Seatbelt wearing rate in a Chinese city: Results from multi-round cross-sectional studies

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ABSTRACT

Objective: Road traffic crashes impose a heavy burden in China's most populous city, Shanghai. Since early 2016, Shanghai police have started deploying high-resolution cameras and an object-detection algorithm in seatbelt enforcement. Around the same time, an international consortium on road safety launched a series of capacity trainings for law enforcement accompanied by infrastructure renovation and social marketing campaigns in Shanghai. Our objective is to assess the level and trend of seatbelt use in Shanghai over 2015-2017.
Methods: Ongoing observational studies evaluate seatbelt use within the city. Data are collected at eight randomly selected locations throughout the city, stratified by road type and geographic locations. Data collection covers most times of the day on both business days and weekends, providing a full representation of varying traffic models during both rush hours and non-rush hours. At each site, trained field workers observe seatbelt use of occupants in all passing motorized vehicles. A multivariate logistic regression model was developed to analyze the data.
Findings: From October 2015 to December 2017, six rounds of data collection were completed with a total sample size of 77,641 drivers and passengers of motor vehicles. The seatbelt use rate has steadily increased over time, from 60.8% (95% CI: 59.9%–61.7%) in round 1 to 84.9% (84.3%–85.4%) in round 6 (p-value < 0.01). The increase is substantial and statistically significant for both drivers and passengers (p-value < 0.01). Results from the multivariate logistic regression show an annual growth rate of seatbelt use of 8.8% (8.4%–9.1%); the wearing rate was 49.8% (49.0%–50.5%) lower among passengers than drivers; 3.5% (2.9%–4.1%) lower in peri-urban areas than central urban areas; 16.3% (14.3%–18.4%) higher among 18–24-year and 18.9% (17.0%–20.9%) higher among 25–59-year olds than other age groups.
Conclusion and policy implications: Seatbelt use in Shanghai has been boosted during a short period of time through a combined strategy that includes training of police, social marketing campaign, and the deployment of computer vision assisted enforcement. Large cities in China and other countries facing similar challenges with seatbelt wearing may learn from Shanghai's experience.

1. Introduction

Shanghai is the most populous city in China, with 24.4 million residents, 6.5 million of whom are motor vehicle drivers (Anon, 2017). According to the city traffic police, 868 people died due to road traffic crashes in 2016, a number that may be underestimated (Li et al., 2016). Due to the urgent need for effective interventions to improve road safety, Shanghai was included in the Bloomberg Initiative for Global Road Safety (BIGRS), a consortium of international partners funded by Bloomberg Philanthropies (Larson et al., 2016). The BIGRS project aims to adopt internationally recognized best practices to promote road safety in 10 selected cities in low- and middle-income countries.

The World Health Organization (WHO) has identified not using seatbelts as a key road safety risk factor globally (WHO, 2015). Seatbelt use reduces the risk of death in the event of a crash by 50% for front seat occupants and 75% for rear seat occupants (Ichikawa et al., 2002). The National Highway Traffic Safety Administration (NHTSA) of United States advises that seatbelt use is one of safest choices that drivers and passengers can make on the road; and NHTSA estimated that seatbelt use in passenger vehicles saved 13,941 American lives in 2015 (NHTSA, 2018). However, seatbelt use rate remains low in China. Previous studies have shown seatbelt use rates ranging widely from 7% to 65% (Fleiter et al., 2009; Routley et al., 2008; Zhang et al., 2006). An observational study conducted at gas stations in five cities found the

seatbelt use rate varied between 23% and 47% by city (Huang et al., 2011). Consequently, promoting seatbelt use was identified as one of targets for the BIGRS project in Shanghai.

Various approaches have been explored around the world to improve seatbelt use, including establishing a national safety committee, developing school-based programs, and running social marketing campaigns (Nishtar et al., 2004; Morrow, 1989; Deng et al., 2016). However, one of the most effective strategies to increase seatbelt use and reduce road fatalities is passing and effectively enforcing seatbelt legislation (Shults and Beck, 2012; Pressley et al., 2016). Chinese traffic laws require all occupants to use seatbelts, but there is little compliance due to a variety of reasons, including low awareness and difficulties with enforcement (Routley et al., 2009).

Chinese traffic laws specify two enforcement approaches for traffic police: onsite and offsite enforcement. In the onsite approach, traffic police pull over a vehicle in which occupants are suspected of a traffic violation, check the driver and vehicle information, inform the driver of the suspected violation, confirm the violation, and potentially issue a ticket. The driver is entitled to dispute the cited violation with the police. Chinese traffic laws forbid police from issuing a ticket to the driver at a later date or time for a violation that they have personally observed. This traditional onsite enforcement approach is widely used in road safety management for many risk factors, such as drink driving, making an illegal left turn, or crossing the road median. A limitation with this approach is that frequently pulling over vehicles may aggravate traffic congestion, a widespread problem that is currently the priority for traffic police in many Chinese cities, including Shanghai. In these highly congested cities, police usually do not pull over vehicles for non-emergency or "minor" violations, such as not wearing a seatbelt, to avoid aggravating traffic congestion. The procedures around onsite enforcement and resulting difficulty in enforcing seatbelt law partially contributed to the low seatbelt compliance rate in China (Huang et al., 2011). As a result, seatbelt requirement is commonly enforced when a driver is stopped for other reasons, such as speeding, illegal lane change, or involvement in a crash.

