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Risky behaviours associated with traffic crashes among app-based motorcycle taxi drivers in Vietnam

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ABSTRACT

Motorcycle taxi services provide an important mobility option for people in developing countries. With the emergence of new transport technologies, app-based motorcycle taxi services have become increasingly popular in recent years. However, little is known about risky driving behaviours and their association with traffic crashes among app-based motorcycle taxi drivers. Through a survey of 602 app-based motorcycle taxi drivers from three cities in Vietnam, this research aimed to investigate the incidence of risky driving behaviours and their association with driver characteristics and traffic crashes. Using a mobile phone while driving was found to be the most common risky driving behaviour (52%) among app-based motorcycle taxi drivers, followed by neglecting to use turn signals (31%), encroaching car lanes (25%), exceeding the speed limit (21%), running red lights (19%) and carrying more than one passenger (17%). In addition, drivers who were students, or those who worked more than 50 h per week, were found to be more likely to engage in risky driving behaviours. Binary logistic regression modelling showed that neglecting to use turn signals, carrying more than one passenger and smoking while driving was significantly associated with self-reported active crash/fall involvement. Turn signal neglect was also associated with active injury crash/fall involvement. The incidence of risky driving behaviours and associated crash involvement was found to be lower among app-based motorcycle taxi drivers compared with regular motorcyclists, yet the findings still highlight the need for ride-hailing firms to deliver improved education and road safety training for their drivers.

1. Introduction

Each year, around 1.35 million people lose their lives due to traffic crashes, with more than 90% located in low and middle-income countries (WHO, 2018). In developing countries, traffic crashes impose a large burden on the economy, cost-

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ing countries around 3% of their Gross Domestic Product (GDP). In Vietnam, motorcycles are the dominant transport mode comprising 95% of vehicle fleet, the highest rate of motorcycle ownership per capita in Southeast Asia. This transport mode contributes to a high proportion of traffic collisions at around 60% of all road traffic crashes (WHO, 2015). During 2016 alone, over 21,000 road traffic crashes occurred in Vietnam, resulting in more than 8400 fatalities and 19,000 injuries (United Nations, 2018).

In developing countries, motorcycle taxis provide a common form of public transport as they offer a flexible, reliable and low-cost form of mobility (Akinlade & Brieger, 2003; Lan, Liem, & Binh, 2013; Sopranzetti, 2012; Tuan & Mateo-Babiano, 2013). Traditional motorcycle taxis in Vietnam are commonly described as services provided by motorcycle drivers to carry passengers from their origins to required destinations based on negotiated fares between drivers and passengers. According to the Vietnamese National Law on Road Traffic (The Vietnamese National Assembly, 2008), those from 18 years of age are eligible to attend an examination for a driver license. All motorcycle taxi drivers must hold a full motorcycle driver license in addition to a legal registered vehicle when transporting passengers. Mandatory helmet regulation also applies to both drivers and pillion passengers since 2007 (Olson et al., 2016). Drivers are permitted to carry no more than one pillion passenger with some special exemptions such as emergency conditions or carrying children under 14 years of age. To facilitate transport safety, motorcycle riders are required to obey road traffic rules such as riding on the right side of the road, travelling in prescribed lanes for motorcycles where available (motorcycles are not permitted to travel in car-only lanes) and using turn signals when making a turn at intersections.

Combined with the rise in information technologies, app-based motorcycle taxi services, which use online-enabled platforms to allow customers to book a ride from the nearest motorcycle taxi registered with a ride-hailing firm, have recently been introduced in developing countries (Nguyen-Phuoc, Nguyen, De Gruyter, Su, & Nguyen, 2019; Nguyen-Phuoc, Nguyen, De Gruyter, Vo, & Le, 2019). Grab was the first firm to launch an app-based motorcycle taxi service in Vietnam, called GrabBike, in 2014 (Roscher, 2018). The number of GrabBike drivers has increased considerably from around 100 drivers in 2014 to more than 50,000 drivers in 2018. The GrabBike app has been downloaded from over 100 million mobile devices across 7 countries and 142 cities in Southeast Asia (Grab, 2018). With significant increases in demand, other online ride-hailing firms have joined the app-based motorcycle taxi market in Vietnam such as GoViet, Aber, Be and Vato. The expansion of such ride-hailing services in Vietnam is providing direct competition to traditional motorcycle taxi services (non-app-based services) (Su, Nguyen-Phuoc, & Johnson, 2019).

