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Questioning penalties and road safety Policies: Are they enough to deter risky motorcyclist Behavior?

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ABSTRACT

Reducing risky behaviors and traffic violations is crucial for preventing road trauma among private and commercial motorcyclists. While legal interventions such as road rules and police enforcement have been somewhat effective, there is a gap in understanding how motorcyclists perceive these deterrents and the psycho-social factors influencing their effectiveness. This research aims to explore the interplay between motorcyclists' psycho-social predispositions and their responses to legal interventions. It also compares two distinct groups of riders - private and commercial motorcyclists - within the urban environment of Da Nang, Vietnam, providing a nuanced consideration of the influence of work-related impacts on risky behavior, which can enable targeted interventions. We propose a theoretical model integrating the Theory of Planned Behavior and Deterrence Theory to analyze how psycho-social and punitive factors influence riders' traffic violations. A total of 423 delivery riders and 411 private riders in Da Nang participated in the study. The results show that attitude, perceived behavioral control, and perceptions of deterrence significantly impact riders' intentions to engage in risky behaviors, with delivery riders being particularly responsive to law enforcement and penalties. To enhance policy effectiveness, interventions should employ tailored enforcement strategies that account for the unique motivations and perceptions of each rider group. For example, increasing the visibility and consistency of law enforcement could be particularly impactful for delivery riders, who are more sensitive to immediate deterrents. Policy adjustments should also focus on reshaping riders' attitudes toward safety and adjusting their perceived control over riding situations. By tailoring interventions to effectively influence each group's behavior, we can ultimately reduce traffic incidents.

1. Introduction

Road traffic crashes (RTCs) present a significant public health challenge and are emerging as a focal issue for policy intervention globally. The World Health Organization projects that by 2030, RTCs will rank as the seventh leading cause of death across all age brackets (WHO, 2023). Vulnerable road users such as motorcyclists and pedestrians are particularly affected, with the problem being pronounced in Southeast Asia, where motorcycles represent nearly half of the vehicular population (WHO, 2018; Haghani et al., 2022). In Thailand alone, traffic fatalities averaged 70 per day in 2020, with a disproportionate 74 % involving motorcyclists (International Traffic Safety Data and Analysis Group, 2023). Vietnam reports a similar trend, with motorcycle-involved incidents constituting approximately 80 % of all traffic collisions (Nguyen et al., 2022). The fact that certain road users are more vulnerable than others in terms of crash involvement is not just a safety issue but also a justice issue, highlighting the urgency of addressing this disparity (Martínez-Buelvas et al., 2022). A comprehensive approach is needed to ensure a sustainable transport system that prioritizes the safety of all road users.

Risky riding behaviors such as errors and violations significantly contribute to traffic crashes (Elliott, 2010; Nguyen et al., 2023). A study by Nguyen-Phuoc et al. (2023) found that 54 % of non-fatal traffic crashes among food delivery motorcyclists in Vietnam are attributed to

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risky behaviors, including using mobile phones while riding (35 %), neglecting turn signals (26 %), running red lights (23 %), riding while tired (20 %), and speeding (19 %) Also, Nguyen-Phuoc et al., (2020a) found that a considerable number of motorcycle riders engage in risky behaviors such as using phones while riding (13.6 %), running red lights (7.3 %), and drunk driving (4.0 %). Similar findings have been reported in other Southeast Asian countries like Malaysia (Rusli et al., 2020). In China, data on e-bike riders' crossing behaviors at signalized intersections reveals that 60.3 % of delivery e-bike riders engage in red-light running behavior, while this figure for ordinary riders is 41.1 % (Zhang et al., 2021a). Given the high prevalence of risky behaviors, addressing the system-wide determinants of such behaviors could reduce the incidence of road trauma.

To deter traffic violations, countries have developed legislation and implemented effective penalties such as penalty point systems, confiscation of riding licenses, and fines. For example, in Thailand, motorcyclists who violate the law by riding on the wrong side of the road or not wearing a helmet are subject to a fine of 2,000 baht (Phuket, 2023). Similarly, in Vietnam, road traffic laws stipulate that participants who do not wear a helmet or wear it incorrectly will be fined between 400,000 and 600,000 VND (2021). In addition to legislative measures, some countries have installed traffic enforcement cameras and used police enforcement to enhance compliance (Oviedo-Trespalacios and Watson, 2021; Truelove et al., 2023). For instance, in the downtown areas of Nanjing, China, traffic enforcement cameras have been implemented to detect red-light running behavior among e-bike riders (Lv et al., 2022). In Khon Kaen, Thailand, CCTV camera technology equipped with an automatic helmet detection system has been installed to monitor helmet use by riders (Satiennam et al., 2020). These interventions have been shown to increase riders' perceived risk of being penalized and directly affect riders' attitudes, reducing their involvement in risky riding behaviors (Elvik and Christensen, 2007; Watling et al., 2014). However, the perceived risk has been found to decrease over time without further reinforcement (Homel, 1986). Therefore, to improve the effectiveness of punitive measures, it is crucial to understand how the deterrent effect of punishment influences riders' psychology and intentions to engage in risky behaviors. While many previous studies have focused on analyzing how psychological factors (e.g., risk perception, attitude, behavioral control, and subjective norms) influence the intention to engage in risky riding behavior among motorcyclists, the impact of punitive measures on risk behavior intention has not received much attention. We still know relatively little about how to develop truly effective deterrents for mitigating risky riding behaviors, particularly when considering social factors unique to regions where these incidents are more prevalent.

Another socio-technical influence to consider when trying to understand the factors impacting motorcyclists' safety is the work-related demands faced by some riders, as the road is not only a means of transport but also their workplace. The rapid growth of the online economy and e-commerce has solidified takeaway services as a norm for acquiring food and goods, providing consumers the convenience of ordering through apps and receiving deliveries directly at their homes (Shen et al., 2020; Nguyen-Phuoc et al., 2023). This convenience is made possible by delivery riders, who form a crucial link between businesses and customers. This arrangement not only spares consumers the effort of picking up their orders but also allows businesses to reduce fixed staffing costs for deliveries, optimizing their expenses (Ray et al., 2019). In 2022, Grab, a leading delivery service, reported over 100,000 delivery riders within its network across Vietnam, notably in densely populated urban centers such as Hanoi and Ho Chi Minh City (Buckley, 2023). The rapid growth of online businesses has led to increased awareness and concern about the safety of food delivery workers, as evidenced by the rising number of traffic injuries involving these workers (Chen, 2023) and the prevalence of risky riding behaviors (Zhang et al., 2021b; Nguyen-Phuoc et al., 2020a; Useche et al., 2024). For example, risky riding behaviors such as speeding and not using helmets are common traffic violations that significantly increase the risk for delivery riders (da Silva et al., 2012; Nguyen-Phuoc et al., 2023). The demands from their work can potentially influence the effectiveness of road rule deterrence in varying ways. For instance, a motorcyclist worried about being financially penalized for delays might decide to run a red light to save time, even if it means risking detection by the police. This aspect introduces a complex layer to understanding how traffic regulations impact rider behavior, particularly for those who depend on the road for their livelihood. However, the differential impact of deterrence measures on these riders remains largely unexplored and highlights a significant gap in current traffic safety research.

