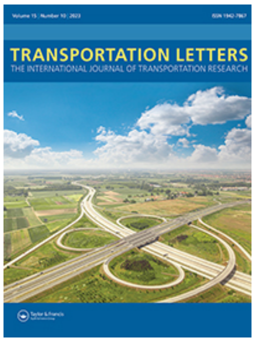

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Work-traffic crashes and aberrant driving behaviors among full-time ride-hailing and taxi drivers: a comparative study

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ABSTRACT

As a product of China's transportation development in the last decade, the issue of road traffic crashes among ride-hailing drivers has become a growing concern for public safety. This study aims to investigate the human factors contributing to traffic crashes among traditional taxi and ride-hailing drivers, and to compare the similarities and differences between the two groups of drivers. The data was collected from 877 taxi drivers and 906 full-time ride-hailing drivers through a self-reported survey. The structural equation model was used to investigate structural interrelationships between the financial burden, work-related fatigue (WRF), road safety attitude, aberrant driving behaviors (ADBs) of the drivers and their influences on work-traffic crashes. Relevant results showed that there were significant differences in the work status between the two groups of drivers. The heavy economic burden increased the perception of WRF among taxi drivers and contributed to traffic crashes. Ride-hailing drivers had a more positive attitude toward road safety and controlled their ADBs better. These results will help formulate policy recommendations aimed at improving road safety among taxi and ride-hailing drivers.

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KEYWORDS
Financial burden; work-related fatigue; road safety attitude; aberrant driving behavior; taxi and ride-hailing drivers; structural equation model (SEM)

Introduction

Taxis, which have experienced rapid development during the last few decades in China, play a crucial role in public transportation for fast and convenient transport services. Meanwhile, the ride-hailing service has developed dramatically during the past decade in China. Compared with traditional taxi services, ride-hailing services have several benefits, such as providing their real-time location, offering predictable prices before the trip, *etc*. However, while ride-hailing provides convenient and comfortable services for people, road traffic crashes involving ride-hailing drivers have become a major public health and safety concern.

The issue of traffic accidents involving taxi drivers has been a constant concern for the community. In 2019, taxis accounted for 40.1% of commercial vehicle traffic accidents in Korea, of which 25.0% involved injuries and fatalities (Mehdizadeh, Shariat-Mohaymany and Nordfjaern 2019). However, the situation of ride-hailing drivers is not encouraging either. Statistics indicated that the accident rate of ride-hailing drivers amounted to 7.53%, which surpassed the 0.28% accident rate for private cars in the same period (Legal Daily 2017). Compared with the existing relatively in-depth studies on accidents involving taxi drivers, studies on the safety issues of ride-hailing services are limited, which makes it necessary to identify the factors contributing to ride-hailing drivers' crashes.

Financial burden and work-related fatigue

Factors related to the financial burden (FB) (Peng, Wang, and Luo 2020) and work-related fatigue (WRF) (Wang, Li, and Prato 2019) have been identified as major contributors to road traffic crashes involving taxi drivers. Ride-hailing drivers have similar characteristics to traditional taxi drivers. Their jobs are low-paying and economically unstable, and they both have to spend a long time driving to earn as many fares as possible, which exposes them to complex and dangerous traffic conditions. It has been reported that nearly 70.86% of taxi drivers frequently felt dissatisfied with their income (Peng, Wang, and Luo 2020), additionally, they have to pay heavy management fees to their companies to obtain qualifications for driving (Shi et al. 2014). Similarly, ride-hailing drivers must pay a certain proportion of the revenue from each order to their online management platform.

This heavy FB drove taxi drivers to work longer hours daily at the expense of shorter rest time. Li et al. (2019) reported that taxi drivers in Beijing drive approximately 12.3 hours per day, with over 3.9 hours of continuous driving. Unlike taxi drivers, ride-hailing drivers are working in more market-oriented and competitive conditions, such as competition with other ride-hailing drivers nearby, eagerness for grabbing orders, and ratings from passengers. These conditions would undoubtedly make them experience more intense work stress and aggravate their WRF. Given the above findings, we have the following hypotheses about the two types of drivers:

H1: FB will be positively associated with work-traffic crashes (WTCs).

H2: WRF will be positively associated with WTCs.

H3: WRF mediates the relation between FB and WTCs.

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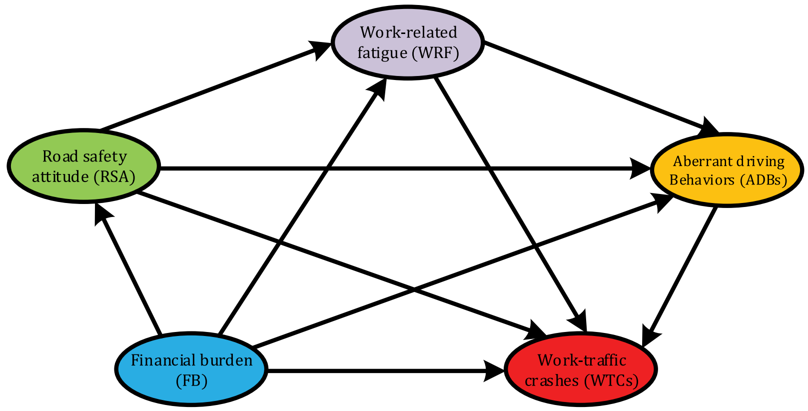

Figure 1. Proposed conceptual model.

Aberrant driving behaviors

The aberrant driving behaviors (ADBs) of drivers have been shown to be associated with driving fatigue (Stern et al. 2019; Rizzo et al. 2019), and apparently lead to an increase in crash risk. This situation may be even more serious for taxi and ride-hailing drivers due to their heavy FB and WRF. As their income depends on the number of orders they collect, taxi drivers have a tendency to engage in ADBs (Useche et al. 2020), such as sudden lane changes, dangerous overtaking, and speeding (Huang, Sun, and Zhang 2018). Moreover, long driving hours place taxi drivers in a fatigued state (Li et al. 2019), which further contributes to the decrease in their ability to maneuver the vehicle and their adoption of an aggressive driving style.