Risky driving behaviours among regular motorcyclists have been investigated in a number of studies in which driving without a helmet, mobile phone use while driving, drink-driving and speeding have been widely discussed among scholars (Adogu, Ilika, & Asuzu, 2009; Hung, Stevenson, & Ivers, 2006; Pérez-Núñez et al., 2014). Compared to regular motorcyclists, motorcycle taxi drivers are considered to have higher exposure to traffic crashes as they tend to ride more frequently on roads (Prak, Kong, & Khoung, 2012; Wolfe, 1982). Previous research has shown that traditional motorcycle taxi drivers, who are not regulated and licensed by governments in most developing countries, have poorer road safety outcomes (Wu & Loo, 2016). In Ghana, more than 50% of motorcycle taxi drivers have been found to be involved in traffic crashes (Agyekum-Boamah, 2012). The incidence of traffic crashes among motorcycle taxi drivers in north eastern Brazil has been found to be higher with 79% of drivers involved in a traffic crash over a 12-month period (Barbosa et al., 2014). In Moshi, Tanzania, in a survey of 300 motorcycle taxi drivers, 148 drivers (49.3%) had experienced a crash and 77.0% of them sustained at least one injury (Nguyen et al., 2016). One of the key causes of traffic crashes are risky driving behaviours (Tuan & Mateo-Babiano, 2013). According to Adisa (2010), riding a motorcycle under the influence of alcohol and/or drugs is a frequent occurrence among rural motorcycle taxi drivers in Nigeria, with around 40% of drivers using 1–3 types of intoxicants at least once a day. Another study conducted by Mwakapasa (2011) found that approximately 68% of commercial motorcyclists in Tanzania reported to not wearing a helmet consistently. Unsafe driving behaviours have been found to be associated with lower education levels and a lack of road safety training (Oginni, Ugboko, & Adewole, 2007).

While previous research has explored risky driving behaviours among conventional motorcycle taxi drivers, no study has investigated these behaviours and their associations with traffic crashes among app-based motorcycle taxi drivers. Unlike conventional motorcycle taxi drivers, app-based motorcycle taxi drivers must participate in safety training organised by ride-hailing firms before commencing employment. A better understanding of risky driving behaviours among app-based motorcycle taxi drivers can help authorities and ride-hailing firms to develop policies that aim to reduce crash risks for drivers as well as their passengers. Through a survey of app-based motorcycle taxi drivers, this paper aims to investigate the incidence of risky driving behaviours among drivers and understand driver characteristics which affect these behaviours. Risky driving behaviours that are significantly associated with traffic crashes are also investigated in this research.

This study is a part of a wider project related to risky riding behaviours and road traffic crash involvement among app-based taxi drivers. A previous published study from this project demonstrated the prevalence and underlying factors associated with reported road traffic crashes among surveyed drivers (Nguyen-Phuoc, Nguyen, et al., 2019). Further investigation into the incidence of risky driving behaviours and their association with active traffic crashes is the main focus of this present study. This paper is structured as follows. A description of the research methodology including the survey design, data collection and analysis techniques is presented in Section 2. Section 3 details the results of the survey using descriptive statistics and binary logistic regression. The paper concludes with a discussion of the implications for practice and areas for further research in Section 4.

2. Methodology

2.1. Data collection

Data for this study was collected in the three largest cities in Vietnam (Hanoi, Ho Chi Minh and Da Nang) where GrabBike services are most widespread to date. Data was collected from a combination of field surveys and an online survey during May and June 2018. It is noted that research ethics approval for conducting a survey is not required in Vietnam. However, to minimise any potential risks to surveyed drivers, all relevant information about the survey was fully explained to respondents, including the survey aim and objectives, as well as their rights to be part of this research. Drivers were also notified that their participation in the survey was completely voluntary.

The survey questionnaire was designed to collect information from app-based motorcycle taxi drivers on their (1) socio-demographics (e.g. age, gender, employment status, level of education), (2) average daily travel time and distance, (3) frequency of undertaking risking driving behaviours (measured on a 5-point Likert scale from never = 1 to regularly = 5), and (4) self-reported road traffic crashes or falls over the last 12 months, including the number of crashes/falls, the level of injury of the most serious crash/fall, reasons for crashing/falling, location/s and road conditions. A pilot test of the survey was conducted with more than 40 students in the Faculty of Civil Engineering in Danang University. The minimum expected time to complete the survey was approximately 10 min. Comments of the participants undertaking the pilot survey were cautiously considered and facilitated to finalise the survey questions.

For the field surveys, a total of seven survey teams were formed comprising undergraduate students located in the three cities. Each team included two surveyors who underwent detailed training on how to administer the survey, in addition to covering the aims and objectives of the study. Survey sites were selected based on locations where app-based motorcycle taxi drivers frequently gather to pick up/drop off passengers such as airports, universities, shopping centres, bus and railway stations. To facilitate the searching process for app-based motorcycle taxi drivers, an online ride-hailing app was used to localise driver positions. At these locations, the paper questionnaires were distributed to all drivers who were easily identified with a ride-hailing firm logo on their clothes and helmets. In order to minimise potential selection bias, the surveyors were required to conduct the survey in multiple places, in different time periods (day and night) and on both weekdays and weekends. As the survey related to traffic crashes, some app-based motorcycle taxi riders were initially hesitant to take part. In these cases (as previously noted), the surveyors clearly explained the aims of the study and highlighted that the survey was confidential and that their responses would be anonymous. There were some cases where drivers agreed to participate in the survey but could not complete it as they received requests from customers. These cases were invalid and therefore excluded from the data analysis. Upon completion of the survey, a prepaid mobile phone card to the value of 20,000 Vietnamese Dong (approximately USD$1) was given to drivers to thank them for their participation. After four weeks of data collection during May 2018, a total of 462 app-based motorcycle taxi riders had completed the field survey in Hanoi (189 responses), Da Nang (178 responses) and Ho Chi Minh (95 responses). The response rate to the survey was estimated to be around 70%, based on information recorded by the surveyors on the number of drivers who declined to participate in the survey.