The literature reveals three critical gaps in understanding the impact of road traffic crashes, particularly in regions where motorcycles are the predominant mode of transport, such as Southeast Asia. Firstly, there is limited research on how punitive measures like fines and penalty points influence riders, especially those under work-related pressures, such as delivery riders. Secondly, detailed studies on adapting safety interventions to the unique cultural and regional contexts of these riders are lacking. Finally, there is an insufficient understanding of the long-term effectiveness of deterrent measures in maintaining rider compliance with traffic laws.

This study aims to bridge these gaps by developing a new model that integrates the Theory of Planned Behavior with Deterrence Theory. The developed model aims to elucidate how psychological factors and punishment influence motorcycle riders' traffic violations, focusing on comparing food delivery riders and private riders in Da Nang, Vietnam. Deterrence Theory suggests that the likelihood of engaging in risky driving behaviors can be influenced by the perceived certainty, severity, and swiftness of punishments. When motorcyclists believe they are likely to be caught and punished for risky driving practices, they are less likely to engage in such behaviors. By integrating psychological factors from the TPB with principles of Deterrence Theory, this study provides a comprehensive framework for understanding and mitigating risky driving behaviors among motorcyclists. The findings will provide insights that can help authorities and platform companies devise targeted interventions to mitigate the risks these riders face, thereby enhancing road safety in the prevailing traffic environment. This approach not only addresses the immediate need for more effective safety interventions but also considers the broader socio-technical and cultural factors that influence rider behavior.

2. Background and hypothesis development

2.1. Risky behavior engagement among motorcyclists

According to previous research, factors influencing risky riding behavior and traffic accidents can be divided into three groups: human-related factors, road and environmental condition factors, and vehicle factors (PIARC, 2015; Nurain and Razelan, 2022). Human factors refer to the range of psychological, behavioral, and physiological characteristics that influence individuals' interactions with systems, environments, and other people. Traffic accidents can result from a single cause or a combination of multiple causes; however, human factors were recognized to account for the highest proportion of the causes affecting motorcyclist accidents. For example, Treat et al. (1977) stated that 95.4 % of road crashes are due to human factors. Similarly, PIARC (2015) reported that human factors contribute to over 93 % of motorcyclist-related traffic accidents.

Prior studies have analyzed that psychological factors such as risk perception, attitude, and subjective norms affect the intention to engage in risky driving behavior among motorcyclists (Falco et al., 2013; Norris and Myers, 2013; Setoodehzadeh et al., 2021). For example, Nguyen--Phuoc et al., (2020b) found that perceived risk, attitudes and beliefs directly affect the frequency of using mobile phones while riding among motorcyclists. Wong et al. (2010a) found that risk perception, riding confidence, and impatience are the main psychological factors affecting

risky behavior intentions among young motorcyclists in Taiwan. Demographic factors are also found to be key factors influencing the riding behavior of motorcycle riders (Nguyen et al., 2024). Previous studies stated that younger riders have a higher risk of engaging in risky riding behaviors or traffic violations compared to older riders (German et al., 2019; Nguyen-Phuoc et al., 2019; Minh and Long, 2021). For example, Wu and Loo (2016) and Nguyen-Phuoc et al. (2019) conducted studies on the relationship between risky riding behaviors and riders' age, reporting that teenagers tend to run red lights and neglect to use turn signals more frequently than older age groups.

In the context of delivery services, work pressure often creates a significant psychological burden that affects the risky driving behavior of delivery riders. Indeed, several previous studies have demonstrated that delivery time pressure leads to risky riding behavior and traffic accidents (Kulanthayan et al., 2012; Chung et al., 2014; Nguyen-Phuoc et al., 2023). The link between risk-taking attitude and road safety compliance among food delivery riders has been confirmed in the study conducted by Nguyen-Phuoc et al. (2022a). Regarding demographic factors, Yang et al. (2014) found that male delivery riders are at a higher risk of traffic violations and speeding compared to their female counterparts.

2.2. Theory of planned behavior

The Theory of Planned Behavior (TPB), developed by Ajzen in 1991 as an extension of the Theory of Reasoned Action (TRA), provides a framework for predicting and explaining human behavior in specific contexts. The central element of TPB is an individual's intention to perform a certain behavior, which varies depending on the individual's goals, contexts, and time frames, as well as the likelihood of successful implementation (Fishbein and Ajzen, 1977). The TPB posits that three main factors influence an individual's intention to perform a behavior: attitude, subjective norm, and perceived behavioral control. Attitude refers to the individual's evaluation of the behavior, whether they view it favorably or unfavorably (Ajzen, 1991). Subjective norms involve the individual's perception of whether others approve or disapprove of the behavior based on the individual's beliefs about other people's attitudes and their motivation to conform to these attitudes (Ajzen, 1991). Perceived behavioral control reflects the individual's belief in their ability to perform the behavior, influenced by past experiences and anticipated obstacles (Ajzen, 1991).

In recent years, TPB has been widely applied, particularly in studies on risky riding behaviors among private riders. Previous research has shown that attitude is the most important factor influencing the intention to engage in risky behaviors (Satiennam et al., 2018; Elliott, 2010; Payani and Law, 2020; Nguyen et al., 2020; Jalaludin et al., 2021). Subjective norms are found to be the most consistent predictor of intention to comply with traffic safety laws, especially among young or novice riders (Satiennam et al., 2018; Chen and Chen, 2011). However, other studies, such as Champahom et al. (2020), have shown that subjective norms have no impact on the intention to use helmets among motorcyclists in urban settings. Brijs et al. (2014) found that while individuals were aware of the social norms for helmet use, they did not see these norms as obligatory for their behavior. Moreover, perceived behavioral control, or one's perceived ability to perform a behavior, has been highlighted as a crucial factor in determining whether individuals will actually engage in that behavior (Moan, 2013; Nguyen et al., 2020; Moan and Rise, 2011). Yang et al. (2019) suggested that achievement rewards and self-efficacy were key in predicting novice riders' intentions regarding risky riding behaviors, with motivated riders who believed in their ability to avoid violations being less likely to intend to engage in such behaviors (Chorlton et al., 2012).

While TPB has not been widely applied to motorcycle delivery riders, it has been successfully used in studies of deliveries by electric vehicles. For instance, Tang et al. (2021) found a positive correlation between attitude and intention to violate traffic laws among delivery riders in China, driven by the desire to maximize earnings even at the risk of safety (Goods et al., 2019). Westerman and Haigney (2000) discovered that emotionally stressed individuals are more likely to engage in risky riding behaviors. Tang et al. (2020) highlighted that perceived behavioral control is a significant predictor of delivery riders' intention to perform actions like running red lights, indicating that those who find it difficult to engage in risky behaviors are less likely to commit violations (Tang et al., 2020). However, studies such as Yang et al. (2018) and Shen et al. (2020) have shown that subjective norms have a weak or variable impact on the intention to violate traffic laws, although Shen noted that family and coworkers significantly influence delivery riders. This influence often leads to imitation of coworkers' traffic violations, fostering a competitive environment among delivery workers that encourages risky riding practices to expedite deliveries (Palat and Delhomme, 2012).

2.3. Deterrence theory

The first philosophical and theoretical introduction to deterrence theory appeared in the 18th century during the Enlightenment era, developed by scholars who are now considered representatives of the classical school of criminology and criminal law. Deterrence Theory (DT) is predicated on the assumption that humans are rational beings who can evaluate the consequences of their actions and adjust their behavior accordingly (Brown and Esbensen, 1988). DT operates by leveraging the threat of punishment to influence people's behavior. According to Kergoat et al. (2017), for deterrence to be effective, individuals must believe that the threat of punishment is highly likely to occur and that they are personally vulnerable to the consequences.