The use of mobile phones while driving has been identified as a significant cause of driver distraction and risky driving behaviors (Beck,Yan, and Wang 2007; Niu et al. 2019). Mobile phone use (MPU) while driving accounted for 20% of distraction-related accidents (Beanland et al. 2013), and nearly 36% of Chinese taxi drivers admitted that they have used a mobile phone while operating the vehicle (Wang, Li, and Prato 2019 et al 2018), which contributed to their involvement in road crashes(Peng, Wang, and Luo 2020). This situation might be more prevalent among ride-hailing drivers. The potential passenger sends a trip request on the mobile phone-based application, the matched ride-hailing driver would receive a sound or message alert, and needs to confirm the passenger's departure and destination points through the mobile phone-based navigation systems, whose navigation information could be unreliable (Szűcs and Sallai 2009). As a result, in the process of picking up the passenger, drivers need to call passengers. This mobile phone-based interaction increases distractions for ride-hailing drivers, thereby raising the likelihood of road crashes. Based on the above findings, we have the following hypotheses for the two types of drivers:

H4: ABDs (including MPU and other aberrant driving behaviors – OADBs) will be positively associated with WTCs.

H5: ABDs mediate the relation between FB and WTCs.

H6: ABDs mediate the relation between WRF and WTCs.

H7: MPU will be positively associated with OADBs.

H8: OADBs mediate the relation between MPU and WTCs.

Road safety attitude

The road safety attitude (RSA) of drivers has an influence on their driving behaviors(Şimşekoğlu, Nordfjærn, and Rundmo 2012). In the present study, RSA refers to the willingness of drivers to behave safely on the road. According to the theory of planned behavior (Ajzen, 1991), the attitude of an individual is one of the most critical determinants of his or her behavioral intentions and execution. Driving attitudes were found to influence the driving style, thus predicting driving behavior (Shi, Hussain, and Peng 2022). Some studies have examined the associations between safety attitudes, safety intentions, and ADBs among truck drivers (Douglas et al. 2019) and bus drivers (Mallia et al. 2015). Various characteristics of occupational driving tasks might result in differences in attitude toward traffic safety. However, there are few studies on the attitude of taxi and ride-hailing drivers toward traffic safety. Based on previous findings on professional drivers, we have the following hypotheses for taxi and ride-hailing drivers:

H9: RSA will be negatively associated with WTCs.

H10: WRF mediates the relation between RSA and WTCs.

H11: ABDs (including MPU and OADBs) mediate the relation between RSA and WTCs.

H12: RSA mediates the relation between FB and WTCs.

Objective

The current study sought to clarify the following two questions. The first was to determine the associations between FB, WRF, RSA, ADBs, and WTCs. Therefore, a conceptual model (Figure 1) was developed for the traditional taxi drivers and ride-hailing drivers on the basis of the twelve previously proposed hypotheses. The second was to investigate the similarities and differences between the two groups of drivers with respect to human factors contributing to their WTCs.

Methods

Survey design and data collection

The survey data used in this study were collected from November 1 2021, to December 15 2021, in Changchun, China. This online survey, called 'Survey on road safety and driving behaviors of taxi and ride-hailing drivers in Changchun', was conducted using the online questionnaire Soujoup platform (https://www.wjx.cn/), which provides online survey services in China. Once the survey is posted, the backend automatically matches the information of the registrant with the target occupation, years of experience, and other requirements of the user who posted the questionnaire and then sends them a request to fill out the questionnaire. This investigation targeted traditional taxi drivers and ride-hailing drivers with over two years of working experience.

Only taxi drivers who had driven an average of above 50,000 km per year in the last 2 years were deemed to be eligible for the survey. The questionnaire survey website was accessed by 1,011 traditional taxi drivers, of which 912 were eligible for the survey. After removing 35 questionnaires due to incomplete information, a total of 877 traditional taxi drivers were included in the study.

Drivers whose only source of income was from providing ride-hailing services and were online in excess of 8 hours, with more than 20 fares per day were deemed to be full-time ride-hailing drivers. The survey collected a total of 997 questionnaires from ride-hailing drivers. After removing 91 questionnaires due to incomplete information, a total of 906 ride-hailing drivers were included in the study.

Questionnaire

Except for demographic information (*i.e.*, age, sex, *etc.*), the drivers were asked to answer the following questions about the following 5 aspects: (i) FB, (ii) WRF, (iii) ADBs, (iv) RSA, and (v) WTCs.

Financial burden

The taxi and ride-hailing drivers were asked to describe the FB they have experienced as professional drivers, including daily income (ICOM), and level of dissatisfaction with current income (DISC). Additionally, taxi drivers were required to report their monthly management fees (MFEE), and ride-hailing drivers were required to report monthly platform services fees paid to the online management platform (PSFE), which mainly include the share of each order to the platform, fines paid to the platform due to passenger complaints, *etc.*

Work-related fatigue

All participants were also asked to report their WRF while driving taxi or ride-hailing vehicles on a work-related trip, such as dropping off, picking up, or finding a passenger, by answering the following three questions using five Likert scale ranging from 'never (1)' to 'always (5)', which were taken from a previous study (Hu and Chen, 2019). The three items were: 'I have difficulty focusing on driving when driving for a long time (DFFD)' and 'sitting in a fixed position while driving makes my body sore and tense (SFST)', and 'I feel inattentive when I have driven for a long time (INDL)'.

Aberrant driving behaviors

All taxi and ride-hailing drivers surveyed were required to report their daily aberrant driving performance while working, in terms of 'How often do you engage in the following ADBs while working?' using five Likert scale ranging from 'never (1)' to 'always (5)'. According to a report by Wang, Li, and Prato (2019) on aberrant behaviors in which Chinese taxi drivers frequently engage, as well as the characteristics of the work for ride-hailing drivers, ADBs were further subdivided into two parts:1) MPU: navigation (PNAV), making a call (PCON), and mobile-based app use (PAPP); 2) OADBs: disregarding the speed limits (SPEE), showing hostility toward others (HOST), failure to keep enough distance (DIST), and failure to notice a pedestrian crossing (PECR).

