets in the event of a collision (Haworth, Schramm, King, & Steinhardt, 2010), with the difficulties of incorporating helmets within a bike share program (Fishman et al., 2012), such as losses from theft and hygiene issues. Observational studies conducted in Boston,

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Washington, DC, and London found that private bike riders were four times more likely to wear a helmet (Fischer et al., 2012; Goodman, Green, & Woodcock, 2013). In line with these results, Graves et al. (2014) found the proportion of head injuries among bicycle-related injuries to increase in North American cities after introduction of a bike share program.

To summarize, bike share users tend to ride at lower speeds and are reluctant to wear helmets. As the former is likely to improve cycling safety while the latter compromises cycling safety, behavioral research is not suitable to formulate hypotheses about safety. To our best knowledge, the only study including crash risk is by Woodcock, Tainio, Cheshire, O'Brien, and Goodman (2014) on the health impact of London's bike share program, which included road safety risk. The observed injury risks while using the cycle hire scheme were found to be lower than those estimated for cycling in general. The difference was significant for slight injuries and almost significant for serious injuries (Woodcock et al., 2014). Drawing firm conclusions has to be done with caution because, according to Woodcock et al. (2014), the analyses for serious injuries and fatalities were underpowered. As research on crash risk of bike share schemes is scarce, this study sets out to examine the impact of bike share programs on cyclist's crash risk. Based on the Woodcock et al. (2014) study, we hypothesize that bike share programs are associated with lower injury risks.

2. Materials and methods

Gathering high-quality bicycle crash injury data is a challenge, particularly because of underreporting of non-fatal bicycle crashes in the often used police crash databases. While police statistics are sufficiently complete for cyclist fatalities, hospital data are needed for victims treated at emergency departments or admitted to hospital (Langley, Dow, Stephenson, & Kypri, 2003; Schepers et al., 2015). This study examines injury risk associated with bike share programs using two substudies to make maximum use of the qualities of different data sources.

Study 1 is a secondary analysis of longitudinal hospital injury data from the Graves et al. (2014) study from 10 North American cities, divided into two categories: 5 bike share cities and 5 non-bikes share cities. The analysis presented in the current study was not reported by Graves et al. (2014) because they focused on head injuries. Study 2 examines injury risk for bike share programs based on data provided by bike share operators who were contacted for this study. Although more cities were contacted, we present data only for the two large bike share programs of Paris and London, because these could be matched to general police reported bicycle injury data including cyclist fatalities, which is important given the low level of underreporting of fatalities. Both systems are open all year long.

2.1. Study 1: Longitudinal hospital data from bike share and non-bike share cities

Graves et al. (2014) assessed trauma center data for bicycle-related injuries. They compared cities that recently introduced bike share programs with cities that did not with 24 months before and 12 months after intervention data. Comparison cities were selected in similar geographic regions. The study did not distinguish between private bicycle riders and bike share users. This means that the outcomes relate to cycling safety in general with and without the introduction of bike share systems. In other words, the data are aggregated according to four conditions (before/after crossed with control/bike share).

Importantly, the Graves et al. (2014) study lacked exposure data. The study only provides injury counts under the aforementioned four conditions and an analysis of these data therefore relies on the assumption of exposure remaining constant before and after the introduction of bike share. However, as more cycling is the purpose of introducing bike share, we can safely assume that the volume of cycling increased in bike share cities after the introduction of the programs (see, e.g., Fishman, Washington, & Haworth, 2013; Woodcock et al., 2014). This implies that if everything else remains equal, the increase of bicycle use in bike share cities after the introduction of a bike share program can be expected to increase the number of injuries among cyclists. As we don't know by how much, we only compare the number of injuries among cyclists before and after the introduction of the bike share programs. This means that our analysis leads to an overestimation of risk in terms of injuries per bicycle kilometer in bike share cities after the introduction of the bike share program. Due to this fact, we should bear in mind the risk of a Type II error, namely, not rejecting the null hypothesis that cities with and without bike share programs are equally safe, while bike share cities are actually safer. Practically, this means that we can only draw conclusions if the absolute number of injuries in bike share cities significantly decreases after the introduction of bike share because that would suggest that the risk decrease (in terms of injuries per bicycle kilometer) is greater than the increase of bicycle use (with injuries being the product of risk and kilometers traveled by bicycle). On the contrary, if the absolute number of injuries remains constant or increases, we are unable to distinguish between decreased risk and increased bicycle use. For instance, a 20% increase of injuries could result from a 20% lower risk and 50% more bicycle kilometers ($0.8 \times 1.5 = 1.2$), but also from an unchanged risk and 20% more bicycle kilometers ($1 \times 1.2 = 1.2$).

2.2. Study 2: Injury data from bike share users and private bicycle riders

This study examines injury risk for bike share programs in Paris and London. The study used fatal and serious injuries reported to the bike share operator. It is standard practice for bike share users to be required to report injuries to the bike share operator and, although it is possible (indeed likely) that some incidents fail to be reported, this measure has been used because it is a relatively easily captured data source and provides a comparable data source across different systems. In the bike share operator data used in this study, injury severity has been divided into fatal injuries and injuries needing hospital admission. A fatality is defined as a death occurring within 30 days of the crash (Department of Transport, 2013). The bike share operators were provided with a description of categories of severity (see Appendix 1), and asked to identify the number of incidents reported to them in each category, for 2013. Because of the high number of zero fatalities among bike share users in 2013, we searched for additional police reported fatalities among bike share users using reports by authorities in the same regions.

The respective bike share operator has provided ridership and system data. This includes the number of trips and trip duration, which allow for estimates for total distance traveled, by applying an assumed travel speed of 10.2 km/h. These data are captured automatically each time a bicycle is removed and returned to a bike share docking station (see Fishman, 2015). Speed estimates used in this study are derived from previous studies (Jensen et al., 2010). This speed is the travel speed which accounts for stops made between origin and destination, such as dwell times at intersections. Higher travel speeds for bike share users were reported by Rojas-Rueda, de Nazelle, Tainio, and Nieuwenhuijsen (2011), but we restrict to the lowest value by Jensen et al. (2010) to avoid underestimation of the risk of bike share users (a higher assumed speed contributes to a greater number of kilometers in the denominator of the risk ratio). We reflect on the sensitivity of the analyses for speed in Section 3.2.3.

To gain a measure of risk for private bicycle users, in terms of injury and fatality per unit of distance, travel survey data for the Paris region and Greater London were combined with police-recorded injury figures between 2009 and 2011. It should be noted that these sources do not allow the exclusion of the minority of bike share users. We reflect on this limitation in Section 5. Travel surveys generally collect one-day travel diaries of all members of households (e.g., among about 8,000