The effective application of DT hinges on three main principles: the certainty, severity, and swiftness of sanctions. The first principle posits that the higher the perceived likelihood of receiving punishment, the lower the likelihood of a rule violation (Brown and Esbensen, 1988). Simply put, individuals are more likely to be deterred from committing crimes if they believe they are likely to be caught and punished (Davey and Freeman, 2011). The second principle suggests that the severity of the punishment also plays a critical role; according to classical DT, harsher punishments dissuade people from committing crimes (Von Hirsch et al., 1999). The third principle asserts that punishment is most effective when it is applied promptly after the crime has been committed (Homel, 2012).

Previous research has shown that these factors not only underpin DT but also influence risky riding behavior. For example, Szogi et al. (2017) found that the threat of fines positively impacts alcohol-related riding behavior in Australia. Conversely, Ochenasek et al. (2022) determined that the certainty of fear of receiving a fine is not a significant predictor of whether riders will follow another vehicle too closely. Studies have also demonstrated that the severity of punishment for traffic violations can affect the likelihood of repeat offenses (Szogi et al., 2017; Truelove et al., 2021a). Additionally, Leal et al. (2009) revealed that participants perceived vehicle impoundment penalties as overly harsh for traffic violations. The promptness of punishment has been found to be an ineffective deterrent to alcohol use while riding (Szogi et al., 2017; Freeman et al., 2006b), suggesting that in practice, sanctions are seldom applied swiftly, particularly where legal or court processes are involved (Davey and Freeman, 2011).

Recent research has started to argue that there is a need to expand the Deterrence Theory to include factors more closely related to societal norms and the personal perceptions of road users. Research should explore how social influences, community standards, and individual perceptions of fairness and justice affect riders' responses to deterrent measures (Truelove et al., 2023; Hasan et al., 2022, 2024). Understanding these social dimensions could enhance the effectiveness of Deterrence Theory by aligning legal sanctions more closely with the cultural and social contexts of the riders, thus potentially leading to more sustained compliance with traffic laws. This approach recognizes that the decision-making process of riders is not only influenced by the immediate consequences of their actions but also by their integration within the broader social fabric.

2.4. Hypothesis development

The present study explores the relationship between psychological factors in TPB and the intention to engage in risky riding behaviors of delivery riders and private riders. Previous studies have identified that there is a correlation between psychological factors and risky riding behaviors such as speeding (Elliott, 2010; Chen and Chen, 2011), drunk driving (Moan and Rise, 2011; Moan, 2013), drugged driving (Hasan et al., 2022), red light running (Satiennam et al., 2018; Yang et al., 2018; Shen et al., 2020; Tang et al., 2020), using a phone while riding (Nguyen et al., 2020; Nguyen-Phuoc et al., 2020b Truelove et al., 2021a,b), etc. Therefore, the hypotheses related to psychological factors to predict motorcycle users' intentions are stated as follows:

H1: Attitude has a direct and positive impact on the intention to engage in risky riding behavior.

H2: Subjective norms have a direct and positive impact on the intention to engage in risky riding behavior.

H3: Perceived behavioral control has a direct and positive impact on the intention to engage in risky riding behavior.

DT provides valuable principles to explore the relationship between the perception of deterrence and the intention to engage in risky riding behavior. Previous research has established that the perceptions of certainty and severity of penalties can reduce the recidivism of traffic violations such as speeding (Ritchey and Nicholson-Crotty, 2011; Kergoat et al., 2017) and drunk driving (Freeman et al., 2006a; Szogi et al., 2017). While the relationship between the swiftness of punishment and motorcyclists' intention to engage in risky riding behaviors is debatable, prompt punishment may potentially deter such behaviors. Therefore, the following hypotheses are proposed:

H4: Certainty has a direct and negative impact on the intention to engage in risky riding behavior.

H5: Severity has a direct and negative impact on the intention to engage in risky riding behavior.

H6: Swiftness of sanctions has a direct and negative impact on the intention to engage in risky riding behavior.

Although the relationship between the factors in DT model and TPB model has not been clearly established for motorcycle riders, several studies have shown that the severity of punishment has a negative impact on compliance with security policies (Peace et al., 2003; Safa et al., 2019; Koranteng et al., 2020). Additionally, Herath and Rao (2009) and Safa et al. (2019) demonstrated that the certainty of punishment is a variable that is directly related to individuals' attitudes toward security behavior. Based on this evidence, the following hypotheses are proposed:

H7: Certainty has a direct and negative impact on attitude toward the intention to engage in risky riding behavior.
H8: Severity has a direct and negative impact on attitude toward the intention to engage in risky riding behavior.
H9: Swiftness of sanctions has a direct and negative impact on attitude toward the intention to engage in riksy riding behavior.

Fig. 1 shows the proposed model of this study.

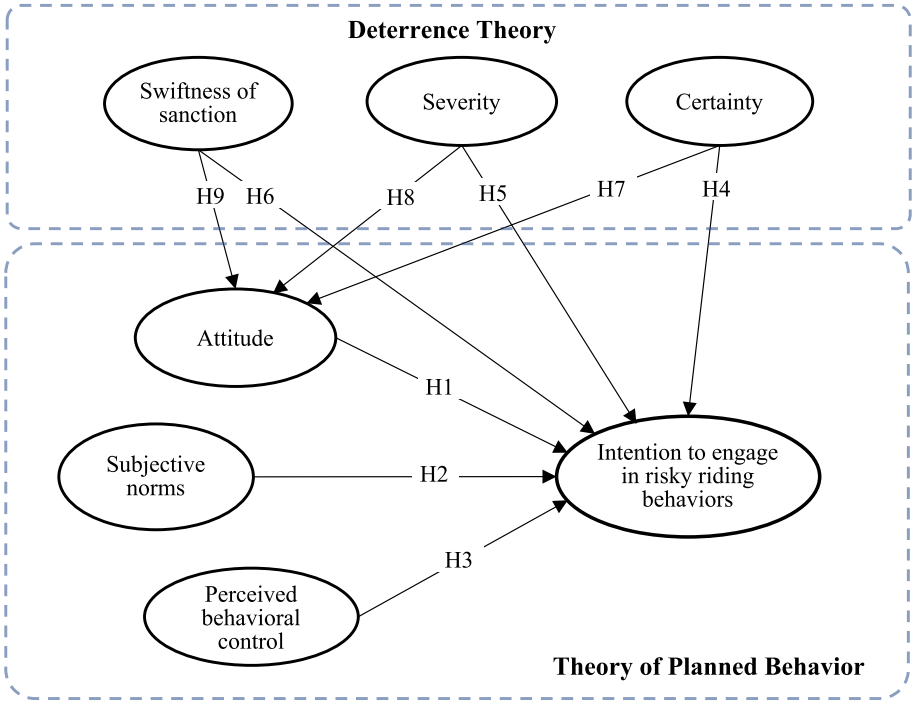

Fig. 1. Proposed theoretical model.

Table 1
Measurement questions.