Road safety attitude

All participants were asked to state their attitudes toward road safety as professional drivers by answering the following three-question questionnaire using five Likert scale ranging from 'strongly disagree (1)' to 'strongly agree (5)'. The three-question questionnaire was developed by Iversen and Rundmo (2004), and adapted for taxi and ride-hailing drivers in China. The three questions are 'Personal driving behavior plays a critical role in road safety (PDCR)', 'Driving a vehicle in accordance with traffic rules is not just about not being punished, following traffic rules is effective in reducing accidents (NBRA)', and 'Ensuring road safety is a personal responsibility (PSRS)'.

Work-traffic crashes

Drivers were asked to report their crash history as professional taxi or ride-hailing drivers during the past 2 years before the date of the survey, including property damage only (PDO) and personal injury (PI) collisions, which were measured by numeric values.

Statistical analysis

First, basic descriptive analyses (*i.e.*, means and standard deviations of the variables) were performed, the Shapiro-Wilk test was used to evaluate the normality of research data distribution, and Mann-Whitney U tests were used to determine whether there were significant differences between traditional taxi drivers and ride-hailing drivers. Second, Cronbach's alpha values were calculated to evaluate the reliability of each construct. A Cronbach's alpha value between 0.35 and 0.7 is considered moderately reliable, and highly reliable when greater than 0.9 (Shi, Hussain, and Peng 2022). Thus, it was acceptable only when the threshold of 0.35 was reached in this study.

Finally, a confirmatory factor analysis (CFA) with maximum likelihood was performed to examine the structure interrelationships between FB, WRF, RSA, ADBs, and WTCs. The performance of the CFA in the current study was assessed by the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSEA). The CFI and TLI values above 0.90, RMSEA values below 0.05, and Chi-square/df (χ^2/df) below 5 indicate an adequate fit for the model (Hu and Bentler,1999).

Structural equation modeling (SEM) was used to investigate the associations between the above factors, postulated in Figure 1, for the two groups of drivers. According to the concept working model of this study (Figure 1), first, there are four types of direct effects to explain work-related crashes: FB, WRF, ADBs, and RSA. Second, the indirect effect of RSA on WTCs, when WRF acts as a mediator variable, is a product of the two regression weights, namely the regression weight between the RSA and the mediating factor WRF, and the regression weight between the mediator and WTCs (RSA → WRF → WTCs). The level of significance for all tests was taken as 0.05. In addition, a powerful bootstrapping method with 1,000 samples (Ozer 2011) was used to test the statistical significance difference in the total effect of WRF, FB, RSA, and ADBs on WTCs between taxi and ride-hailing drivers.

Table 1. Descriptive statistics of the sample.[a]

Variables	Percentage (%) T-D	Percentage (%) R-D	Variables	Percentage (%) T-D	Percentage (%) R-D
SEX			Daily income (CNY)		
female	18.81	13.91	0 ~ 100	1.94	1.32
male	81.19	86.09	100–200	21.44	22.74
EDU			200–300	36.6	35.98
primary school	3.76	0.66	300–400	24.06	20.31
middle school	29.42	12.25	400–500	11.74	15.89
junior high school	48.92	30.13	500–600	3.42	2.65
higher education	17.90	56.95	>600	0.8	1.1
AGE			Monthly manage fee/Platform service fee (CNY)		
≤25	1.48	3.31	0 ~ 1500	5.25	9.71
26–30	7.75	17.00	1500 ~ 3000	13	43.27
31–35	29.19	47.90	3000 ~ 1500	28.85	19.65
36–40	32.04	17.99	4500 ~ 6000	35.23	14.02
41–45	17.56	9.93	>6000	17.67	13.36
46–50	8.44	2.65	Level of dissatisfaction with current income		
51–55	2.39	0.66	never	3.2	4.2
56≥	1.14	0.55	seldom	23.8	22.1
			sometimes	41	46.2
			frequently	28.1	24.2
			always	3.9	3.3

Note: T-D: taxi drivers; R-D: ride-hailing drivers.

Table 2. Mann-Whitney U tests results for taxi and ride-hailing drivers.

Variable	T – drivers MEAN	T – drivers SD	R – drivers MEAN	R – drivers SD	M-W test t-value	M-W test p	Variable	T – drivers MEAN	T – drivers SD	R – drivers MEAN	R – drivers SD	M-W test Z-value	M-W test p
AGE	39.85	6.42	36.38	5.67	−12.44	***	SEX[b]	0.81	0.39	0.86	0.35	−2.80	**
EDU[a]	2.81	0.77	3.43	0.73	−16.79	***	PNAV	2.31	1.14	2.75	1.23	−7.71	***
DFFD	3.71	0.95	2.74	1.06	−17.91	***	PCON	2.91	1.13	3.21	1.29	−5.36	***
SFST	3.76	0.90	2.87	1.05	−17.38	***	PAPP	1.34	1.04	2.78	1.04	−24.42	***
INDL	3.88	0.93	2.87	1.01	−19.64	***	PDCR	3.49	1.03	3.94	1.06	−9.79	***
SPEE	2.38	1.06	2.03	1.12	−7.40	***	NBRA	3.57	1.05	4.01	1.07	−9.64	***
HOST	2.79	1.20	2.17	1.19	−10.76	***	PSRS	3.63	1.00	3.84	1.02	−4.91	***
DIST	2.75	1.06	2.33	1.10	−8.33	***	ICOM	3.36	1.15	3.39	1.18	−0.37	.710
PECR	2.60	1.17	2.09	1.16	−9.34	***	DISC	3.06	0.89	3.00	0.87	−1.18	.240
PDO	1.61	1.44	0.62	0.98	−15.99	***	MFEE/ PSFE	3.47	1.09	2.78	1.2	−12.79	***
PI	0.53	1.21	0.36	0.92	−2.55	**							

Note: a:1 = Primary school, 2 = Middle school, 3 = Junior high school, 4 = Higher education;
b: 0 = female, 1 = male.
*** p < 0.001; ** p < 0.01; * p < 0.05.