In order to increase the number of respondents, data was also collected using an online survey that was posted on social networking sites of app-based motorcycle taxi drivers in the three cities. Two screening questions were used to target those who had been an app-based motorcycle taxi driver for more than 12 months: 'Are you an app-based motorcycle driver?' and 'How long have you worked for a ride-hailing firm'. As there was only one field survey team in Ho Chi Minh, the number of field survey respondents was much lower in this city than Hanoi and Da Nang. Hence, the surveyors also sent private messages to each member of the Ho Chi Minh app-based motorcycle taxi rider Facebook group to boost survey participation so that an approximately equal number of total survey responses could be achieved in each of three cities. From May to June 2018, a total of 177 web-based respondents completed the survey in Hanoi (23 respondents), Da Nang (33 respondents) and Ho Chi Minh (121 respondents).

Both the field surveys and online survey resulted in 639 completed questionnaires from drivers comprising 177 web-based respondents and 462 field-based respondents. After discarding questionnaires with no meaningful value on any of the key outcome variables, a total of 602 valid responses including 172 web-based (97.2%) and 430 field-based (93.1%) formed the basis for the analysis, as detailed in Table 1. A similar number of total survey responses was achieved in each city: 193 in Hanoi, 198 in Da Nang, and 211 in Ho Chi Minh City.

2.2. Data analysis

The 602 valid survey responses were firstly transferred from the survey forms to SPSS. Two methods were then used to analyse the data, including descriptive statistics and binary logistic regression. The former calculated the incidence of road traffic crashes with 95% confidence intervals while the latter determined factors associated with road traffic crashes. Socio-demographic variables such as age and education level were used to classify the calculated incidence of traffic crashes. Since the app-based firms do not publish information about their employees, it was not possible to assess the representativeness of the sample. However, it is noted that data was collected in the three largest cities in Vietnam (Hanoi, Ho Chi Minh and Da Nang) where GrabBike services are most widespread to date.

Table 1
Number of respondents by data collection method in each city.

City	Data collection method	Number of respondents
Hanoi	Online survey	20
	Field survey	173
Da Nang	Online survey	32
	Field survey	166
Ho Chi Minh	Online survey	120
	Field survey	91
Total		602

Binary logistic regression analysis has been used to test the significance of traffic crash risk factors previously (Chen, Cao, & Logan, 2012; Nguyen-Phuoc, Nguyen, et al., 2019; Yan, Radwan, & Abdel-Aty, 2005). Since in this research, the main purpose is to determine significant independent variables and their effects correctly, multicollinearity can be a problem (Tay, 2017). Therefore, before undertaking the binary logistic regression, correlations between variables were checked. If the Pearson correlation coefficients indicated a high level of correlation ($r > 0.70$), only one variable from each pair was selected for the model.

The incidence of traffic crashes among app-based taxi drivers, which was explored in this study, was then compared to what is known regarding traditional taxi drivers in similar traffic contexts.

3. Results

3.1. Descriptive statistics

Around 30% of respondents reported that they had been involved in at least one crash/fall during the last 12 months by driving. If a driver experienced more than one crash during the past year, they are asked to report the most serious crash. Of these, 21.9% (40 respondents) said that they were hit by other road users (passive crash) while 78.1% (143 respondents) reported that their unsafe driving behaviour was the major cause (active crash). Approximately 20% of respondents who experienced an active crash indicated that they were involved in at least one injury crash that resulted in injuries for them or their passengers (Fig. 1).

Fig. 2 provides additional descriptive statistics about the sample, including active crash incidence among drivers. Of the 602 survey respondents, 494 (82.1%) were aged 30 years old or less and 571 (94.9%) were male. As there was a significant imbalance between males and females (with only 31 female drivers), gender was excluded from the analysis. Most surveyed drivers were migrants who were born and grew up in other cities but came to the surveyed cities for studying or doing business (over 80%), around half were students[1] (46.8%), and most were employed as app-based motorcycle taxi drivers on a part-time basis (79.2%). In this survey, a full-time driver was defined as someone who was not a student and worked as an app-based motorcycle taxi driver at least 8 h each weekday.

Higher incidence of active crashes (those caused by the respondent's own driving behaviour) was reported by older drivers (more than 30 years old) at 47.2%, compared to 18.6% for younger drivers. Higher active crash incidence was also reported by drivers who were not students (34.4% vs. 11.7% for non-students) and those with a lower education level (26.1% vs. 13.1% for those with an education level greater than high school). As expected, due to less time spent driving, part-time app-based motorcycle taxi drivers were found to have a lower reported incidence of crashes (19.9%) than full-time drivers (38.4%). Similarly, drivers who worked less than 50 h per week reported a lower crash incidence (19.1%) than those working at least 50 h per week (33.3%).

Table 2 and Fig. 3 indicate the incidence of risky driving behaviours among app-based motorcycle taxi drivers by frequency. Using a mobile phone while driving was found to be the most common behaviour with more than half of all respondents (52.0%) reporting to have engaged in this behaviour. Around one in five respondents (21.6%) indicated that they use a mobile phone while driving a few times a day. Other risky driving behaviours included neglecting to use turn signals (31.1%), encroaching car lanes[2] (24.9%), exceeding speed limits (20.9%), running red lights (19.4%) and carrying more than one passenger (17.3%). Incidence of smoking while driving, driving without a helmet and recklessly overtaking was lower at 12.6%, 11.1% and 9.1% respectively. Approximately 7.6% of drivers indicated that they had engaged in drink driving, with very few (0.7%) doing so on a regular basis (few times a day).

