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Assessing Risky Riding Behaviors Among Food Delivery Motorcyclists in Thailand: Insights from the Motorcycle Rider Behavior Questionnaire and Health Belief Model

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Abstract: Background: Food delivery motorcyclists face unique risks that often lead to risky riding behaviors. Thailand, with one of the highest rates of motorcycle-related injuries and fatalities globally, has seen a surge in food delivery services following the COVID-19 pandemic, increasing the number of motorcyclists on the roads. Delivery motorcyclists are especially vulnerable due to frequent exposure to traffic congestion, time pressures, and adverse weather. This study aims to identify key health beliefs and external factors contributing to risky riding behaviors among food delivery motorcyclists in Thailand. Methods: The study surveyed 2000 food delivery motorcyclists across five regions in Thailand, employing the Motorcycle Rider Behavior Questionnaire and the Health Belief Model. Structural equation modeling was used to analyze the relationships between health beliefs and risky riding behaviors. Results: The analysis revealed that health motivation, perceived susceptibility, perceived severity, perceived benefits, and cues to action were negatively associated with risky riding behaviors. Conversely, perceived barriers positively influenced these behaviors. Fatigue and aggressive riding were significant predictors of increased risky behaviors at the 0.001 level. Conclusions: Addressing individual health beliefs and external factors like fatigue and aggression is essential for reducing risky riding behaviors and preventing severe injuries.

Keywords: risky riding behaviors; food delivery; health belief model; MRBQ; structural equation modeling

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1. Introduction

Road accidents continue to be a major issue globally, especially in developing countries, where they result in a high number of fatalities [1]. Statistics reveal that over half of these fatalities involve vulnerable groups, with 75.29% being motorcyclists (Figure 1). This road danger for motorcyclists must be urgently addressed. There are many types of road accidents, such as crashes between cars, cars and pedestrians, or cars and animals [2], each of which has different factors. A road accident affects the parties both directly (a person is hurt or dies, experiences regret, must pay medical fees, or shoulders the cost of damaged property) and indirectly (working time is wasted, incomes drop, and there are mental and emotional effects on surrounding people). A high accident rate inevitably affects the nation's social and economic health. Addressing road safety issues, particularly for motorcyclists, is therefore an urgent priority [3]. Pervez et al. [4] note that motorcycle crashes are associated with particularly high fatality rates, underscoring the need for targeted safety interventions.

At present, Thailand is a middle-income developing country [5] but has the highest rank of road accidents in the world (with a mortality rate of 32.7 motor vehicle deaths per hundred thousand population) [1], a significant and worrying statistic. In addition, Thailand's proportion of deaths from motorcycle accidents reached 24.3 people per hundred thousand population (the highest rate in the world) [1], the causes of which relate to the motorcyclists' riding behavior. The report [6] spans 10 years of retroactive data (2011–2021) of 366,779 motorcycle trips per year (1005 per day). Therefore, where the number of motorcycles was higher, the number of road users was also greater, and this also may have been the cause of high accidents.

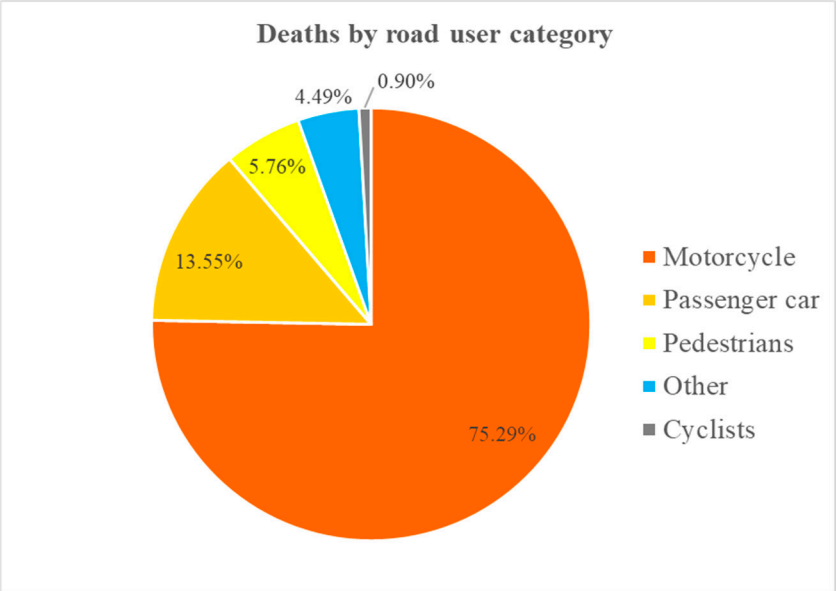

Figure 1. Proportion of road traffic fatalities in Thailand by vehicle type (Source: Road Traffic Death Data Integration [7]).