Constructs	Items		References
Attitude (ATT)	ATT1	During the delivery process, violating traffic rules saves me time.	(Yang et al., 2018)
	ATT2	If you are a good rider, it is acceptable to violate traffic rules sometimes	(Iversen, 2004)
	ATT3	Taking chances and breaking a few traffic rules does not necessarily make bad riders	(Iversen, 2004)
	ATT4	Traffic rules are often too complicated to be carried out in practice	(Iversen, 2004)
Subjective norms (SUN)	SUN1	Most people who are important to me would accept my violating traffic rules when riding for work	(Tang et al., 2021)
	SUN2	Most people who are important to me would approve of my violating traffic rules when riding for work	(Tang et al., 2021)
	SUN3	Most people whose opinions I value would tolerate my violating traffic rules when riding for work	(Tang et al., 2020)
Perceived behavioral control (PBC)	PBC1	If I want, I can easily violate traffic rules	(Nguyen-Phuoc et al., 2022b)
	PBC2	I feel confident that I could violate traffic rules	(Yang et al., 2018)
	PBC3	Whether or not I violate traffic rules is completely within my control.	(Yao et al., 2011)
Intention to engage in risky riding behaviors (ITT)	ITT1	I will violate traffic rules when riding for work	(Tunnicliff et al., 2012)
	ITT2	I intend to violate traffic rules when riding to work	
	ITT3	I am likely to violate traffic rules when riding for work	
	ITT4	I will not ensure high levels of safety when I carry out my job.	
Certainty (CER)	CER1	There is a high likelihood that I would be caught by police officers if I violated traffic rules	
	CER2	I believe I would have a high chance of being caught by police officers if I violated traffic rules	
	CER3	My chances of being caught by police officers would be high if I violated traffic rules	(Freeman et al., 2006a)
	CER4	There is a high likelihood that I would be caught by traffic cameras if I violated traffic rules	
	CER5	I believe I would have a high chance of being caught by traffic cameras if I violated traffic rules	
	CER6	My chances of being caught by police officers would be high if I violated traffic rules	
Severity (SER)	SER1	The penalty I have to receive if caught by the police will be very heavy on my life.	(Freeman et al., 2006a)
	SER2	The penalty I'd receive if caught by a police officer would have a considerable impact on my life.	
Swiftness of sanction (SOS)	SOS1	The fine will be given immediately when I am caught by a police officer	
	SOS2	The time between getting caught by a police officer and receiving a fine would be very short	(Freeman et al., 2006a)
	SOS3	It would not take long after I was caught by a police officer to receive a fine	

3. Method

3.1. Survey

To gather data for testing the proposed model in Fig. 1, the study conducted a thorough literature review to develop a three-part self-report questionnaire. The introduction of the questionnaire provided participants with a comprehensive overview of the study, including its purpose, goals, and potential benefits. The second section of the questionnaire was designed to measure the variables in the proposed model. Participants were instructed to provide their answers on a 7-point Likert scale, with '1' being 'strongly disagree' and '7' being 'strongly agree.' The questions in this section were adapted from previous studies on measuring the constructs of the model. The structure of this section is presented in Table 1. The third section of the questionnaire included questions about the riders' demographic characteristics, such as age, gender, education level, and income.

Before collecting data, the questionnaire was initially written in English and then translated into Vietnamese. Feedback was sought from transportation experts, and their comments were thoroughly addressed. A pilot survey was conducted with 30 students from Da Nang University to meticulously scrutinize the questionnaire for potential errors, including issues related to word usage and spelling. The outcomes from these pilot studies affirmed the questionnaire's robust design and indicated its readiness for the forthcoming data collection phase. This validation process ensured that the instrument was finely tuned and poised to yield reliable data for the study.

3.2. Data collection

A survey of food delivery riders and private riders was conducted in August 2022 on both weekdays and weekends. To recruit qualified participants, student enumerators were trained to identify and approach food delivery riders in crowded areas where these riders often gather while waiting to receive orders, such as parks, lakes, and shopping malls. Once a potential participant was identified, they were asked to provide informed consent, which included information about the voluntary nature of their participation, potential risks and benefits, and the procedures in place to ensure confidentiality. Delivery riders who agreed to participate in the survey were given a questionnaire and a pen to complete it. To minimize the risk of bias, investigators ensured that participants were informed their responses would be anonymous. As a token of appreciation, delivery riders received a voucher worth 30,000 VND, while private riders received a voucher worth 20,000 VND (about 1 USD). After the survey was completed, researchers compiled a total of 480 responses from delivery riders and 492 responses from private riders. After reviewing and selecting the data, removing incomplete and questionable responses, the final dataset included 423 delivery riders and 411 private riders.

3.3. Data analysis

Partial least squares structural equation modeling (PLS-SEM) is a relatively new type of structural equation modeling (SEM) that was used in this study because it has several advantages over other SEM methods. Essentially, PLS-SEM is a versatile statistical method that can be used to analyze complex models with many variables and indicators, even with small sample sizes and non-normal data (Hair et al., 2016). This makes it particularly well-suited for studies of traffic behavior, which often involve complex relationships between many different variables (Wong et al., 2010; Wang et al., 2020; Nguyen-Phuoc et al., 2023). Unlike another version, covariance-based SEM, PLS-SEM does not fit a common factor model to the data. PLS-SEM better fits the aggregate model by maximizing the amount of variance explained. PLS-SEM consists of two constitutive models: a measurement model that elucidates the relationships between scales and latent constructs and a structural model that describes the correlations between latent variables. In this investigation, SmartPLS 4.0 was used to evaluate measurement and structural models designed in accordance with the theoretical model outlined in Section 2.

Table 2
Demographic information.

Characteristics	Food delivery riders		Private riders			Food delivery riders		Private riders	
	n	%	n	%		n	%	n	%
Gender					*Occupation*				
Male	419	99.1	406	98.8	Student	147	34.8	180	43.8
Female	4	0.9	5	1.2	Full-time	115	27.2	176	42.8
Age					Part-time	144	34.0	47	11.4
Mean (Standard deviation)	25.3 (6.165)		25.4 (6.815)		Other	17	4,0	8	2.0
Education level					*Income (VND)*				
Secondary school	30	7.1	17	4.1	None	22	5.2	124	30.2
High school	193	45.6	250	60.8	<=5 million	115	27.2	61	14.8
College	90	21.3	38	9.2	5–<10 million	196	46.3	99	24.1
University	107	25.3	89	21.7	10–<15 million	72	17.0	84	20.4
Above university	3	0.7	16	3.9	>= 15 million	18	4.3	43	10.5

4. Results

4.1. Descriptive statistics

Table 2 provides a summary of the demographic characteristics of the survey respondents. The majority of respondents in both groups (delivery riders and private riders) were male (99.1 % and 98.8 %, respectively). The average age of respondents was relatively young, at 25.3 years for delivery riders and 25.4 years for private riders, with standard deviations of 6.165 years and 6.815 years, respectively. Table 2 also presents detailed information about the education level and income of the two groups of participants.

4.2. Measurement model assessment

PLS-SEM was used to evaluate the reliability of the measurement model for the proposed constructs. As recommended by (Hair et al., 2021), Cronbach's alpha (CA) and composite reliability (CR) scores were used to assess the internal consistency reliability of the measurement scales. The results of these assessments are presented in Table 3, and all of the scores were above the cutoff value of 0.7, indicating that the measurement model has satisfactory internal consistency reliability (Nunnally, 1975). The researchers then estimated the external factor loadings of each indicator to assess how well each question reflected the corresponding construct. For delivery riders, the results showed that three items (ATT3, PBC3, and CER1) had external factor loadings below the threshold value of 0.7 (Henseler et al., 2009). These items were, therefore, removed from the theoretical scales of attitude, perceived behavioral control, and certainty, respectively. For private riders, two questions (ATT1 and ATT2) were kept in the external model even though their factor loadings (0.685 and 0.699, respectively) were close to the threshold value of 0.7. This was because removing these questions did not increase the average variance extracted (AVE) value of the construct of risky riding behavior. Additionally, the AVE scores for all seven variables ranged from 0.525 to 0.916 in private riders, which is well above the recommended threshold of 0.5. This indicates that the measurement model has adequate convergent validity.