3.2. Logistic regression modelling

No large correlations were found among each pair of variables ($r < 0.7$) so all variables were used in the model (Table A1). Table 3 presents the results of logistic regression modelling for risky driving behaviours classified by socio-demographics

[1] "Student" in this study is defined as a full-time university or college student who are undertaking a higher education program at a university or a college.
[2] "Car lane" is defined as a road lane that only cars are permitted to use.

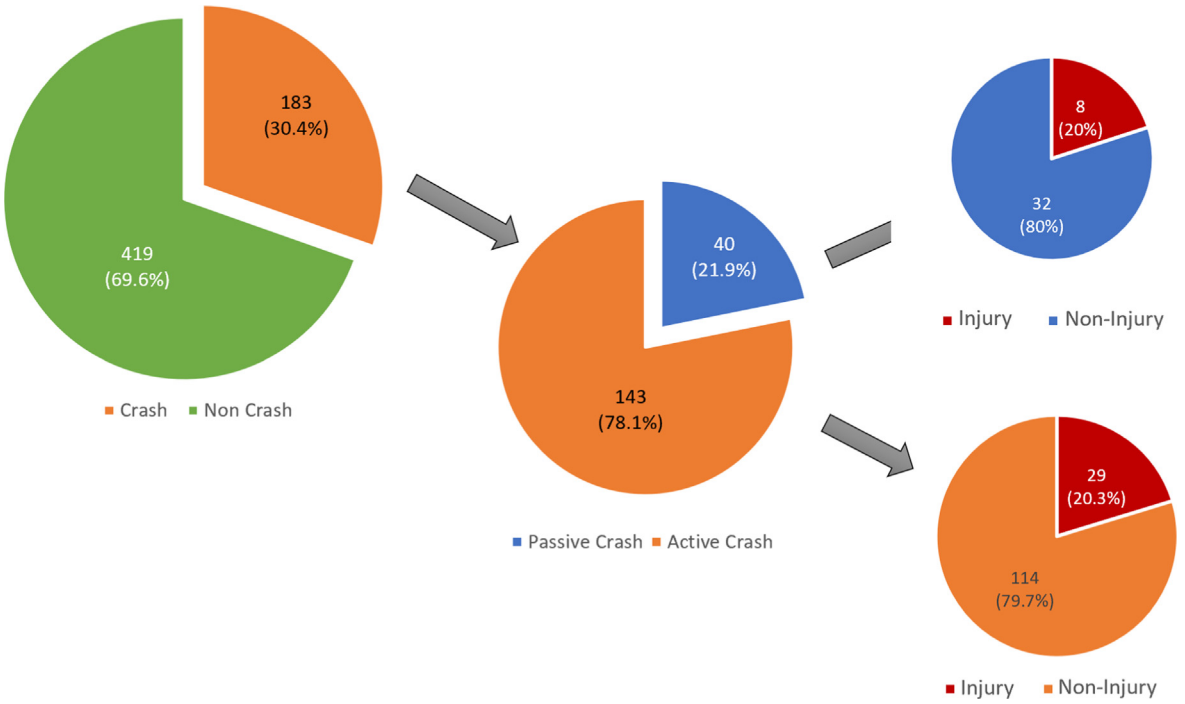

Fig. 1. Self-reported involvement in road traffic crashes among app-based motorcycle taxi drivers. *Note:* Passive Crash = caused by another drivers' behaviour (hit by another road user/s) Active Crash = caused by own drivers' behaviour.

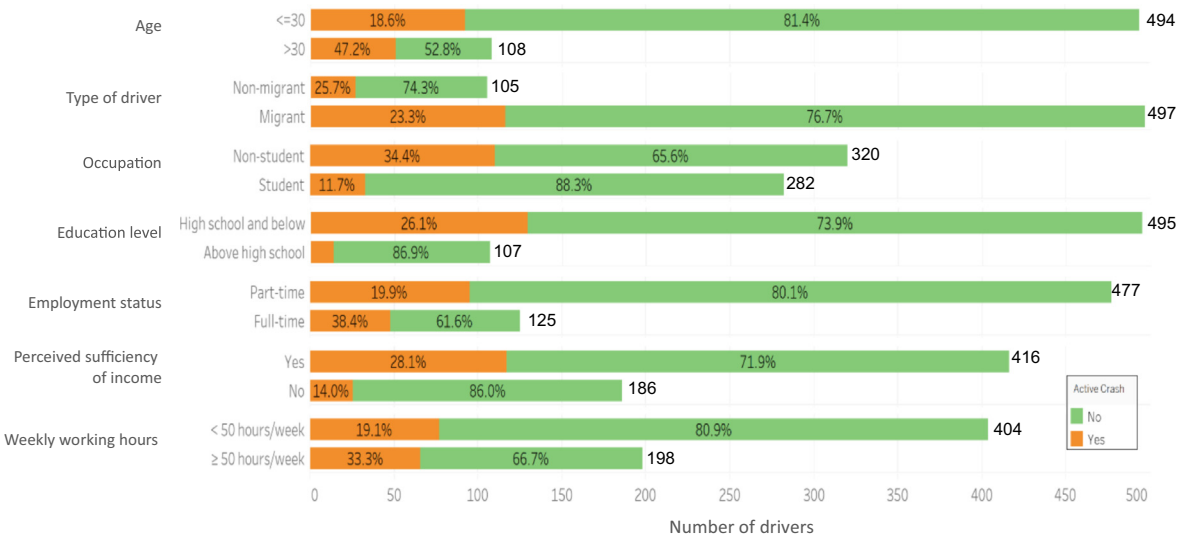

Fig. 2. Characteristics of app-based motorcycle taxi drivers.