Offsite enforcement mainly refers to electronic enforcement, which has become increasingly popular in traffic law enforcement with the widespread availability of high-tech devices, particularly in speed and red light enforcement (Brian Bochner and PTOE, 2010; Luoma et al., 2012; Retting et al., 2008; Thomas et al., 2008; He et al., 2013). In the electronic enforcement approach, electronic devices document the violations, usually in the form of pictures and videos. When a traffic ticket is issued to a driver, it is substantiated by proof, giving the driver an opportunity to dispute the violation. For example, several photos of the vehicle before and after the intersection are needed to substantiate a ticket for a red light violation. With recent development of computer vision techniques and increasing availability of high-resolution traffic cameras, some cities have started using the electronic approach in seatbelt enforcement, and achieved substantial increase in seatbelt use rate (Zhou, 2013). Compared with onsite enforcement, the electronic approach increases productivity, accuracy, efficiency and safety during traffic law enforcement (Decina et al., 2007).

In early 2016, Shanghai police started using computer vision algorithms to detect violations in seatbelt enforcement, following the *"Technical specifications for image forensics of road traffic offences (GA/T 832–2014)"* issued by the Ministry of Public Security of China. All images are automatically captured through high-resolution traffic cameras and analyzed using computer algorithms, with suspected violations manually confirmed by police officers before issuing tickets.

The BIGRS project launched a series of interventions almost simultaneously with the introduction of electronic enforcement of seatbelt use laws in Shanghai. Seatbelt-related intervention activities include convening stakeholder meetings, improving law enforcement capacity, educating general public through social marketing campaigns, and building the capacity on road safety among local professionals. In particular, given the limited experience in seatbelt enforcement among

traffic police, BIGRS partners organized a series of training workshops where the experience with seatbelt enforcement was shared by police officers from other countries, such as Australia and Poland.

As a result of the combination of information and enforcement, the goal of this paper is to assess the level and trend in compliance with seatbelt laws in Shanghai. The specific objectives: 1) estimate the prevalence of seatbelt use from a city-level representative sample; 2) obtain the prevalence of seatbelt use disaggregated by sex, type of occupant, and type of vehicle; and 3) assess the temporal trend of seatbelt use through multi-round cross-sectional observations.

2. Data and methods

Ongoing observations assess seatbelt use in Shanghai. Our observational studies are conducted at eight locations selected using a stratified sampling approach. Two ring expressways divide Shanghai into central urban area (within inner ring expressway), urban area (between inner and outer ring expressways), and peri-urban areas (outside outer ring expressway). Given the difference in traffic density and mode in those areas, our site selection was stratified by several road classifications (elevated road and ground road; varying speed limits) and geographic locations (Fig. 1). All eligible sites meet the following three criteria: location must be safe for observers; observers may be located at an elevation that is higher or equal height to passing vehicles; and locations where local population rather than tourists are more likely to be observed.

Then from the list of eligible sites, two were selected from the central urban area, two from the urban area, and four from the peri-urban area. Data collection covers both business days and weekends; it also covers the whole period from 07:00 to 20:00 h, providing a full representation of varying traffic models during both rush and non-rush hours.

At each site, trained field workers from the Shanghai Municipal Center for Disease Control and Prevention (CDC) observe seatbelt use of occupants in all passing motor vehicles. Field workers also collect information on the age and sex of all drivers and passengers, and type of vehicle. Site description including weather, traffic volume, road surface conditions, number of lanes, and law enforcement activities was collected before each observation session.

The observational method has been extensively used in road safety studies (G-l et al., 2008; Akaateba et al., 2014; Wu et al., 2012). This method provides access to road safety behaviors of interest in real life situations, has stronger validity than interviews that are vulnerable to misreporting, and is able to reach a wide range of people at a reasonable cost (Boyko, 2013). We provided comprehensive trainings to all field workers before the first round data collection, and repeated refresher trainings before each subsequent round. Through the trainings, the field workers practiced the observational methods on the roads; and their observational results were compared with records from video footages taken at the scene.

Both descriptive statistical method and multivariate logistic model were used to analyze the data. For bivariate analysis, a proportion test based on a binomial distribution was used to test the statistical significance of difference between groups or change over time (Acock, 2008). For multivariate analysis, the following logistic model was used

$$logit(y_i) = X_i\beta$$

where i indexes occupant; $y_i = 0/1$ is an indicator of occupant i not wearing (0) or wearing (1) seatbelt; X_i is the vector of covariates for occupant i including an intercept; β is the vector of regression coefficients. The covariates included in the model are observation date (measured in years), sex of occupant, type of vehicle, day of week (weekend; weekday), type of occupant (driver; passenger), city development area (central urban; urban; peri-urban), and age group (< 18 or > 59 years; 18–24 years; 25–59 years). The model coefficients measure the impact of a one-unit change in a model covariate on the