Commercial motorcyclists, particularly food delivery riders, have become an integral part of urban transportation due to the rapid growth of on-demand delivery services, especially following the COVID-19 pandemic. This surge is especially notable in Thailand, where the food delivery industry has expanded significantly in recent years. Thailand consistently reports one of the highest rates of motorcycle-related accidents and fatalities globally, making it crucial to focus on this specific group to enhance road safety. Food delivery motorcyclists in Thailand face unique challenges such as intense time pressures to meet delivery deadlines, navigating heavy traffic congestion, and operating in adverse weather conditions. These factors contribute to heightened stress and encourage risky riding behaviors aimed at maximizing earnings and meeting customer expectations. The compensation models used by delivery platforms in Thailand often incentivize speed over safety, combining per-delivery payments with bonuses for high-volume deliveries. Prak et al. [8] found that this system can lead to hurried and fatigued riders who are more prone to traffic violations and accidents. Similarly, studies in South Korea [9] and China [10] have found that food delivery motorcyclists frequently break traffic rules to expedite deliveries, resulting in increased accidents [11]. Despite these risks, there is a lack of comprehensive research in Thailand focusing on this demographic, highlighting the need for focused studies to develop effective safety interventions tailored to their specific circumstances.

To understand the factors contributing to risky riding behaviors among Thai food delivery motorcyclists, this study employs the Motorcycle Rider Behavior Questionnaire (MRBQ) and the Health Belief Model (HBM). The MRBQ is a validated tool widely used to assess self-reported riding behaviors and identify specific risk patterns among motorcy-

clists. The HBM provides a psychological framework for understanding how individual beliefs and perceptions influence health-related behaviors, including safety practices. Food delivery motorcyclists represent a unique subgroup of riders who frequently experience intense time pressures, fatigue, and stressful conditions due to the nature of their work. These factors often lead to aggressive riding behaviors, increasing the risk and severity of accidents. Focusing on this group in Thailand is particularly important, as the country has one of the highest rates of motorcycle-related injuries and fatalities globally. The rapid growth of the food delivery industry in Thailand has led to more motorcyclists on the roads, navigating through congested traffic and adverse weather conditions, which compounds the risks they face. Integrating the MRBQ with the HBM, this study offers a comprehensive examination of both the risky behaviors exhibited by food delivery motorcyclists and the underlying cognitive influences that contribute to these behaviors. This dual approach allows for the identification of specific behavioral patterns and the health beliefs that motivate them, which is essential for developing targeted interventions.

A comprehensive review of the existing literature, summarized in Table 1, indicates that previous studies have predominantly focused on factors such as speed violations, traffic errors, control errors, and social media use among motorcyclists. However, there is a notable scarcity of research addressing work-related factors specific to delivery motorcyclists, including time pressure, fatigue, and aggressive riding behavior. Additionally, critical influences like alcohol use and stunt behavior are frequently overlooked, with only sporadic consideration across studies. This limited focus highlights a significant gap in understanding the full range of risky behaviors impacting food delivery motorcyclists.

This study aims to bridge existing research gaps by focusing exclusively on food delivery motorcyclists—a high-risk group that has received insufficient attention in prior studies. Unlike general or non-commercial riders, food delivery motorcyclists face unique pressures such as strict delivery deadlines, extended working hours, and navigating congested urban traffic. These specific stressors have not been thoroughly explored in previous research. To assess the various risky behaviors associated with this group, we employed the Motorcycle Rider Behavior Questionnaire (MRBQ) with 43 variables, the Health Belief Model (HBM) with 35 variables, and work-related factors (time pressures, fatigue, and aggressive driving behaviors) with 14 variables, resulting in a comprehensive set of 92 variables tailored to food delivery motorcyclists.

