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Predicting personal injury crash risk through working conditions, job strain, and risky driving behaviors among taxi drivers

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Abstract

Introduction: Taxis play an important role among public transport modes in China, but there has been very little in-depth research regarding taxi drivers' crash risk. Thus, this study aimed to develop a quantitative method to predict taxi drivers' crash risk and identify contributory factors.

Methods: Nine hundred fourty-eight professional taxi drivers in Xi'an, China completed an anonymous, structured face-to-face questionnaire reporting their demographic information, work-related stress, daily risky driving behaviors, and crash experience within the 3 years prior to the survey. A Negative-Binomial regression model was used to predict the risk of personal injury collisions for taxi drivers.

Results: Drivers' 7 risky driving behaviors (e.g., disregarding red lights, speeding, aggressive driving, driving while sleepy or fatigued, etc.) were significantly and positively related to the risk of personal injury collisions, while driver's parking at will to pick up/drop off passengers was not a significant predictor of such risk for taxi drivers. Furthermore, driver's sociodemographic characteristics and level of occupational workload were not found to be significantly correlated with the personal injury crash risk.

Conclusions: Risk traits appear to peak among male taxi drivers who drive more hours per day, pay high management fees, and frequently engage in risky behaviors while driving. These findings provide implications to design potentially useful policy initiatives as well as targeted safety promotion programs to prevent road crashes involving professional taxi drivers.

Keywords: Taxi drivers, Working pressure, Risky driving behaviors, Crash risk, Negative-binomial regression model

1 Introduction

Today, taxis are an important component of China's urban public transit network. However, taxi drivers frequently work under extremely stressful and hazardous conditions, including long working hours, frequent driving, and occasional disputes with passengers, all of which increase drivers' physical and mental stress. A survey in Beijing reported that taxi drivers worked up to 11 h per day and at least 27.8 days per month [1]. Taxi drivers in Tlahuac, Mexico City were found to drive 11.1 h a day behind the wheel [2]. Another survey in Sydney showed that 67% of taxi drivers drove at least 50 h per week [3]. Obviously, taxi drivers' e daily earnings rely heavily on their driving distance within a scheduled period, so they must spend long hours driving in order to carry more passengers and earn more money. Therefore, it is no surprise that taxi drivers engage in occupational risks while driving.

Many studies have been conducted to examine the significant effect of exposure to hazardous working conditions on taxi drivers' health and to identify potential risk factors contributing to road crashes, such as drivers' age, job experience [4], license, type of employment [5], and physical and mental health [3, 6, 7]. Generally, taxi drivers are regularly obliged to work long hours into the late night or early morning and are therefore vulnerable to fatigue or sleepiness while driving [3, 4, 8, 9]. Moreover, occupational illness [10], irregular shifts [3], and

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income dissatisfaction [11] have also been significantly correlated with taxi drivers' risk of serious crashes.

Because taxi drivers' daily earnings depend on their driving distance with occupants, they try to drive faster to save time and carry more passengers; as such, they often commit traffic violations. A study of taxi collisions in Taiwan [12] revealed that 25.6% of the observed drivers committed at least one speeding violation during a one-year period, and the frequency of speeding behavior was significantly related to the driver's age, years of job experience, daily driven kilometers, number of off-duty days per month, etc. Moreover, taxi drivers who exhibited more passive-aggressive driving behaviors were found to be easily distracted and to have an increased crash risk [13]. A survey in Wuhan, China showed that taxi drivers' attitudes about driving violations had a serious negative influence on their risky driving behaviors [14].

To date, there have been very few studies regarding taxi drivers' work-related stress and risky driving behaviors. Understanding the relationship between these factors is essential to devising potential strategies to reduce and prevent road accidents and injuries for taxi drivers. Thus, this research aimed to 1) examine the association between their sociodemographic information, self-reported work-related stress, frequency of risky driving behaviors, and involvement in personal injury collisions; and 2) propose a quantitative model of predicting the potential crash risk among professional taxi drivers.

2 Data collection and processing

2.1 Participants

A cross-sectional survey was conducted in Xi'an, China (Fig. 1) between May and July 2015. Initially, a representative sample of 1042 professional taxi drivers with a minimum of 2 years post-license taxi driving experience and an annual working mileage of at least 50,000 km during the past 2 years was selected from 14 taxi companies; however, 94 drivers did not agree to participate in the survey. In total, 948 participants (868 male, 80 female, aged 20–57 years with a mean age = 36.23 years, SE = 8.10 years) were included in the final dataset (response rate = 90.98%). Of the drivers surveyed, 50% held a senior high school diploma or above; 19.62% had received primary school education or below.