To assess the discriminant validity of the measurement model, the

Table 3
Measurement model evaluation.

Latent variables		Food delivery riders				Private riders			
	Item	Outer loadings	CA	CR	AVE	Outer loadings	CA	CR	AVE
Attitude (ATT)			0.708	0.719	0.633		0.703	0.719	0.525
	ATT1	0.835				0.685			
	ATT2	0.836				0.699			
	ATT3	–				0.796			
	ATT4	0.710				0.714			
Subjective norms (SUN)			0.751	0.757	0.666		0.760	0.780	0.671
	SUN1	0.786				0.822			
	SUN2	0.800				0.776			
	SUN3	0.860				0.857			
Perceived behavioral control (PBC)			0.760	0.769	0.806		0.738	0.736	0.657
	PBC1	0.844				0.835			
	PBC2	0.911				0.839			
	PBC3	–				0.755			
Intention to engage in risky riding behaviors (ITT)			0.837	0.849	0.673		0.732	0.734	0.555
	ITT1	0.836				0.757			
	ITT2	0.879				0.738			
	ITT3	0.829				0.781			
	ITT4	0.732				0.702			
Certainty (CER)			0.925	0.973	0.761		0.899	0.912	0.664
	CER1	–				0.732			
	CER2	0.894				0.839			
	CER3	0.892				0.842			
	CER4	0.857				0.830			
	CER5	0.869				0.832			
	CER6	0.850				0.808			
Severity (SER)			0.865	0.906	0.879		0.911	0.976	0.916
	SER1	0.954				0.944			
	SER2	0.921				0.970			
Swiftness of sanction (SOS)			0.720	0.770	0.637		0.816	0.845	0.728
	SOS1	0.738				0.801			
	SOS2	0.874				0.892			
	SOS3	0.775				0.863			

Table 4
Heterotrait-Monotrait Ratio (HTMT) of the factor model.

Construct	ATT	CER	ITT	PBC	SER	SUN	SOS
ATT		0.249	0.716	0.647	0.271	0.457	0.254
CER	*0.200*		0.355	0.281	0.464	0.345	0.435
ITT	*0.769*	*0.172*		0.662	0.376	0.420	0.313
PBC	*0.521*	*0.116*	*0.605*		0.186	0.486	0.188
SER	*0.218*	*0.479*	*0.195*	*0.105*		0.214	0.411
SUN	*0.471*	*0.123*	*0.440*	*0.517*	*0.128*		0.211
SOS	*0.194*	*0.301*	*0.209*	*0.140*	*0.201*	*0.051*	

Note: Italic values: food delivery riders; Normal values: private riders.

Table 5
Results of direct effects between each construct.

Hypothesis	Food delivery riders			Private riders		
	Coefficient	t-value	p-value	Coefficient	t-value	p-value
H1: ATT→ITT	0.434^{***}	7.707	< 0.001	0.311^{***}	6.665	< 0.001
H2: SUN→ITT	0.097^{ns}	1.947	0.052	0.057^{ns}	1.101	0.271
H3: PBC→ITT	0.266^{***}	5.456	< 0.001	0.272^{***}	4.991	< 0.001
H4: CER→ITT	-0.046^{ns}	1.321	0.186	-0.068^{ns}	1.114	0.265
H5: SER→ITT	-0.052^{ns}	1.332	0.183	−0.138*	2.293	0.022
H6: SOS→ITT	0.091^{**}	2.612	0.009	-0.056^{ns}	1.026	0.305
H7: CER→ATT	-0.168^{***}	3.303	0.001	-0.107^{ns}	1.827	0.068
H8: SER→ATT	−0.128*	2.468	0.014	−0.140*	2.315	0.021
H9: SOS→ATT	0.200^{***}	4.521	< 0.001	−0.124*	1.959	0.050

Note: ^{ns} p > 0.05. * p <= 0.05, ** p <= 0.01, *** p <= 0.001.

researchers used the Heterotrait-Monotrait Ratio (HTMT) to test the similarity between the proposed latent variables (Henseler et al., 2015).. The HTMT statistics in Table 4 are well below the threshold of 0.85, indicating that the latent variables are sufficiently distinct. This observation serves as compelling evidence that the latent variables exhibit a high degree of distinctiveness from one another, affirming the robust discriminant validity of the measurement model. In this section, the researchers thoroughly tested the reliability, discrimination, and convergence of the measurement model. The results of these tests showed that the model is well-developed and ready for further analysis.

4.3. Structural model assessment

4.3.1. Model fit

In the present study, the examination of the fit of the PLS-SEM model was conducted through the estimation of the standardized root mean square residual (SRMR). The calculated SRMR coefficients for delivery riders and private riders are noteworthy, registering at 0.061 and 0.073, respectively. Both values fall below the predetermined threshold of 0.08 (Henseler et al., 2016). This discrepancy from the threshold serves as compelling evidence that the two proposed structural models demonstrate a commendable fit with the empirical data, substantiating its validity within the contexts of both delivery riders and private riders.

4.3.2. Hypothesis assessment

A bootstrapping procedure with 5,000 resamples was used to test the proposed hypotheses in a sample of 834 participants consisting of two groups of subjects (delivery riders and private riders). Upon meticulous examination of the outcomes, detailed in Table 5, it is discerned that among delivery riders, the results showed that six of the nine hypothesized path relationships were significant, while the remaining three relationships were not significant (Fig. 2 and Fig. 3). Among private riders, only five of the nine hypothesized path relationships were significant. In both groups of participants, attitude and perceived behavioral control had a significant positive impact on the intention to engage in risky riding behaviors (for delivery riders: $\beta_{ATT\rightarrow ITT} = 0.434$, t = 7.707, p < 0.001 and $\beta_{PBC\rightarrow ITT} = 0.266$, t = 5.456, p < 0.001; for private riders, $\beta_{ATT\rightarrow ITT} = 0.311$, t = 6.665, p < 0.001 and $\beta_{PBC\rightarrow ITT} = 0.272$, t = 4.991, p < 0.001, respectively). Meanwhile, certainty and severity also have a significant impact on the intention to engage in risky riding behaviors in delivery riders ($\beta_{CER\rightarrow ATT}$ = -0.168, t = 3.303, p < 0.001 and $\beta_{SER\rightarrow ATT}$ = -0.128, t = 2.468, p = 0.014, respectively). For delivery riders, it is intriguing to note that the immediacy of punishment also has a significant impact on attitudes and intentions to be involved in risky riding behaviors ($\beta_{SOS\rightarrow ATT} = 0.200$, t = 4.521, p < 0.001 and $\beta_{SOS\rightarrow ITT} = 0.091$, t = 2.612, p = 0.009, respectively). However, this relationship has the opposite effect on private riders. Concluding this comprehensive examination, it is noteworthy that in the present study, subjective norms did not emerge as a predictive factor for the intention to engage in risky riding behaviors within either cohort of subjects.