This research provides a nuanced understanding of the unique challenges and risks faced by food delivery motorcyclists in Thailand. The findings will inform the development of targeted and sustainable policies and road safety measures specifically designed for this group. Furthermore, by addressing both behavioral and cognitive aspects, the study contributes to enhancing road safety and reducing accidents among food delivery motorcyclists, thereby filling a critical void in the current body of knowledge.

2. Literature Review

Extensive research has been undertaken to identify factors associated with risky behaviors among motorcyclists. For instance, research by Huth et al. [12] considered the human factor as an important part of motorcycle accidents, seeking to understand interactions between individual riding behaviors of motorcyclists and road users as well as environmental danger. Theofilatos and Yannis [13] found that riding behavior had complications, expressed through various actions. Motorcyclists' risky riding behavior has attracted the attention of many researchers. Issues that have been widely addressed in academic research include speed violations [14,15], traffic errors, stunts [16,17], control errors [18], social media use [19], and alcohol [20,21]. Despite this comprehensive body of work, there is a noticeable lack of studies focusing on the risky riding behaviors of food delivery workers in Thailand. Most existing research concentrates on general motorcyclists or specific groups with distinct riding styles, thereby neglecting the unique pressures and challenges faced by food delivery riders. Factors such as strict delivery deadlines, prolonged working hours, and the need to navigate congested urban traffic are unique

to this group but remain underexplored in the literature. This omission restricts our understanding of the specific elements that contribute to the risky behaviors of food delivery workers, leaving critical questions about their safety and the challenges they encounter on the road unanswered.

Multiple methods have been developed that have led to examinations of riding behavior and its relationship to accident occurrence. Among these, the MRBQ is an outstanding tool that has received extensive use in the study of motorcycle riding behavior, as it reports the response characteristics of the riders in many situations, such as overtaking, making turns, and curve turning, which explains the accident probability due to the expression of riding behavior. In addition, the principle of MRBQ has been applied to the study of many countries, including developed ones, such as Australia [14,22], Slovenia [23], and the United Kingdom [24]; countries where two-wheeled vehicles and motor tricycles are largely used for entertainment or sport, such as Iran [25] and Turkey [18]; and developing countries having a high motorcycle use. The latest studies have been conducted in developing countries, such as Thailand [26], Nigeria [27], India [28], Vietnam [29], and Pakistan [30].

The HBM concept was designed to explain health behavior by focusing on attitudes and individual beliefs [31], and it consists of six factors, as follows:

Health Motivation

Health motivation refers to the level of interest or valuation a person has for health. Someone with a high degree of health motivation prioritizes health and is motivated to follow safety measures [32]. Health motivation has a high influence on individual risky behaviors and road safety behaviors. For example, the studies have shown that person with high health motivation tend to use the safer riding methods, such as wearing a helmet [33,34], wearing a seat belt, and following traffic rules [35]. By contrast, a lack of health motivation may cause nonfeasance and increase road accidents. These considerations led to the following research hypothesis:

H_1: *Health motivation has a significant and negative effect on risky riding behaviors.*

Perceived Susceptibility

Perceived susceptibility describes the individual belief in meeting health problems or dangerous situations [36]. This concept forms the basic composition of many health behavior theories, including the HBM. Moeini et al. [37] identified that someone with high perceived susceptibility will tend to ride carefully and tend to follow the safety guidelines. Further, someone who has low perceived susceptibility may perform risky behavior, increasing the likelihood of an accident and serious injury [38]. Moreover, research by Morowatisharifabad [39] and Soltani and Sharifi Rad [40] has shown that perceived susceptibility is a supportive factor in safe riding behavior. Thus, the research hypothesis was proposed:

H_2: *Perceived susceptibility has a significant and negative effect on risky riding behaviors.*

Perceived Severity

Perceived severity is related to a person's beliefs concerning the severity of a health problem and its effects [41]. The context of this study relates to the perceived severity of accidents' effects on life and property accidents. The perceived severity of accidents and injuries affects riding behavior. A previous study showed a relationship between perceived severity and rider behavior. Dadipoor et al. [42] showed that the perceived severity of accidental injury leads to safety measures, and Özbay [38] emphasized that riders who are aware of the serious effects of road accidents tend to reduced dangerous riding behavior.