Results

Descriptive statistics

The results of the descriptive statistics for taxi and ride-hailing drivers are summarized in Tables 1 and 2. The Kolmogorov-Smirnov test showed that none of the variables had normal distribution ($p < 0.05$). Therefore, the Mann-Whitney U test was performed to evaluate the differences between the two types of drivers, as shown in Table 2. The average age of taxi drivers surveyed was 39.85 years, older than that of ride-hailing drivers at 36.38 years ($z = -12.44$, $p < 0.01$; Table 1), and the majority of drivers in both groups were male. The education level of ride-hailing drivers was higher than that of taxi drivers ($z = -16.79$, $p < 0.01$).

The monthly management fee for taxi drivers was significantly higher than that of the platform service fee for ride-hailing drivers ($z = -12.79$, $p < 0.01$; Table 2). Most of the taxi and ride-hailing drivers were low-paid, as 84.04% of taxi drivers and 80.35% of ride-hailing drivers had an average daily income of less than 400 yuan. Not surprisingly, approximately 32% of taxi drivers and 27.5% of ride-hailing drivers 'frequently' or 'always' complained about their income situation. There was no significant difference in daily income ($z = -0.37$, $p = 0.710$) and levels of dissatisfaction with income ($z = -1.18$, $p = 0.240$) between taxi and ride-hailing drivers.

The perceived WRF of taxi drivers while driving was significantly higher than that of ride-hailing drivers, as shown in Table 2. Taxi drivers adopted ADBs more frequently, such as speeding ($z = -7.40$, $p < 0.01$) and failure to keep enough distance ($z = -8.33$, $p < 0.01$). However, ride-hailing drivers used mobile phones more frequently while driving, such as making mobile phone calls ($z = -5.36$, $p < 0.01$) and mobile phone-based apps use ($z = -24.42$, $p < 0.01$). Meanwhile, ride-hailing drivers had a more positive RSA than taxi drivers.

Regarding the crash involvement history of both groups of drivers, the average number of PDO and PI collisions for taxi drivers during the past two years was 1.61 ± 1.44 and 0.53 ± 1.21, respectively, while those for ride-hailing drivers was 0.62 ± 0.98 and 0.36 ± 0.92, respectively. Thus, taxi drivers had a higher probability of WTCs.

Structural equation modeling (SEM)

The SEM results for taxi drivers and ride-hailing drivers, shown in Figure 2 and Figure 3, respectively, reveal that the RMSEA was 0.023 and 0.047, CFI was 0.985 and 0.937, TLI was 0.979 and 0.916,

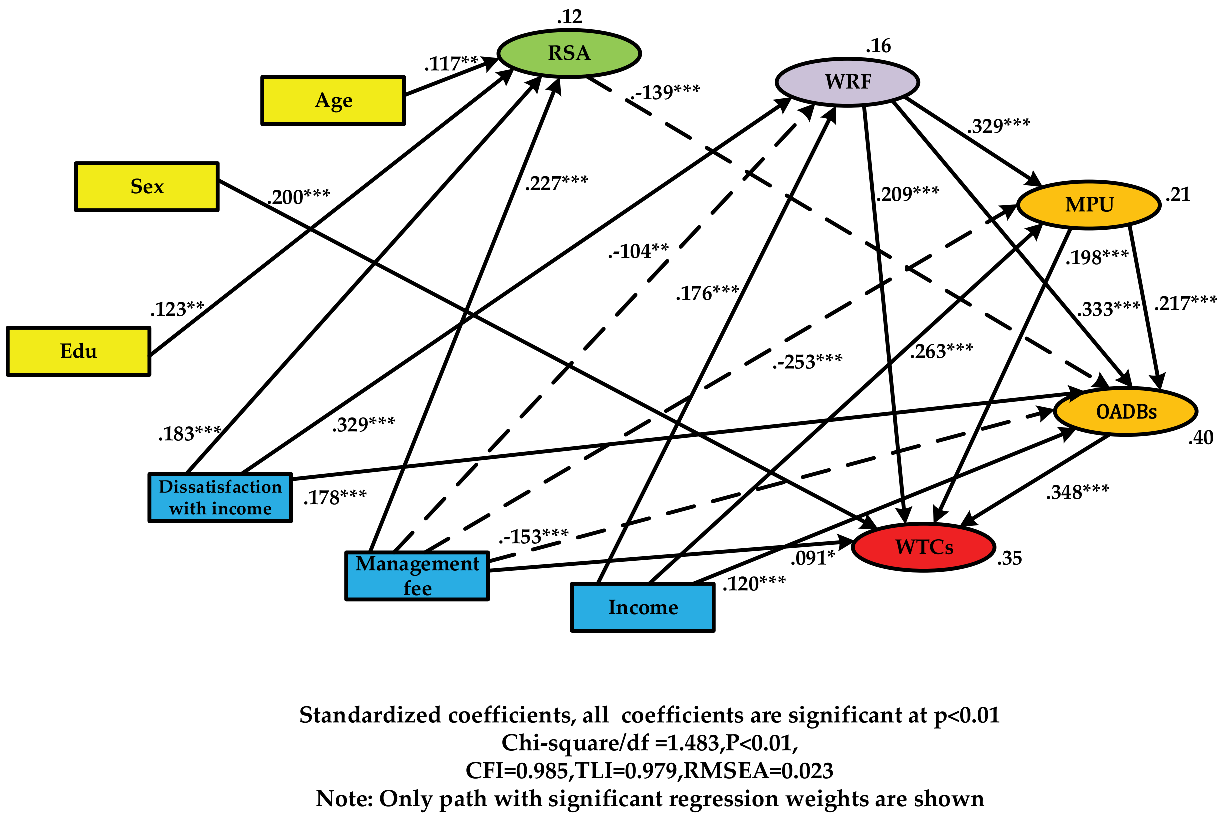

Figure 2. Graphic presentation of SEM for taxi drivers.