and the working history of app-based motorcycle taxi drivers. This shows that drivers who are students are more likely to encroach into car lanes (Adj. OR = 2.165, $p < 0.01$), exceed speed limits (Adj. OR = 2.606, $p < 0.001$), run red lights (Adj. OR = 2.349, $p < 0.01$), recklessly overtake other vehicles (Adj. OR = 3.383, $p < 0.01$) and drive under the influence of alcohol (Adj. OR = 4.874, $p < 0.01$). Those who perceived their income to be sufficient from driving an app-based motorcycle taxi were less likely to engage in a number of risky behaviours such as encroaching into car lanes (Adj. OR = 0.447, $p < 0.001$), exceeding the speed limit (Adj. OR = 0.487, $p < 0.001$), red-light running (Adj. OR = 0.529, $p < 0.01$) and drink driving (Adj. OR = 0.378, $p < 0.01$). Working hours were found to be a key influence that was positively associated with most risky

Table 2
Incidence of risky driving behaviours by frequency.

Risky driving behaviour	Regularly (few times a day)		Often (few times a week)		Sometimes (few times a month)		Seldom (few times a year)		Never	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Mobile phone use	21.6	18.3–24.9	7.0	4.9–9.0	9.8	7.4–12.2	13.6	10.9–16.4	48.0	44.0–52.0
Turn signal neglect	4.0	2.4–5.5	6.3	4.4–8.3	7.6	5.5–9.8	13.1	10.4–15.8	68.9	65.2–72.6
Encroach car lanes	4.7	3.0–6.3	4.0	2.4–5.5	4.7	3.0–6.3	11.6	9.1–14.4	75.1	71.6–78.5
Exceed speed limit	4.2	2.6–5.7	3.3	1.9–4.8	6.5	4.5–8.4	7.0	4.9–9.0	79.1	75.8–82.3
Red-light running	2.8	1.6–4.4	3.0	1.6–4.4	6.3	4.4–8.3	7.3	6.1–8.2	80.6	74.8–81.4
Carry more than one passenger	1.2	0.3–2.0	1.3	0.4–2.2	5.1	3.4–6.9	9.6	7.3–12.0	82.7	79.7–85.7
Smoke while driving	2.2	1.0–3.3	1.0	0.2–1.8	2.0	0.9–3.1	7.5	5.4–9.6	87.4	84.7–90.0
No helmet	3.0	1.6–4.4	1.5	0.5–2.5	2.0	0.9–3.1	4.7	3.0–6.3	88.9	86.4–91.4
Reckless overtaking	1.5	0.5–2.5	2.0	0.9–3.1	2.0	0.9–3.1	3.7	2.2–5.2	90.9	88.6–93.2
Drink driving	0.7	0.0–1.3	0.8	0.1–1.6	2.2	1.0–3.3	4.0	2.4–5.5	92.4	90.2–94.5

Note: CI = Confidence Interval.

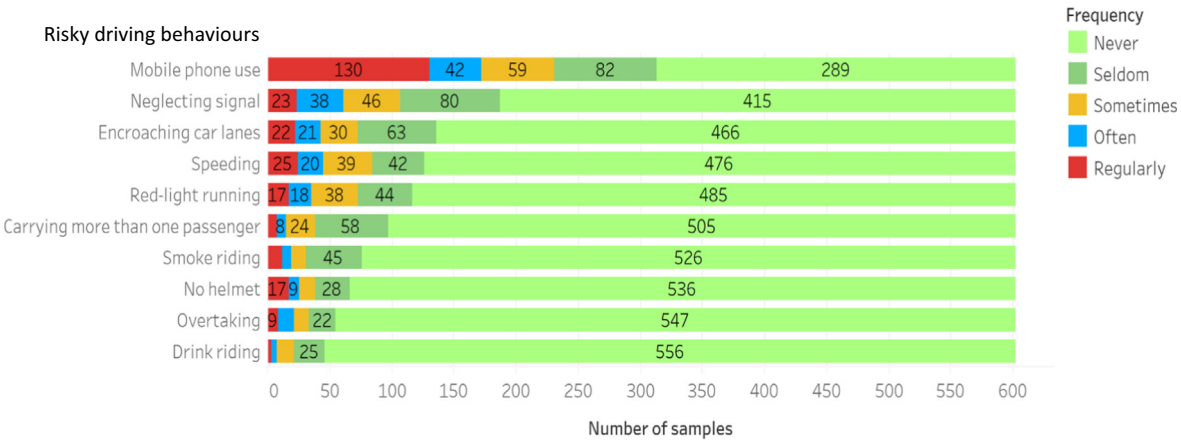

Fig. 3. Number of drivers engaging in risky driving behaviours by frequency.

driving behaviours (all except smoking while driving and drink-driving). Drivers who worked more than 50 h per week were more likely to engage in most risky driving behaviours with adjusted odds ratios ranging from 1.636 to 5.777.