2.2 Measures

A questionnaire was designed to examine taxi drivers' personal views on work-related stress, daily risky driving behaviors, and crash risk. The survey consisted of 16 questions ranging from sociodemographic characteristics, level of workload, frequency of risky driving behaviors and crash experience over the past 3 years.

In the survey, drivers were asked to provide their age (AGE), gender (GEND), and educational background (EDU). Additionally, each participant was encouraged to report his/her average hours of work per day (HOUR) and number of off-duty days per week (DRES) during the past 3 years. Because taxi companies in China charge taxi drivers considerable management fees to cover operational costs, including periodic training and renewal of operating licenses, this survey also required each participant to report his/her company-charged daily management fees (FEE) to capture taxi drivers' average economic burden.

Taxi drivers' daily risky driving behavior, including disregarding red lights (REDL), speeding (SPEE), showing annoyance to disliked driver's behavior by sounding horn or throwing something whatever means (ANNO), aggressive driving like sudden acceleration, deceleration or braking (AGGR), driving while fatigued (FATI), using a mobile phone while driving (PHON), dangerous overtaking

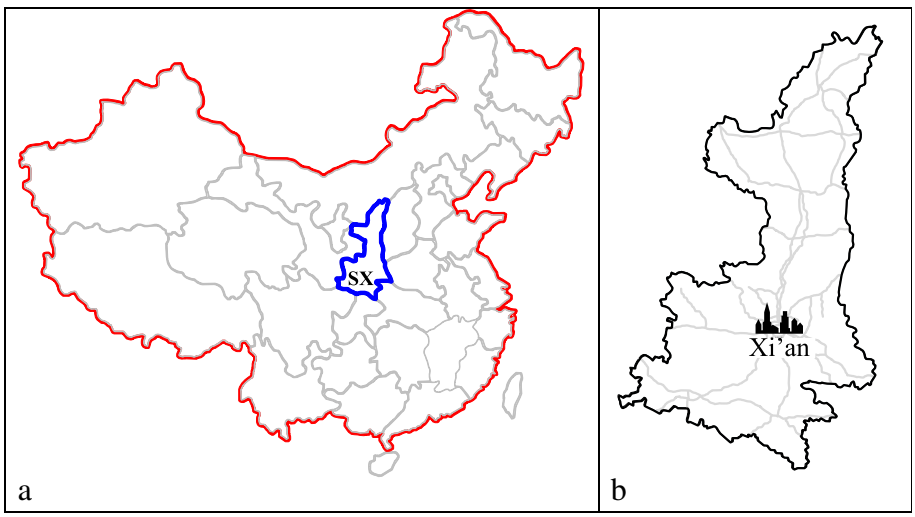

Fig. 1 Location of the questionnaire survey. **a** Shaanxi (SX) Province in China; **b** Xi'an in the center of the Guanzhong Plain

(OVTA) and parking at will (PARK), was rated on a 7-point Likert-type scale (0 = never, 1 = hardly ever, 2 = occasionally, 3 = quite often, 4 = frequently, 5 = nearly all the time, and 6 = always) in response to the question, "How often do you commit the following risky driving behavior?"

More specifically, each participant was invited to report his/her own crash experience in personal injury (PIN) collisions over the past 3 years, as shown in Table 1.

2.3 Procedure

Taxi companies selected to conduct the survey were validly registered with the Xi'an Taxi Administrative Office and owned at least 1000 taxis. Registered taxi drivers with a fixed schedule were randomly called to the office to participate in face-to-face interviews with qualified graduate students. Before the interview, each driver was informed of the purpose and definition of each item as well as how to complete the questionnaire. Furthermore, participants were ensured the survey was anonymous and their personal information and individual responses to the questions would be kept strictly confidential. Only those who gave consent were invited to complete the 15-min survey and were compensated 10 CHY for their time.

A Negative-Binomial model was proposed to predict taxi drivers' risk of being involved in PIN collisions based on their reported sociodemographic information (age, gender, and education level), work-related stress (hours of work per day, off-duty days per week, and daily management fees), and frequency of risky driving behaviors, which was performed in STATA 14 package. Here, $p < 0.05$ was considered statistically significant.

3 Results

Table 2 presents the variables used in the regression model. Overall, there were high levels of self-reported workload due to long hours of work (M = 9.385, SE = 1.23), inadequate rest (M = 0.325, SE = 0.516), and high management fees (M = 166.74, SE = 17.93). A more detailed examination of responses to workload-related categories revealed that 76.37% of the sample reported having to work 9 h or more per day; 16.67% admitted having to work 8 h per day, and only 6.96% indicated working 7 h or fewer daily. Additionally, more than two-thirds (69.83%) of respondents worked 7 days per week; only 30.17% reported having time to rest. On the other hand, 64.56% were charged 151~ 180 CHY per day as a daily management fee, and another 20.68% were charged 180~ 210 CHY every day.