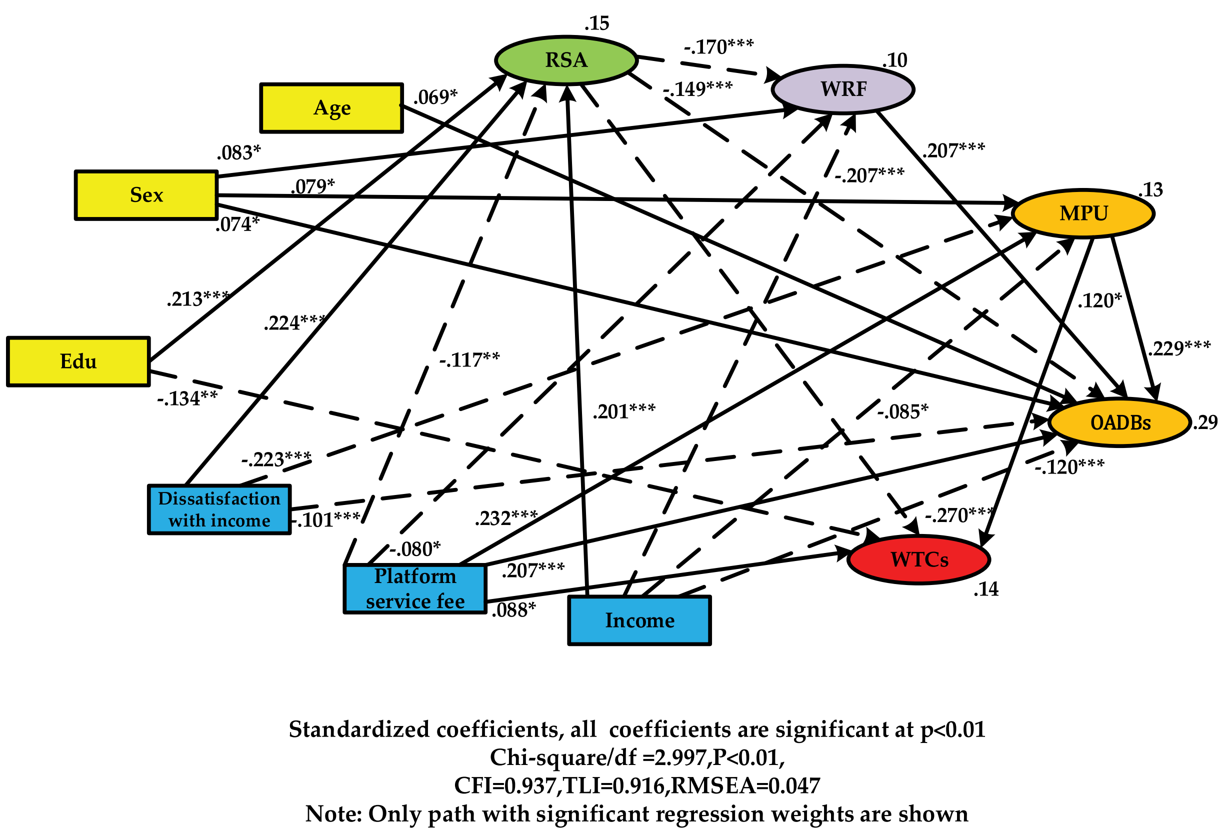

Figure 3. Graphic presentation of SEM for ride-hailing drivers.

Table 3. Estimates of the confirmatory factor analysis (CFA).

Dependent Variables		Independent Variables	Taxi drivers			Ride-hailing drivers		
			Est.	p	Cronbach's a	Est.	p	Cronbach's a
DFFD	<-	WRF	0.772	-	0.764	0.734	-	0.753
SFST	<-	WRF	0.687	***		0.680	***	
INDL	<-	WRF	0.690	***		0.694	***	
PDCR	<-	RSA	0.688	-	0.750	0.738	***	0.782
NBRA	<-	RSA	0.725	***		0.743	-	
PSRS	<-	RSA	0.714	***		0.711	***	
PNAV	<-	MPU	0.750	-	0.815	0.766	-	0.760
PCON	<-	MPU	0.776	***		0.715	***	
PAPP	<-	MPU	0.771	***		0.680	***	
SPEE	<-	OADBs	0.731	-	0.861	0.768	-	0.885
HOST	<-	OADBs	0.789	***		0.834	***	
DIST	<-	OADBs	0.735	***		0.781	***	
PECR	<-	OADBs	0.823	***		0.833	***	
PI	<-	WTCs	0.318	-	0.435	0.229	*	0.392
PDO	<-	WTCs	0.881	***		0.792	-	

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Table 4. Association between FB, WRF, RSA, ADBs and WTCs.