A binary logistic regression model was also developed to understand the impact of the frequency of each risky behaviour on active crash/fall involvement. Before undertaking the regression, correlations between each risky driving behaviour was checked. No large correlations were found among each pair of risky driving behaviours ($r < 0.7$) so all behaviours were included in the model.

Table 4 shows that turn signal neglect, carrying more than one passenger and smoking while driving was significantly associated with active crash/fall involvement (Adj. OR = 1.411, 2.562 and 3.636 respectively, $p < 0.001$). Of those, smoking while driving had the highest odd ratio which showed that drivers engaging in this risky driving behaviour were more likely to be involved in an active crash/fall. However, and somewhat surprisingly, app-based motorcycle taxi drivers who frequently encroached car lanes were less likely to be involved in active crashes/falls (Adj. OR = 0.522, $p < 0.001$).

Table 5 shows the results of binary logistic regression for active injury crash/fall involvement. Only one risky behaviour was found to be significantly associated with active injury crash/fall involvement: turn signal neglect (Adj. OR = 1.903, $p < 0.001$). Therefore, drivers who frequently neglected to use signals while turning were more likely to be involved in injury crashes.

4. Discussion and conclusion

This paper has examined the association between risky driving behaviours and the characteristics of app-based motorcycle taxi drivers. This paper has also contributed to the literature through providing an understanding of risky driving behaviours that are associated with road traffic crashes/falls. Results show that around 30% of app-based motorcycle taxi drivers reported to have been involved in at least one crash/fall during last 12 months. Of these, almost 80% indicated that their own risky driving behaviours were the main cause. Self-reported crash rates from this study are considerably lower than those

Table 3
Logistic regression results (adjusted odds ratio) for risky driving behaviours.

Variable	Mobile phone use	Turn signal neglect	Encroach into car lanes	Exceed speed limit	Red-light running	Carry more than one passenger	Smoke while driving	No helmet	Reckless over-taking	Drink driving
Intercept	1.045	0.429*	0.259***	0.305**	0.266***	0.131***	0.087***	0.127***	0.057***	0.048***
Socio-demographics										
Age										
≤30 years old	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
>30 years old	1.331	1.566	1.133	0.973	0.570	0.832	1.431	0.112**	0.724	1.719
Type of driver										
Non-migrant	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Migrant	0.824	0.875	0.610	0.632	0.572*	0.823	1.920	0.723	0.538	0.650
Occupation										
Non-student	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Student	1.181	0.8949	2.165**	2.606***	2.349**	1.478	0.651	1.650	3.383**	4.874**
Education level										
High school and below	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Above high school	1.266	0.942	2.003*	0.837	1.557	1.116	0.450**	1.025	1.253	1.447
Working history										
Employment status										
Part-time	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Full-time	0.940	0.934	1.221	0.819	1.474	1.341	2.625	2.376*	1.179	3.030*
Perceived sufficiency of income										
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.795	0.975	0.447***	0.487***	0.529**	0.709	0.613	0.648	0.551	0.378**
Weekly working hours										
<50 h/week	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
≥50 h/week	1.891**	1.636*	2.147**	2.208**	2.024**	3.629***	1.666	1.877*	5.777***	1.637
Log likelihood	−409.198	−366.064	−303.615	−288.926	−278.747	−247.941	−206.842	−191.661	−162.731	−149.768
AIC	834.397	748.129	623.230	593.853	573.494	511.883	429.685	399.323	341.463	315.537
BIC	869.599	783.331	658.432	629.055	608.696	547.085	464.887	434.526	376.665	350.739

*p < 0.05, **p < 0.01, ***p < 0.001.

Table 4
Binary logistic regression model results for active crash/fall involvement.

Variable	Coefficient	Std. Error	Adj. OR	95% CI
Intercept	−1.928***	0.302	0.145	0.080–0.263
Mobile phone use	0.552	0.071	1.057	0.920–1.214
Turn signal neglect	0.345***	0.098	1.411	1.166–1.709
Encroach into car lanes	−0.649***	0.192	0.522	0.358–0.762
Exceed speed limit	−0.033	0.134	0.967	0.743–1.259
Red-light running	−0.010	0.170	0.990	0.709–1.381
Carry more than one passenger	0.941***	0.236	2.562	1.611–4.071
Smoking while driving	1.291***	0.288	3.636	2.069–6.390
No helmet	0.027	0.137	1.027	0.785–1.345
Reckless overtaking	0.019	0.184	1.019	0.710–1.462
Drink driving	−0.430	0.237	0.650	0.409–1.034
Log likelihood	−291.311			
AIC	604.622			
BIC	653.025			

Note: n = 602, model is significant at p < 0.001 (Chi-square = 77.45, degree of freedom = 11); *p < 0.05, **p < 0.01, ***p < 0.001. 1 = Never, 2 = Seldom, 3 = Sometimes, 4 = Often, 5 = Regularly.

reported by conventional motorcycle taxi drivers in other developing countries, including Ghana (50%) and Nigeria (46%) (Agyekum-Boamah, 2012; Oginni et al., 2007).