In the comprehensive analysis undertaken to clarify the intricacies of the structural model, particular attention was devoted to the exploration of its mediating effects (Table 6). Certainty and severity did not have a direct effect on risky riding behaviors in delivery riders. This prompted a meticulous examination of the causal pathways, revealing that the influence of certainty and severity on risky riding behaviors is entirely mediated by attitude, with the coefficients −0.073 (p = 2.939) and −0.056 (p = 0.023), respectively. The researcher also found that the mediator variable of attitude played a significant role in the relationship between swiftness of sanctions and intention to engage in risky riding behaviors in delivery riders ($\beta_{SOS\rightarrow ATT\rightarrow ITT}$ = 0.087, t = 3.554, p < 0.001). Shifting the focus to private riders, only the indirect effect of the swiftness of sanctions on intention to commit risky riding behaviors through the mediator variable of attitude was statistically significant ($\beta_{SER\rightarrow ATT\rightarrow ITT}$ = -0.044, t = 2.197, p = 0.028).

The present study also examined the total effect of all the constructs on risky riding behaviors (Table 7). In terms of delivery riders, the results showed that ATT ($\beta_{ATT\rightarrow ITT} = 0.434$, t = 7.707, p < 0.001) and PBC ($\beta_{PBC\rightarrow ITT}$ = 0.266, t = 5.456, p < 0.001) were the strongest variables affecting the intention to engage in risky riding behaviors (ITT), followed by three Deterence Theory-related variables, including SOS ($\beta sos_{\rightarrow ITT}$ = 0.178, t = 4.347, p < 0.001), CER ($\beta_{CER\rightarrow ITT}$ = -0.119, t = 2.943, p = 0.003) and SER ($\beta_{SER\rightarrow ITT}$ = -0.108, t = 2.225, p = 0.026). Regarding private riders, the strongest variables affecting the intention were also ATT and PBC; however, only one of three Deterence Theory-related variables, Severity (SER), was found to have a significantly total effect on ITT ($\beta_{SER\rightarrow ITT} = -0.182$, t = 2.842, p = 0.004). SUN did not significantly impact the intention to engage in risky riding behaviors among both groups.

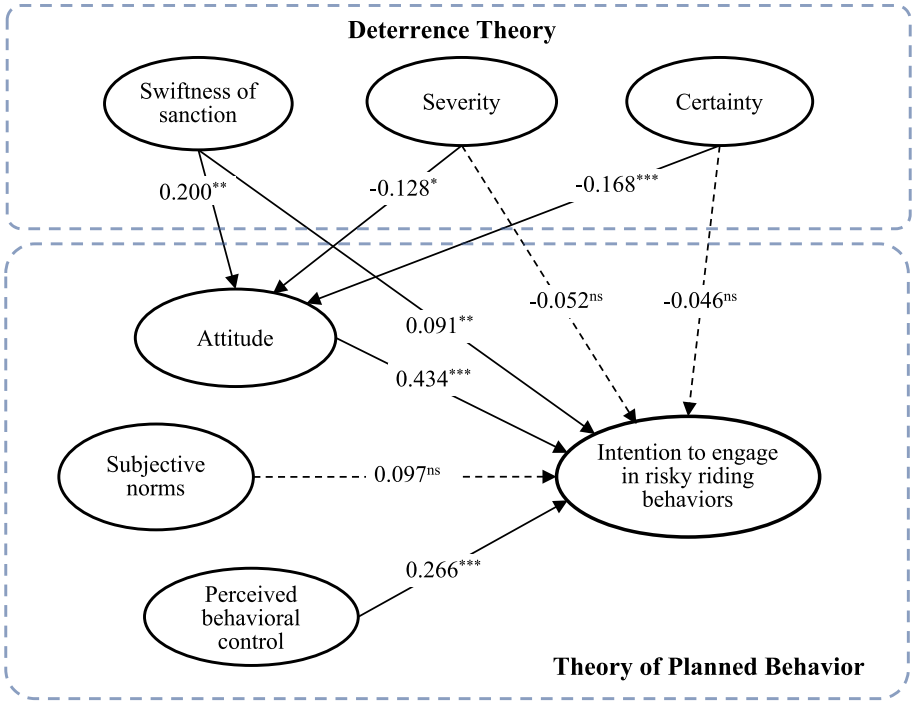

Fig. 2. Results of PLS-SEM model – Food delivery riders.

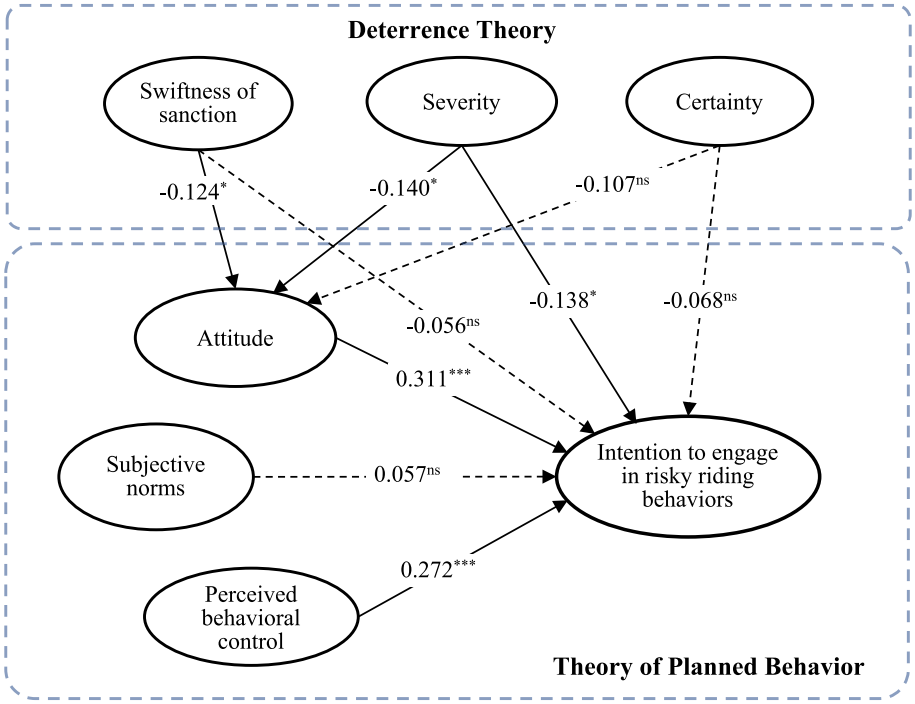

Fig. 3. Results of PLS-SEM model – Private riders.

Table 6
Results of indirect effects between each construct.

Indirect Effect	Food delivery riders			Private riders		
	Coefficient	t-value	p-value	Coefficient	t-value	p-value
CER→ATT→ITT	−0.073**	2.939	0.003	−0.033ns	1.692	0.091
SER→ATT→ITT	−0.056*	2.279	0.023	−0.044*	2.197	0.028
SOS→ATT→ITT	0.087***	3.554	< 0.001	−0.039ns	1.877	0.061

Note: ns p > 0.05, * p <= 0.05, ** p <= 0.01, *** p <= 0.001.

Table 7
Results of total effects.

Total effect	Food delivery riders			Private riders		
	Coefficient	t-value	p-value	Coefficient	t-value	p-value
ATT→ITT	0.434^{***}	7.707	< 0.001	0.311^{***}	6.665	< 0.001
PBC→ITT	0.266^{***}	5.456	< 0.001	0.272^{***}	4.991	< 0.001
SOS→ITT	0.178^{***}	4.347	< 0.001	-0.094^{ns}	1.585	0.113
CER→ITT	-0.119^{**}	2.943	0.003	-0.101^{ns}	1.540	0.124
SER→ITT	-0.108^{*}	2.225	0.026	-0.182^{**}	2.842	0.004
SUN→ITT	0.097^{ns}	1.947	0.052	0.057^{ns}	1.101	0.271

Note: ^{ns} p > 0.05, * p <= 0.05, ** p <= 0.01, *** p <= 0.001.