Dependent Variables			Independent Variables		T-D		R-D		
					Est.	P	Est.	P	Hypotheses
RSA		<-	FB	ICOM	-	-	0.201	***	
		<-		MFEE/PSFE	0.227	***	−0.117	**	
		<-		DISC	0.183	***	0.224	***	
WRF		<-	FB	ICOM	0.176	***	−0.207	***	
		<-		MFEE/PSFE	−0.104	**	−0.080	*	
		<-		DISC	0.329	***	-	-	
		<-	RSA		-	-	−0.170	***	
ADBs	MPU	<-	FB	ICOM	0.263	***	−0.085	*	
		<-		MFEE/PSFE	−00.253	***	0.232	***	
		<-		DISC	-	-	−0.223	***	
		<-	WRF		0.196	***	-	-	
	OADBs	<-	FB	ICOM	0.120	***	−0.120	***	
		<-		MFEE/PSFE	−0.153	***	0.207	***	
		<-		DISC	0.178	***	−0.101	***	
		<-	WRF		0.333	***	0.207	***	
		<-	ADBs	MPU	0.217	***	0.229	***	H7
		<-	RSA		−0.139	***	−0.149	***	
WTCs		<-	FB	MFEE/PSFE	0.091	*	0.088	*	H1
		<-	RSA		-	-	−0.270	***	H9
		<-	WRF		0.209	***	-	-	H2
		<-	ADBs	OADBs	0.348	***	-	-	H4
		<-		MPU	0.198	***	0.120	*	

Note: *** $p < 0.001$;
T-D: taxi drivers, R-D: ride-hailing drivers
-: the insignificant path is omitted when its regression weight is not significantly different from zero ($p < 0.05$).

and CMIN/DF was 1.483 and 2.997 f, respectively, indicating that the models can be accepted. For ease of interpretation, only the paths with significant regression weights are reported, showing the paths with negative regression weights as dashed lines, and those with positive regression weights as solid lines. Additionally, the latent factors confirmed by the CFA are shown in Table 3. The direct effect between observed (FB: ICOM, MFEE/PSFE, and DISC) and latent variables (WRF, RSA, ADBs: OADBs and MPU, and WTCs) are summarized in Table 4.

The results presented in Table 4 show a similar significant structure of regression weights between FB, ADBs, and WTCs. For example, the DISC and ICOM had no direct effects on the WTCs of either type of driver, but the MFEE and PSFE had evident positive direct effects on the WTCs of taxi drivers (β = 0.091) and ride-hailing drivers (β = 0.088), respectively, which partly support H1 for both groups of drivers. MPU directly increased the occurrences of WTCs among both groups of drivers (T-D: β = 0.198, R-D: β = 0.120), while OADBs were only significantly associated with WTCs among taxi drivers. This result completely supports the validity of H4 for taxi drivers but partly for ride-hailing drivers. Additionally, MPU had a significant positive effect on OADBs of both groups of drivers, which support the validity of H7.

It is worth noting that the relationship between FB and ADBs was somewhat reversed among the two types of drivers, for example, DISC was negatively related to ADBs of ride-hailing drivers but a positive relationship was observed among traditional taxi drivers (T-D: β = 0.178, R-D: β = −0.101). Increased MFEE decreased the ADBs of taxi drivers, while the PSFE had a positive effect on the ADBs of ride-hailing drivers (T-D: β = −0.153, R-D: β = 0.207).

The RSA decreased the occurrence of WTCs among ride-hailing drivers (β = −0.270; Table 4), but this suppression effect was not significant among taxi drivers, which supports the validity of H9 only for ride-hailing drivers. Compared with the significant direct effect of WRF on WTCs of taxi drivers (β = 0.209), WRF was not associated with WTCs of ride-hailing drivers. Remarkably, increasing DISC improves the RSA of both taxi and ride-hailing drivers (T-D: β = 0.183, R-D: β = 0.224).

Table 5. Mediation effect of FB, WRF, RSA and ADBs on WTCs.

Dependent Variables	Mediator Variables		Independent Variables		T-D Est.	R-D Est.	Hypotheses
WTCs	WRF		FB	ICOM	0.037	-	H3
				MFEE/PSFE	−0.022	-	
				DISC	0.069	-	
	ADBs	OADBs		ICOM	0.042	-	H5
				MFEE/PSFE	−0.053	-	
				DISC	0.062	-	
		MPU		ICOM	0.052	−0.025	
				MFEE/PSFE	−0.050	-	
				DISC	-	−0.343	
	RSA			ICOM	-	−0.054	H12
				MFEE/PSFE	-	−0.032	
				DISC	-	−0.060	
	ADBs	OADBs	WRF		0.116	-	H6
		MPU			0.068	-	
	WRF		RSA		-	-	H10
	ADBs	OADBs			−0.048	-	H11
		MPU			-	-	
		OADBs	ADBs	MPU	0.043	-	H8

Table 6. The standardized direct, indirect, and total effects between dependent and independent variables.

Dependent variables		Independent variables		T-D DE	T-D IE	T-D TE	R-D DE	R-D IE	R-D TE	Diff TE(T-R) Est.	P
WTCs	<-	FB	ICOM	−0.012	0.185	0.173	0.008	−0.046	−0.038	0.211	***
	<-		MFEE/PSFE	0.091	−0.187	−0.096	0.088	0.036	0.125	−0.221	***
	<-		DISC	−0.066	0.167	0.101	−0.043	−0.072	−0.115	0.216	***
	<-	WRF		0.209	0.169	0.378	0.01	−0.027	−0.017	0.395	***
	<-	RSA		−0.038	−0.071	−0.109	−0.27	0.013	−0.257	0.148	***
	<-	ADBs	MPU	0.198	0.075	0.273	0.12	−0.02	0.100	0.173	***
	<-		OADBs	0.348	0.000	0.348	−0.088	0.000	−0.088	0.436	***

Note: DE – direct effect; IE – indirect effect; TE – total effect;
Diff TE(T-R) – Difference of total effect (traditional taxi drivers – ride-hailing drivers)
*** $p < 0.001$.

The mediation effects of independent variables on WTCs are summarized in Table 5. The results demonstrate that WRF mediates the relationship between FB and WTCs for taxi drivers, supporting the validity of H3 for taxi drivers but not for ride-hailing drivers. Noteworthy, the heavy FB led to increased frequency of OADBs and MUP among taxi drivers, which thus boosted their WTCs, but a heavy FB only contributes to the occurrence of WTCs of ride-hailing drivers through MPU. The result completely supports the validity of H5 for taxi drivers, but only partly for ride-hailing drivers. The RSA only mediated the relationship between FB and WTCs for ride-hailing drivers, but not for taxi drivers, as the RSA failed to prevent WTCs for taxi drivers. This result supports the validity of H12 for ride-hailing drivers.