H_3: *Perceived severity has a significant and negative effect on risky riding behaviors.*

Perceived Benefit

Perceived benefit refers to the belief in expected benefits from following safety measures. For food delivery motorcyclists, perceived benefits may consist of the belief that advantages arise from following safe riding behavior. These benefits include improved individual safety, decreased risk of accident, and better work efficiency. Razmara et al. [41] found that perceived benefit had a positive relationship to safety riding behavior, which is a factor of behavior evaluation, finding that it influenced the safety riding behavior in a commercial rider group.

H_4: *Perceived benefit has a significant and negative effect on risky riding behaviors.*

Perceived Barriers

In all compositions of the HBM, perceived barriers play an important role and can influence individual actions. However, perceived barriers relate to an individual's evaluation of the barriers preventing the following of health behavior suggestions. Perceived barriers include sight of the barriers or difficulty in following the traffic rules and are a factor that positively affects risk behavior. Perceived barriers may include time limitations or uncomfortable working conditions. Mazengia et al. [36] found that perceived barriers had a positive relationship with risky riding behavior.

H_5: *Perceived barriers have a significant and positive effect on risky riding behaviors.*

Cues to Action

Cues to action are stimuli or motivations encouraging individuals to participate in healthy behavior and can be internal (thought or emotion) or external (environmental factors or social influences). They have an important role in specifying behavior supporting safety [32,43]. Razmara et al. [41] showed that the cues to action, such as campaign messages regarding public health or private experience, form an important predictor for safety riding behavior. In the context of food delivery motorcyclists, cues to action may include safety measures for a company or an organization. The campaign of safety riding and the influence of colleagues play an important role in riders' decisions to follow or ignore safety riding. Previous research, as described above, led to the following research hypotheses as follows:

H_6: *Cues to action have a significant and negative effect on risky riding behaviors.*

However, the behavior of food delivery motorcyclists differs from that of riders in general. This study considers the factors that relate to the working characteristics of food delivery motorcycle riders, who face significant risks and challenges in their working conditions. The three related factors of work consisted of exhaustion, time pressure, and aggressive riding behavior.

Time Pressure

Time pressure provides an important factor that affects food delivery riding behavior. Food delivery service as a type of business stresses speed and efficiency, always rewarding rapid delivery with higher compensation or a higher rank, making it a high-pressure environment and forcing riders to meet specific times to earn more income and continue working. The serious time pressure of the delivery platform is an important factor in the dangerous behavior and accidents of food delivery motorcyclists [44]. This pressure can lead to high-speed riding, ignoring traffic lights, and driving on the wrong side of the road, along with other risky behavior. The pressure of rapid delivery goes beyond decreasing safety to include stress levels that can impede decision-making. The riders who are under time pressure tend to ride aggressively, which is dangerous to themselves and to other users of the road. Dong et al. [44] identified that the most outstanding characteristic dividing food delivery riders from other riders was the working conditions of the riders who seek to always deliver food on time, as if they do not deliver food, they

could receive complaints from customers or could be punished by their working platform. For this reason, food delivery riders always ride under time pressure, an important factor in causing aggressive riding behavior [45–47]. From the cited studies, the following research hypotheses are developed:

H_7: *Time pressure has a significant and positive effect on aggressive driving behaviors.*

H_8: *Time pressure has a significant and positive effect on fatigue.*

Fatigue

Fatigue is a serious problem for delivery riders, who work for long periods without sufficient rest. Delivery riders require alertness and the ability to respond rapidly, but working for a long time without rest can lead to mental and physical fatigue. Fatigue impedes brain functions, decreases reaction times, and reduces alertness, all of which may increase the risk of an accident. Truong et al. [48] studied the participants in accidents involving hired motorcyclists related to fatigue in Hanoi, Vietnam, and found that 16% of hired motorcyclists reported that their accident was due to fatigue, and 57% of all reported accidents due to hired motorcyclists were related to fatigue. Zheng et al. [10] studied participation in crashes and risky riding behavior of food delivery workers in China and found that food delivery staff face unsafe working conditions due to long working times and deficient rest; they also reported that fatigue and risky riding behavior are serious enablers of accidents while working.