4.3.3. Predictive assessment

In PLS-SEM, the predictive accuracy of a structural model can be tested through the level of prediction accuracy (R^2) and the level of predictive relevance (Q^2) (Hair et al., 2017). The R^2 and Q^2 values must be greater than zero for a particular endogenous structure to indicate the predictive accuracy and the predictive relevance of a PLS-SEM model. According to the rule of thumb suggested by Chin (1998), R^2 values of 0.67, 0.33 and 0.19 for the endogenous constructs can be described as substantial, moderate, and weak, respectively. Consequently, the R^2 values for the intention to engage in risky riding behaviors (ITT) are 0.455 for the delivery rider model and 0.391 for the private rider model, indicating a moderate level of predictive accuracy in both models. According to Hair et al. (2016), Q^2 values of 0.02, 0.15, and 0.35 indicate small, medium and large predictive relevance, respectively for a certain endogenous construct. The Q^2 values of ITT are 0.289 for the delivery rider model and 0.207 for the private rider model, revealing a medium level of predictive relevance for both models.

5. Discussion

5.1. Theoretical implications

This study investigates the complex dynamics of how psycho-social and legal factors influence the intentions of risky riding behaviors within two distinct groups: food delivery riders and private motorcycle riders. The research evaluates a combined theoretical model based on the Theory of Planned Behavior and Deterrence Theory. A key theoretical contribution of this study is the confirmation that the TPB plays a crucial role in explaining the underlying factors influencing the intention to engage in risky riding behavior, even when controlling for legal factors. Specifically, attitude was identified as the strongest predictor of intention within both groups, consistent with previous studies indicating that individuals with a more positive attitude toward risky riding behaviors are more likely to intend to engage in them (Nguyen et al., 2020; Tang et al., 2020). According to Satiennam et al. (2018), delivery riders' attitudes toward risky riding reflect their inclination to prioritize time efficiency and convenience throughout the food delivery process. Additionally, perceived behavioral control significantly impacted the intention to engage in risky riding behaviors in both groups, aligning with earlier research (Moan and Rise, 2011; Moan, 2013; Tang et al., 2020). However, subjective norms did not significantly impact the intention to engage in risky riding behaviors in either group, which is consistent with many previous studies (Yang et al., 2018; Ketphat et al., 2013). This finding suggests that although individuals may be aware of the negative consequences of risky riding behaviors, they may not be influenced by the expectations of others regarding their own riding practices (Brijs et al., 2014; Nguyen et al., 2020) in Vietnam. This may also reflect a broader societal norm where such behaviors are generally accepted within the community.

The swiftness of penalties and certainty are found to be significant predictors of the intention to engage in risky riding behaviors through attitude, a full mediator, among the delivery riders but not among the private riders. This is consistent with the findings of Szogi et al. (2017), which highlighted the importance of swiftness in the prevention of risky driving behaviors. An explanation for this is that having to quickly deal with penalties might represent an immense burden for drivers due to both time constraints and the economic impact, as they are generally in conditions of economic distress since salaries are not necessarily the best.

Regarding certainty, previous studies show that certainty significantly reduces recidivism for traffic violations (Ritchey and Nicholson-Crotty, 2011; Kergoat et al., 2017; Truelove et al., 2017; Truelove et al., 2021a). However, this variable was found to influence the intention to engage in risky riding behaviors via attitude among delivery riders, not among private riders. Arguably, the heightened impact of punishment certainty on delivery riders' intentions stems from their heightened identifiability due to the use of the company uniform, making them highly conspicuous on the road. Consequently, these riders perceive themselves to be at an elevated risk of receiving fines, especially in the presence of traffic police or at locations equipped with surveillance cameras. It would not be strange that targeted actions by police with groups already identified to have a higher risk might have contributed to this effect. Naturally, these strong relationships could result in the development of attitudes, which in turn affects their intention to engage in risky riding behaviors. Associations between legal and psychosocial factors are rarely explored in the literature, but the fact that they were significant in this study confirms the need to continue exploring how they intersect to influence behavior. This adds further evidence to the thesis that legal factors alone are not sufficient as an intervention to prevent risky behavior on the road.

Perceptions of severity of punishment are found to significantly impact the intention to engage in risky riding behaviors for both delivery riders and private riders. The influence of this variable has been consistently reported within previous research (Freeman et al., 2006a; Ritchey and Nicholson-Crotty, 2011; Kergoat et al., 2017; Szogi et al., 2017). Perceptions of severity in this study acted as a substantial deterrent, making individuals in both groups less inclined to engage in risky riding behaviors. This was somewhat expected as Vietnam's road traffic law imposes fines ranging from 400,000 to 600,000 VND for infractions such as not using a helmet or improperly fastening helmet straps (2021), which is rather high. Notably, the study participants unanimously agreed that this fine is relatively substantial, especially against the backdrop of the average personal income in Vietnam, which is 4.2 million VND per month (Nguyen, 2023).

Among the three constructs of Deterrence Theory examined, severity was the only predictor influencing the attitudes of private riders, in line with the findings of previous studies (Peace et al., 2003; Koranteng et al., 2020). Conversely, the swiftness of sanction was the only predictor of delivery riders' attitudes, contradicting the findings of Abramovaite et al., (2023), which identified that longer waiting times for punishment could increase law violations. This could be indicative of the varying psychological impacts that the timeliness and severity of sanctions have on different groups. For private riders, the severity of penalties consistently shapes compliance, aligning with previous findings within the information security industry. In contrast, the immediacy of penalties significantly influences delivery riders' behaviors, reflecting their unique operational pressures and expectations. This difference could lead to a sense of uncertainty and anxiety among delivery riders when

sanctions are delayed, potentially exacerbating stress and impacting their decision-making processes on the road.

The overall results of the study strongly suggest that relying solely on deterrence as a model for traffic violation prevention is insufficient for policymakers. While deterrence can shape certain behaviors through the severity and immediacy of sanctions, it fails to address the broader social determinants that significantly influence individual behavior. For instance, the distinct ways in which private and delivery riders react to penalties highlight the need to consider factors such as economic pressures, workplace expectations, and social norms. These factors can deeply affect attitudes and behaviors, potentially neutralizing or even overpowering the effects of deterrence-based strategies.

To craft more effective traffic safety policies, policymakers must adopt a multifaceted approach that not only incorporates enforcement strategies but also a deep understanding of these social determinants. This approach involves engaging with the community to understand the specific challenges and motivations of different rider groups and designing policies that encourage positive behaviors through education, awareness campaigns, and community engagement initiatives. Additionally, interventions should be tailored to address the specific needs and circumstances of the target populations, considering factors like economic conditions, cultural norms, and occupational demands. By integrating these elements, policymakers can create more sustainable and responsive traffic safety policies that acknowledge the complexities of human behavior and societal dynamics.

The findings that delivery riders are more significantly affected by deterrence measures may also relate to the increased scrutiny they face from both police and the general public, who often perceive them as contributing disproportionately to traffic issues due to their visible presence and urgent riding behaviors. This perception can lead to what might be seen as targeted enforcement and societal bias, exacerbating the vulnerability of delivery riders. These riders, who already navigate significant risks on the roads without substantial physical protection and under strict job demands (Nguyen-Phuoc et al., 2023), are further challenged by this additional societal pressure. To address these concerns effectively, policies should focus on creating a more balanced understanding of the pressures and risks associated with delivery work. It is crucial to ensure equitable treatment by law enforcement and to foster a public attitude that supports safety and acknowledges the essential services provided by these workers rather than reinforcing stigma or discrimination.