The incidence of ten risky driving behaviours among drivers were also investigated in this study. Mobile phone use while driving had the highest incidence with 52% of respondents reporting to have engaged in this behaviour. This is not surprising as mobile phones are considered a necessary tool for app-based motorcycle taxi drivers. Drivers need to use smartphones to receive ride requests from customers and contact them if necessary to confirm pick-up points. Some drivers also use their

Table 5
Binary logistic regression model results for active injury crash/fall involvement.

Variable	Coefficient	Std. Error	Adj. OR	95% CI
Intercept	−5.237***	0.577	0.005	0.002–0.016
Mobile phone use	−0.145	0.154	0.864	0.638–1.171
Turn signal neglect	0.644***	0.164	1.903	1.381–2.624
Encroach into car lanes	−0.146	0.222	0.863	0.558–1.336
Exceed speed limit	0.393	0.205	1.481	0.990–2.216
Red-light running	−0.031	0.252	0.969	0.591–1.588
Carry more than one passenger	0.474	0.331	1.606	0.838–3.077
Smoking while driving	−0.353	0.674	0.702	0.187–2.631
No helmet	0.146	0.198	1.157	0.784–1.707
Reckless overtaking	−0.075	0.265	0.927	0.550–1.562
Drink driving	0.008	0.350	1.008	0.507–2.003
Log likelihood	−90.626			
AIC	203.252			
BIC	251.655			

Note: n = 602, model is significant at p < 0.001 (Chi-square = 51.24, degree of freedom = 11); *p < 0.05, **p < 0.01, ***p < 0.001. 1 = Never, 2 = Seldom, 3 = Sometimes, 4 = Often, 5 = Regularly.

smartphones as a GPS device which migh impact on their driving performance (Oviedo-Trespalacios, Haque, King, & Washington, 2016; Oviedo-Trespalacios, King, Haque, & Washington, 2017). In a separate study conducted by Truong, Nguyen, and de Gruyter (2018), mobile phone use among students was also found to be the most prevalent risky driving behaviour with 74% of conventional motorcyclists reporting to engage in this behaviour. In the present study, neglecting to use signals when making a turn was found to be the second most common risky behaviour among app-based motorcycle taxi drivers. Failure to use turn signals is considered to be one of the primary causes for vehicle crashes (Ponziani, 2012). In the survey, approximately 31% of drivers stated that they did not signal when making a turn at least several times a year. This figure is much lower compared to findings from a separate observational study of turn signal use among motorcyclists in Da Nang, Vietnam, which showed that nearly 60% of observed motorcyclists did not use turn signals at intersections (Nguyen-Phuoc, Phuong Tran, De Gruyter, Kim, & Ngoc Su, 2019).

Traffic crash rates and the incidence of risky driving behaviours appear to be lower among app-based motorcycle taxi drivers compared with conventional motorcyclists surveyed in previous research. This may be due to the presence of greater road safety training requirements for app-based motorcycle taxi drivers, as organised by ride-hailing firms. In addition, the driving performance of app-based motorcycle taxi drivers can be assessed by customers through ratings and comments on ride-hailing apps. If a driver is reported as being engaged in risky driving behaviours, their ride-hailing firm can lock their account for several days or even ban it permanently. For instance, if an Uber driver's rating drops below 4.6 out of 5, they are at risk of being deactivated (Ridester, 2018). In contrast, a driver can increase their earnings through reward programs if they maintain high ratings.

The results from this study show that student drivers are more likely to engage in risky behaviours such as encroaching into car lanes, exceeding speed limits, running red lights, recklessly overtaking and driving under the influence of alcohol. Indeed, students aged from 18 to 23 years old have been found in previous studies to be more likely to engage in risky driving behaviours (Jonah, 1990; Oviedo-Trespalacios & Scott-Parker, 2018; Sarkar & Andreas, 2004). Drivers who perceived that their income was sufficient were less likely to encroach into car lanes, exceed speed limits, run red lights and drive under the influence of alcohol. Previous research has shown that drivers with lower levels of income tended to engage in risky driving and were involved in traffic crashes where they attempted to increase their income by working longer hours (Factor, Mahalel, & Yair, 2008; Shams, Shojaeizadeh, Majdzadeh, Rashidian, & Montazeri, 2011; Wells-Parker et al., 2002). Unsurprisingly, app-based motorcycle taxi drivers working more than 50 h per week were more likely to engage in most of the risky behaviours. Indeed, extending work hours can lead to an increase in risk exposure to traffic crashes (Wolfe, 1982). While working hours was found to be a factor significantly associated with risky driving behaviours, employment status was not. This is because app-based drivers who work part-time for ride-hailing firms, such as a student, can have working hours equal to or greater than those of full-time drivers.

The logistic regression results showed that drivers who neglected to use their turn signals, carried more than one passenger, or smoked while driving, were associated with being more likely to be involved in active crashes/falls. Of those behaviours, neglecting to use turn signals was found to be the only risky behaviour significantly associated with active injury crashes. These findings corroborate previous research (Nguyen-Phuoc, Phuong Tran, et al., 2019), suggesting that turn signal neglect is one of the primary risky driving behaviours associated with road traffic crashes. According to the Society of Automotive Engineers, an estimated two million Americans are involved in traffic collisions each year because of turn signal neglect (Ponziani, 2012). This is more than twice the number of road traffic crashes (950,000) estimated to be due to distracted driving, such as using a mobile phone. Turn signal neglect is a key road safety focus for the U.S. Department of Transportation (NHTSA, 2010). Additionally, carrying more than one pillion passenger and smoking while driving was found to affect traffic crashes. This was consistent with the findings from previous studies which found that these behaviours had significant effect on the controllability and stability of drivers (Kashani, Rabieyan, & Besharati, 2016; Salako, Abiodun, & Sholeye, 2013).