Table 1 Distribution of personal injury (PIN) collisions among taxi drivers surveyed

Number of collision	N	%	Number of collision	N	%
0	725	76.48	3	13	1.37
1	169	17.82	4	1	0.11
2	40	4.22	> 4	0	0

Table 2 Descriptive characteristic for variables

Variables	Mean	SE	Min	Max
GEND	0.914	0.281	0	1
AGE	36.23	8.104	20	57
EDU	2.409	0.948	1	4
HOUR	9.385	1.231	6	14
DRES	0.325	0.516	0	2
FEE	2.066	0.610	1	4
REDL	2.241	1.359	0	5
SPEE	2.494	1.312	0	5
ANNO	2.611	1.083	0	5
AGGR	1.347	1.149	0	4
FATI	3.272	1.270	0	6
PHON	1.082	1.018	0	4
OVTA	2.177	1.254	0	5
PARK	2.210	0.871	0	5

SE Std. Err

Moreover, respondents reported that they drove their taxi while sleepy or fatigued more than "quite often" but less than "frequently" (M = 3.272, SE = 1.270), followed by showing annoyance (M = 2.611, SE = 1.083), speeding (M = 2.494, SE = 1.312), running a red light (M = 2.241, SE = 1.359), parking at will to pick up/drop off passengers (M = 2.210, SE = 0.871) and overtaking other drivers under dangerous conditions (M = 2.177, SE = 1.254). Mobile phone use while driving was rated the lowest of all items (M = 1.082, SE = 1.018), consistent with findings from Wang et al. [14].

With regard to taxi drivers' involvement in crashes during the past 3 years, respondents reported having been involved in 0.308 injury crashes (SE = 0.627). Among the 948 respondents, 17.83% admitted having been involved in one PIN collision and only 5.70% experienced two or more PIN collisions.

The mean of PIN collisions is 0.308 and the variance is 0.392, and these data therefore contain a small amount of systematic variation. Then a Negative-Binomial regression model was introduced to examine the relationship between taxi drivers' sociodemographic information (age, gender, and educational background), work-related stress (hours of work per day, off-duty days per week, and daily management fees), frequency of daily risky driving behaviors, and PIN collision involvement, as Table 3 shows.

In Model I, all 14 self-reported variables were collectively entered to determine the predictor of PIN crash rate of taxi drivers, and 7 risky driving behavior variables except parking at will (coef. = 0.025, $p = 0.915$) were statistically significant predictors of PIN crash risk with all $p < 0.05$. For simplicity, the significant variables identified in Model I

Table 3 Negative Binomial Model estimation of PIN crash risk among taxi drivers

Variables	Model I				Model II			
	Coef	SE	z value	*p*	Coef	SE	z value	*p*
Intercept	−7.082	0.901	−7.857	< 0.001	−6.850	0.364	−18.80	< 0.001
GEND	−0.101	0.250	−0.406	0.684				
AGE	0.004	0.011	0.423	0.671				
EDU	−0.043	0.088	− 0.492	0.625				
HOUR	0.004	0.059	0.064	0.956				
DRES	0.164	0.111	1.473	0.142				
FEE	0.055	0.109	0.506	0.606				
REDL	0.450	0.068	7.319	< 0.001	0.521	0.065	8.054	< 0.001
SPEE	0.242	0.093	2.596	0.001	0.241	0.074	3.253	0.001
ANNO	0.153	0.085	1.791	0.024	0.154	0.068	2.260	0.024
AGGR	0.278	0.069	4.037	< 0.001	0.276	0.069	3.981	< 0.001
FATI	0.331	0.061	5.468	< 0.001	0.313	0.057	5.524	< 0.001
PHON	0.230	0.083	2.757	< 0.001	0.220	0.057	3.905	< 0.001
OVTA	0.222	0.084	2.651	< 0.001	0.245	0.055	4.467	< 0.001
PARK	0.025	0.231	0.107	0.915				
Log likelihood	− 366.1				− 368.5			
AIC	764.1				755.0			

SE Std. Err

were together collected to determine Model II to predict the PIN crash risk of taxi drivers. Clearly, all risky driving behavior variables were again found to be significant. Compared with Model I, Model II had the better performance of fit (AIC = 755.0 vs. 764.1), but with fewer input independent variables (14 vs. 7).

As mentioned in Model II, positive coefficient is an indication of high risk for injury crashes [15], and thus the frequent behaviors while driving, including running a red light (coef. = 0.521, SE = 0.065), speeding (coef. = 0.241, SE = 0.074), showing annoyance (coef. = 0.154, SE = 0.068), aggressive driving (coef. = 0.276, SE = 0.069), driving while fatigued (coef. = 0.313, SE = 0.031), mobile phone use (coef. = 0.220, SE = 0.057) and dangerous overtaking (coef. = 0.245, SE = 0.055), were identified as the risk factors contributing to PIN collisions among taxi drivers with all $p < 0.05$, which were consistent with the findings from Wang et al. [15]. These findings should be recommended to their respective taxi companies for occupational safety protection.