5.2. Practical implications

The present research highlights several practical implications for reducing the intention to engage in risky riding behaviors among delivery riders and private riders, particularly within the context of developing countries. Firstly, the results indicate that attitude is the strongest predictor of the intention to engage in risky riding behaviors. Consequently, evidence-based psychological interventions are needed to target attitudes among both cohorts, especially food delivery riders – who displayed higher intentions to engage in risky behaviors – which could effectively reduce such intentions. Moreover, the three deterrent factors of deterrence theory collectively shape the attitude of delivery riders. This means there is scope to optimize enforcement to modify behavior and attitudes, which could ultimately return greater safety benefits.

Secondly, perceived behavioral control, identified as the second strongest predictor of risky riding behaviors in both groups, significantly impacts how riders behave on the road, especially among delivery riders who often exhibit marked confidence in their riding abilities, which tends to amplify under favorable traffic conditions. This heightened confidence can paradoxically lead to increased risk-taking; for instance, riders might choose to maneuver through traffic more aggressively to meet tight delivery schedules, believing they can handle potentially hazardous situations due to their skills. This becomes especially problematic when it encourages behaviors such as speeding, weaving through traffic, or ignoring traffic signals – actions that they might perceive as efficient strategies to maximize work outputs and manage time pressures (Gupta et al., 2024). For example, a delivery rider might decide to run red lights when streets are less congested, justifying this decision with their ability to quickly and safely clear intersections before oncoming traffic presents a danger. This behavior not only increases the risk of crashes but also sets a dangerous precedent that could influence other riders' perceptions of what is acceptable. Managing these risk perceptions is crucial and involves not only reinforcing the potential dangers associated with such behaviors through training and awareness campaigns but also structuring work incentives and schedules in ways that do not encourage risky riding.

Thirdly, the significant negative correlation between the severity of penalties and the intention to engage in risky riding behaviors in both groups highlights the importance of considering higher penalties by regulatory agencies or platform companies to strengthen the deterrent effect against risky riding behaviors. Implementing harsher and alternative penalties, such as confiscation of rider's licenses or vehicle impoundment, should be part of a broader strategy that includes increased law enforcement efforts. This dual-pronged approach is crucial for enhancing the certainty of arrest and thereby reinforcing the overall deterrent impact on risky riding behaviors. Care must be taken to ensure that penalties are not so harsh that police might not want to apply them, as has been shown in previous research (Truelove et al., 2023). For delivery riders, the swiftness of sanctions and the certainty of punishment were identified as the deterrent influence, underscoring the effectiveness of road traffic management. In response to this finding, proactive measures such as the strategic deployment of law enforcement personnel at traffic hotspots – areas with high traffic volumes and increased accident risks – could be considered by the government. Additionally, enhancing penalties through the use of traffic cameras to identify and document violations can further improve this deterrent effect. Riders tend to have a higher perception of certainty regarding punishment for infractions detected by cameras compared to traditional police enforcement methods. Nonetheless, we must also warn against the use of technologies that help riders avoid penalties from cameras (Oviedo-Trespalacios and Watson, 2021; Truelove et al., 2023), as we need practitioners to rally against their existence.

The industry, particularly companies that employ delivery riders and private motorcyclists, must adopt comprehensive strategies to ensure safer riding behaviors. A crucial step is the implementation of regular, paid, and mandatory evidence-based safety training programs that cover traffic laws, risk assessment, defensive driving techniques, and the importance of using safety gear. These programs should be practical and tailored to the specific challenges riders face daily. Other recommendations should also follow the development of rider resources in the workplace, such as adequate feedback and social support (Nguyen-Phuoc et al., 2022a). Moreover, companies should enhance rider support by providing quality safety equipment, such as helmets and protective clothing, and by maintaining the motorcycles to ensure they are in good working condition. Additionally, implementing a supportive work environment that does not incentivize risky behaviors through unreasonable delivery times or performance pressures is vital. By promoting a culture that prioritizes safety, companies can significantly reduce the incidence of traffic incidents involving their riders and contribute to broader road safety initiatives (Nguyen-Phuoc et al., 2022a).

5.3. Limitations

The study presents several limitations that offer opportunities for further research. Firstly, its scope is confined to delivery personnel using internal combustion engine motorcycles in a low- and middle-income country. Future research could extend to individuals involved in e-scooter delivery or e-bike in more advanced economies, exploring both common characteristics and unique challenges specific to different

contexts and technologies. Additionally, the current study has not examined the influence of participants' demographic characteristics (e.g., gender, age, and education level) on the intention to engage in risky riding behaviors as well as the interactions between risky riding behaviors and the contributing factors. Addressing this gap could provide deeper insights into how different demographic groups are affected by and respond to various deterrents and educational interventions. Furthermore, there is a need to improve the quality of data in future research surveys. This improvement can be achieved by moving away from an over-reliance on self-report methods and toward more objective, possibly observational approaches that mitigate the biases often associated with self-reported data. This strategic shift is crucial for enhancing the robustness and reliability of research outcomes in future investigations, ensuring that findings are both valid and applicable across broader contexts.

6. Conclusion

The present investigation underscores the importance of the Theory of Planned Behavior and Deterrence Theory in understanding and predicting the intentions and behaviors of delivery and private motorcycle riders in Da Nang City concerning risky riding practices. This research highlights that attitude is the strongest predictor of intention to engage in risky riding behaviors for both groups. Delivery riders, in particular, are significantly influenced by perceived behavioral control and the swiftness and certainty of penalties, whereas subjective norms do not significantly impact their behaviors.

The research reveals that delivery riders are more affected by legal deterrents, possibly due to their high visibility and the economic pressures they face, which are further exacerbated by swift and costly penalties. These riders perceive themselves as more identifiable and thus at higher risk of penalties due to company uniforms, contributing to a heightened impact of punishment certainty on their intentions. Conversely, private riders are more influenced by the perceived severity of penalties, aligning with findings that severe penalties consistently shape compliance behaviors. These findings suggest that while legal measures such as fines and penalties can deter risky behaviors, they are insufficient on their own. Instead, a multifaceted approach that integrates social determinants, such as economic pressures and workplace expectations, alongside legal interventions, is essential for effectively reducing risky behaviors. Policymakers and platform companies should design interventions that incorporate tailored educational programs and community engagement initiatives to address the diverse influences on rider behavior. To enhance the effectiveness of traffic safety policies, further research should focus on improving data collection methodologies to obtain more objective and comprehensive data. By considering the social and economic contexts of riders and implementing strategies that balance enforcement with education and social initiatives, a safer riding environment can be fostered. Ultimately, this approach will lead to more rule-aware and compliant riders, significantly reducing the incidence of traffic crashes among delivery and private motorcycle riders.

CRediT authorship contribution statement

Duy Quy Nguyen-Phuoc: Writing – review & editing, Writing – original draft, Software, Methodology, Data curation, Conceptualization. **Nhat Xuan Mai:** Writing – review & editing, Writing – original draft, Conceptualization. **Inhi Kim:** Writing – review & editing, Writing – original draft, Conceptualization. **Oscar Oviedo-Trespalacios:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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