As shown in Table 5, both OADBs (β = 0.116) and MPU (β = 0.068) mediated the association between WRF and WTCs for taxi drivers, which confirms the validity of H6. Furthermore, the RSA decreased the frequency of occurrence of OADBs among taxi drivers, which indirectly reduces the occurrence of WTCs among them (β = −0.048). This result partly supports H11 for taxi drivers. Given that OADBs did not contribute to the WTCs of ride-hailing drivers, The results only corroborate H8 for taxi drivers (β = 0.043). H10 was invalid for both types of drivers.

The direct, indirect, and total effects of independent variables on WTCs are summarized in Table 6. Remarkably, it was found that there was an opposite total effect of FB on the WTCs of the two types of the driver (*e.g.*, DISC, T-D: 0.101 *vs*. R-D: −0.115; Diff TE, 0.216; Table 6). Compared with ride-hailing drivers, taxi drivers were more prone to WTCs due to WRF (TE, T-D: 0.378 *vs*. R-D: −0.017; Diff TE 0.395) and ADBs. RSA had a stronger disincentive effect on WTCs for ride-hailing drivers than for taxi drivers (TE, T-D: −0.109 *vs*. R-D: −0.257; Diff TE, 0.148).

Discussion

Using data from an online survey conducted in Changchun, China, this study investigated the structural interrelationships between FB, WRF, RSA, ADBs, and WTCs among traditional taxi and full-time ride-hailing drivers. Relevant results demonstrated that there was a significant difference in the work status between taxi and ride-hailing drivers, which contributed to the various effects of the above human factors on WTCs.

Financial burden and work-related fatigue

This study found that there are significant differences in the associations between FB and WTCs for taxi and ride-hailing drivers. The results indicated that dissatisfaction with income significantly increases WRF among taxi drivers (β = 0.183), and furthermore, increased income levels resulted in stronger feelings of work fatigue (β = 0.176). This is consistent with the finding by Wang, Li, and Prato (2019), that income dissatisfaction is positively correlated with the degree of perceived fatigue while driving. The higher number of working days in a week and the increased duration of the working day further exacerbated WRF among Chinese taxi drivers. Similar findings by Peng, Wang, and Luo (2020) also support the notion that a major contributing factor to WTCs is income dissatisfaction. Therefore, it is possible to infer, to some extent, that the FB did cause taxi drivers to work longer shifts in exchange for higher remuneration, exposing them to relatively exhausting working conditions and resulting in crashes either directly or indirectly through the mediating effects of ADBs.

It is worth noting that the FB relieved the WRF of ride-hailing drivers, which is the opposite of the situation of traditional taxi drivers. On the one hand, the online management platform would force drivers who pick up passengers online for an extended period of time (up to 4 hours) to go offline, making it possible to get sufficient rest. On the other hand, WRF, as shown in Figure 3, induced dangerous driving behavior among ride-hailing drivers, and frequent complaints from passengers resulted in high fines to be paid to the platform (Platform service fee → OADBs: $\beta = 0.207$; Figure 3), and the passenger supervision mechanism of the online platform effectively reduced their aggressive driving behaviors, part of which is due to driving fatigue. Therefore, the issue of WRF for ride-hailing drivers was further mitigated (Platform service fee → WRF: $\beta = -0.080$, in Figure 3).

The above findings are in line with a study by Mao et al. 2021), which reported that ride-hailing drivers choose to control their driving behavior and enhance the travel comfort and experience of the passengers in exchange for a higher rating (Mao et al., 2020). A higher rating brings more bonus shares as well as the dispatch priority of the platform, which indirectly increases their income. This explains the negative effect of income on WRF, as well as the milder fatigue perception of ride-hailing drivers compared to taxi drivers. This result is contrary to the finding by Mao et al (2021), that ride-hailing drivers face severe driving fatigue problems. A possible explanation for this inconsistency of their conclusions is that part-time ride-hailing drivers account for a major proportion of the drivers in the study by Barrios et al., and the fatigue caused by primary jobs is the main source of their driving fatigue.

Aberrant driving behaviors

Significant differences were found in the driving behaviors of the two groups of drivers. As mentioned above, the mechanism of rating by passengers and dispatching orders by ride-hailing platforms enables ride-hailing drivers to be more proactive in controlling their ADBs. Thus, the frequency of their other ADBs, other than MPU, was significantly lower, compared to taxi drivers.

There is a plausible explanation for the negative effect of the dissatisfaction of ride-hailing drivers with income on aggressive driving behaviors. Quality travel services would earn high ratings from passengers and better priority in dispatching orders, which further contributes to increased revenue and reduction in income dissatisfaction. In contrast to taxi drivers who mindlessly work longer hours and drive more dangerously in order to pick up more passengers in exchange for compensation (Li et al. 2019), the reward and punishment mechanism of ride-hailing online platforms with autonomous control functions allows for increasing the income of professional drivers in a way which is safer for road travel.

The current research confirms that management fees reduce ADBs among taxi drivers. This FB compels taxi drivers to reduce ADBs to avoid additional repair expenses caused by road crashes, thus preventing economic losses (Shi, Hussain, and Peng 2022). In contrast to traditional taxi drivers, platform service fees paid by ride-hailing drivers were positively dependent on the frequency of their ADBs. Different from the monthly management fee that taxi drivers pay to obtain the license to operate the taxi cab, the platform service fee is derived from a portion of each order and the corresponding penalties for passenger surveillance complaints. The high platform service fees of ride-hailing drivers are due to a large order volume, as well as frequent complaints from passengers. Ride-hailing platforms precisely use the leverage between 'income dissatisfaction' and 'platform service fees' to control the driving behaviors of drivers.