4 Conclusions and discussion

Since drivers who drive for work purpose are known to be more prone to a wide range of risks [16], and thus such professional drivers have been reported to have above average crash frequencies compared to personal vehicle drivers as reported in the literature [17]. In Britain, 31% of fatal crashes and 26% of serious injury crashes involve occupational drivers [18]. A survey in Xi'an, China revealed that the average number of taxi crashes per month was 8.500 over the period of 2006 to 2011 [4]. Our previous study also showed that 47.34% of the occupational bus, taxi, lorry, company car and shuttle drivers in Xining, China had caused crashes at some point [19]. Accordingly, it is quite necessary to identify the potential crash risk for these professional drivers.

This questionnaire study tries to investigate for the first time the association between work-related stress, risky driving behaviors and involvement in personal injury crashes using the self-reported data from taxi drivers in Xi'an, China and then determine their predictor of such potential crash risk. Unsurprisingly, taxi drivers aged between 30 and 40 were more likely to be involved in collisions while driving. Because drivers often had young children and elderly parents to care for, they felt compelled to use their time more efficiently by driving faster and transporting more passengers in order to earn more money within a limited time window. Similar findings were reported among taxi drivers in Shanghai and New York City [20].

Additionally, the results found that more than three-quarters of participants had to drive 9 h or more per day, and 18.56% sat behind the wheel up to 11 h or more every day. More concerningly, 69.83% of respondents reported working all week without a day of rest. About three-quarters (74.57%) admitted to drive while sleepy or fatigued "quite often" or more frequently than that. On the other hand, approximately 85% had to pay a daily

management fee of 150 CHY to their respective taxi companies, equal to nearly half their total daily gross income; therefore, it is unsurprising that the taxi drivers surveyed engaged frequently in risky behaviors such as speeding, running red lights, overtaking other drivers dangerously, and so on. Since it is impossible to cancel the daily management fee charged by taxi companies, it is strongly demanded to be reduced to some extent.

The results also provide insight into how to prevent and reduce traffic crashes among taxi drivers, namely by increasing their income. Taxi drivers could also be offered taxi ownership and operating rights under the centralized administration of taxi companies. It is worth noting that the government should play a major role in guiding reform to change the taxi industry's present managerial approach; for example, tax incentives could be given to taxi companies to help subsidize employee benefits (e.g., medical insurance, accident insurance, paid leave, etc.). Taxi companies are strongly suggested to set up special funds to help those engaged in injury crashes. Furthermore, both the government and taxi companies should develop stricter rules and regulations to limit registered drivers' maximum daily and weekly hours of work, which may help to prevent fatigued driving [21, 22].

On the other hand, taxi drivers should receive education about the dangers of risky driving behaviors to encourage them to obey the traffic rules and avoid serious traffic violations [23], such as speeding and disregarding red lights, etc. Those who disobey the rules should be harshly penalized or have their taxi license revoked. Moreover, employers should be required to improve taxi drivers' working conditions, including through the establishment of a trade union, purchase of insurance, periodic training and safety education, and mental health exams for all registered taxi drivers. It would also be worthwhile to open a complaint centre through which passengers and drivers could submit grievances and resolve disputes about service problems; a coordinated problem resolution procedure may help to reduce taxi drivers' risky driving behaviors.

Professional drivers in the world confront the similar excessive workload conditions and considerably high crash risk. A survey in Australia showed that occupational drivers had a higher intention to speed in a work vehicle than their personal one [24], and thus were more likely to have crashes while driving for work. In Sri Lanka, taxi driver's sociodemographic factors (i.e. level of education, marital status) are also found to be significantly associated with their aggressive driving and risk-taking behaviors [25]. 81% of taxi drivers in Ankara, Turkey reported talking by using hand-held phone while driving [26]. On the other hand, many previous studies reported in the literature show that professional driver's crash involvement is significantly related to the sociodemographic factors, working conditions or risky driving behaviors [10, 15, 27–29]; therefore, the proposed quantitative approach using all these possible contributory factors can be used to examine the potential crash risk for professional drivers (i.e., taxi, bus, coach, truck) in China, European countries and other areas in the world [15, 30]. The findings of this study provide valuable data with important implications for worldwide decision-making in public health policy and traffic regulation for professional drivers.

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Authors' contributions
XB designed the study, interpreted results and drafted the manuscript. FZ carried out the survey and performed data analysis. YW helped collected the data and contributed to the interpretation of results. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

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