Results from the logistic regression also showed that app-based motorcycle taxi drivers who encroached into car lanes were less likely to be involved in crashes. This may be explained by the desire to avoid high levels of congestion on mixed traffic lanes (where both cars and motorcycles are permitted) and that by travelling in car-only lanes, app-based motorcycle taxi drivers can reduce their risk of crashing with other motorcyclists as they generally have more space to travel. However, in these cases, they are also exposed to the risk of injury collisions with cars.

Findings from the present study have several implications for practice. First, the results indicated that risky driving behaviours were more common among students. Increasing safety awareness among this group through targeted training sessions organised by rail hailing firms could help to reduce the frequency of these risky behaviours. Second, the results revealed that drivers working more than 50 h per week reported a higher frequency of risky driving practices. This result points to an opportunity for ride-hailing firms to determine those at risk through increased exposure and intervening to reduce risky driving associated with this group. For instance, a limit on working hours could be imposed on app-based motorcycle taxi drivers. Third, the results emphasised the popularity of neglecting to use turn signals and its significant association with traffic crash/fall involvement, particularly injury crashes. This behaviour could be given greater attention in driver education as well as in safety training sessions organised by ride-hailing firms (Muni et al., 2018). In addition, greater enforcement of existing legislation combined with education campaigns could help to boost the use of turn signals.

While this study has provided important insight into the risky driving behaviours of app-based motorcycle taxi drivers, several limitations need to be acknowledged. First, the incidence of risky behaviours and crash/fall rates may be underreported as some drivers may be concerned that their responses could affect their reputation or business. Second, information about drivers who have died in a crash or left the occupation because of serious injuries could not be obtained as part of the survey and so the crash rates are likely to be underestimated. This study has emphasised the association of turn signal neglect with traffic crash involvement, so further research that focuses on this risky behaviour is therefore warranted. Finally, there have been no studies exploring the incidence of traffic crashes among conventional motorcycle taxi drivers in Vietnam. A further study which compares the incidence of crashes among app-based and conventional motorcycle taxi drivers is needed to confirm the lower crash rate among app-based drivers.

In closing, this study has investigated the incidence and factors associated with risky driving behaviours among app-based motorcycle taxi drivers in Vietnam. The significant association between risky driving behaviours and crash/fall involvement was also explored in this study. Given these app-based services are regulated by online ride-hailing firms, the reported incidence of risky driving behaviours among drivers is concerning. With the continual growth and expansion of these services in developing countries, targeted interventions are needed to reduce risky driving and crash rates among app-based motorcycle taxi drivers.

Appendix A

See Tables A1 and A2.

Table A1
Correlation matrix of survey respondent characteristics.

Variable	Age	Type of driver	Occupation	Education level	Employment status	Perceived sufficiency of income	Weekly working hours
Age	1						
Type of driver	−0.217**	1					
Occupation	−0.610**	0.124**	1				
Education level	−0.050**	−0.015**	−0.145**	1			
Employment status	0.270**	−0.067**	−0.382**	−0.150**	1		
Perceived sufficiency of income	0.068**	0.081**	−0.006**	−0.193**	0.094**	1	
Weekly working hours	0.140**	0.022**	−0.219**	−0.091**	0.467**	0.050**	1

**Correlation is significant at 99% confidence ($p < 0.01$, two-tailed).

Table A2
Correlation matrix of risky driving behaviours.

Variable	Mobile phone use	Turn signal neglect	Encroach into car lanes	Exceed speed limit	Red-light running	Carry more than one passenger	Smoke while driving	No helmet	Reckless over-taking	Drink driving
Mobile phone use	1									
Turn signal neglect	0.254**	1								
Encroach into car lanes	0.254**	0.345**	1							

(continued on next page)

Table A2 (*continued*)

Variable	Mobile phone use	Turn signal neglect	Encroach into car lanes	Exceed speed limit	Red-light running	Carry more than one passenger	Smoke while driving	No helmet	Reckless over-taking	Drink driving
Exceed speed limit	0.433**	0.301**	0.407**	1						
Red-light running	0.310**	0.374**	0.566**	0.534**	1					
Carry more than one passenger	0.252**	0.353**	0.532**	0.521**	0.681**	1				
Smoking while driving	0.199**	0.276**	0.170**	0.212**	0.196**	0.221**	1			
No helmet	0.111**	0.310**	0.223**	0.243**	0.295**	0.397**	0.168**	1		
Reckless overtaking	0.224**	0.337**	0.362**	0.490**	0.453**	0.491**	0.231**	0.424**	1	
Drink driving	0.241**	0.213**	0.244**	0.356**	0.321**	0.292**	0.414**	0.291**	0.346**	1

**Correlation is significant at 99% confidence ($p < 0.01$, two-tailed).

Appendix B. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2020.03.010.

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