This study revealed that MPU has a significant effect on the occurrence of OADBs and road crashes among both groups of drivers and road crashes, which is consistent with the study by Peng, Wang, and Luo (2020), which also found a significant effect of cell phone use on the occurrence of traffic accidents involving taxi drivers. Additionally, our study found differences in MPU between the two groups of drivers. Ride-hailing drivers receive assignments through the platform, get in touch with passengers by mobile phone, and follow the mobile phone-based navigation system to pick up passengers and transport them to their destinations, requiring them to use their phones more frequently than taxi drivers. This finding is also consistent with a previous study by Truong and Nguyen (2019).

Road safety attitude

This study revealed that there are differences in RSAs between the two types of drivers, and positive RSAs decrease the occurrence of ADBs. Similar findings have also been reported in previous studies, which showed that positive evaluation of traffic rules resulted in fewer self-reported driving lapses and errors by bus drivers (Mallia et al. 2015). Ride-hailing drivers work in a more market-oriented and competitive environment, which enables them to be better supervised by passengers and indirectly raise their earnings by enhancing their safety awareness and ensuring the travel comfort and security of passengers. In addition, our study showed that the RSAs of ride-hailing drivers are more positive, and have a stronger disincentive effect on their ADBs than those of taxi drivers. The disincentive effect of the RSAs of taxi drivers on crashes is realized in an indirect way (RSA → OADBs → WTCs) compared to that of ride-hailing drivers.

Whether in an indirect (T-D: RSA → OADBs → WTCs, $\beta = -0.048$) or direct (R-D: RSA → WTCs, $\beta = -0.270$) way, the improvement of the RSAs of both types of drivers effectively reduced the occurrence of WTCs, thereby reducing the high economic losses and economic pressure. Specifically, as their income dissatisfaction increased, they would improve their own safety attitude (Platform service fee → RSA: $\beta = 0.183$, in Figure 2; $\beta = 0.224$, in Figure 3), in order to reduce the cost of vehicle maintenance and compensation due to crashes, through which they could relieve part of the FB. This explains the positive association between income dissatisfaction and RSAs found in this study.

As mentioned above, the monthly management fee for taxi drivers represented a severe FB, which led them to improve their own RSAs and reduce the economic loss caused by road crashes to relieve economic pressure. Poor RSA and frequent aggressive driving behaviors resulted in more complaints as well as higher platform service fees. The above analysis explains the opposite relationship between the management fees paid by taxi drivers, the platform service fees paid by ride-hailing drivers, and RSAs.

Improvement measures and suggestions

Considering the identified differences in this study, countermeasures should be tailored to each group of drivers. This study revealed that taxi drivers suffer from more heavy WRF due to their FB, while inferior road safety and more frequent ADBs predispose them to be more frequently involved in WTCs than ride-hailing drivers. In view of these findings on the relationship between the FB of taxi drivers, ADBs, and WTCs, the following recommendations are made:

(1) Intelligent passenger pick-up modes are feasible solutions to alleviate the FB by reducing the fuel consumption associated with their idling on the road in search of passengers. Since the high management fee is a major source of their FB while effectively discouraging ADBs, reducing these costs within a reasonable range, without jeopardizing their positive role in road safety, is an effective way to ease the financial pressure on taxi drivers. (2) The development of more reasonable scheduling or a mandatory monthly break schedule (Wang et al. 2014; Wang, Li, and Prato 2019) is a feasible measure to address the problem of WRF among taxi drivers. (3) The solution to the issue of ADBs is road safety education for taxi drivers. Meanwhile, the regulation of ADBs of taxi drivers could be addressed by referring to the passenger rating mechanism of the ride-hailing industry.

Regarding ride-hailing drivers, the fact that mobile phones are more frequently used while driving is a potential contributor to their involvement in crashes. (1) Reasonable regulations on the use of mobile phones while driving are feasible solutions to their involvement in road crashes. Moreover, ride-hailing companies should provide complete specifications and tutorials about phone usage, specifying when, where, and how drivers use their phones in the course of providing their service.

This study confirmed the effect of platform service fees and income dissatisfaction on improving RSAs and aggressive driving behaviors of ride-hailing drivers, thus curbing road crashes. Indispensable passenger supervision has been shown to be a valid approach to ensuring the road safety of ride-hailing drivers. Therefore, (2) more rationalization of the passenger supervision system is the basis to ensure that its own advantages are brought into play. (3) The essential driving skill training is a prerequisite for ride-hailing drivers to officially start transporting passengers, as they might not be professional drivers (Shi, Hussain, and Peng 2022) or even novice drivers, and have deficiencies in driving skills. As a new product of China's urban public transportation, there are various security issues that need to be resolved in the process of its development.

Conclusion and limitations

In summary, this study adds knowledge to the literature by providing insights into human factors (including FB, WRF, RSA, and ADBs) contributing to road traffic crashes involving full-time ride-hailing and traditional taxi drivers. Mann-Whitney U tests and SEM were used to evaluate the similarities and differences between the two types of drivers in terms of human factors resulting in their WTCs.

Relevant results indicated that both types of drivers are under heavy FB. Ride-hailing drivers choose to control their ADBs to gain higher ratings from customers and assign priority to the platform in exchange for higher remuneration. Instead, taxi drivers adopt a different way of working, they deliver passengers to their destinations as fast as possible for more fares, which contributes to their stronger perception of WRF, higher frequency of ADBs, inferior RSA, and higher road traffic crashes rates than ride-hailing drivers. The higher frequency of MPU among ride-hailing drivers is a potential contributor to their involvement in traffic crashes.

This study is not free of limitations. First, the self-reported data used in this study have its own credit limits, it is susceptible to social desirability bias, which would influence the precision of the results. Second, passenger interference is a significant contribution to traffic crashes of ride-hailing drivers but was not thoroughly examined in this study. Third, the present study is a comparison of full-time ride-hailing *versus* traditional taxi drivers, and a high proportion of ride-hailing drivers only work part-time in this job. We recommend an in-depth comparative analysis of taxi, full-time and part-time ride-hailing drivers.

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