H_9: *Fatigue has a significant and positive effect on risky riding behaviors.*

Aggressive Driving Behavior

Road accidents have a significant relationship to aggressive behavior while driving [49]. In 53% of fatal accidents, the cause of death was aggressive behavior while driving [50]. Aggressive driving behavior includes many types of dangerous behavior, such as high-speed driving, tailgating, changing lanes often and suddenly, and breaking traffic rules. For delivery riders, aggressive riding behavior could be a response to internal and external pressure. An example of internal pressure is the demand to meet the delivery time limitation to increase one's income. External pressure could be the natural competition in which many riders are competing for the same work, increasing the rush and competition on the road. Moreover, aggressive driving behavior greatly increases the risk of an accident's happening. Stanojević et al. [51] found that aggressive driving behavior is also related to drivers' risky behavior. Fitzpatrick et al. [52] showed that when drivers are under time pressure, they tend to increase their speed and exhibit more aggressive driving behavior. Furthermore, when drivers are under time pressure, their thoughts are dominated by their intention to finish their work, even if it comes at the cost of their safety [53,54].

H_{10}: *Aggressive driving behaviors have a significant and positive effect on risky riding behaviors.*

Literature reviews and related research show factors related to driving behavior and accidents; the researcher summarizes these factors in Table 1.

Table 1. Summary of previous studies on MRBQ.

No.	Author	Speed Violations	Traffic Errors	Stunt	Control Errors	Social Media	Alcohol	Fatigue	Time Pressure	Aggressive Driving
1	Sexton et al. [55]	✓	✓	✓	✓					
2	Elliott et al. [24]	✓	✓	✓	✓					
3	Sunday and Akintola [27]	✓		✓	✓					
4	Motevalian et al. [25]	✓	✓	✓	✓					
5	Özkan et al. [18]	✓	✓		✓					

Table 1. *Cont.*

No.	Author	Speed Violations	Traffic Errors	Stunt	Control Errors	Social Media	Alcohol	Fatigue	Time Pressure	Aggressive Driving
6	Putranto et al. [56]	✓	✓	✓						
7	Sakashita et al. [22]	✓	✓	✓	✓					
8	Topolšek and Dragan [23]	✓	✓	✓			✓			
9	Stephens et al. [14]	✓	✓	✓	✓					
10	Azman et al. [57]	✓	✓							
11	Zheng et al. [10]							✓	✓	✓
12	Möller et al. [58]	✓		✓						
13	Uttra et al. [26]		✓	✓	✓					
14	Trung Bui et al. [29]	✓	✓		✓					
15	Chouhan et al. [28]	✓	✓	✓	✓					
16	Ospina-Mateus et al. [16]	✓	✓	✓	✓					
17	Sumit et al. [17]		✓	✓	✓					
18	Babajanpour et al. [59]									
19	Quy Nguyen-Phuoc et al. [60]							✓	✓	
20	Quy Nguyen-Phuoc et al. [61]							✓	✓	✓
	This study	✓	✓	✓	✓	✓	✓	✓	✓	✓

3. Methodology

In Thailand, motorcycles account for over 75% of traffic fatalities and injuries [7]. Understanding motorcyclists' behaviors and adapting the Motorcycle Rider Behavior Questionnaire (MRBQ) to local dynamics is essential due to differences in cultural norms, regulations, and riders' varied experiences [30].

Existing MRBQ studies have identified key factors influencing motorcyclist behaviors, including speed violations [29,55,56], traffic errors [17,25], control errors [24,27,55], and stunts [17,28]. Additionally, recent research highlights alcohol consumption [29] and distractions such as social media use [62] as critical elements explaining risky behaviors among motorcyclists.

This study focuses on capturing risky riding behaviors among food delivery motorcyclists, a distinct group that frequently faces intense time pressures. These pressures often lead to aggressive riding behaviors and increased fatigue, significantly heightening both the likelihood and severity of accidents [10,61]. To achieve a more comprehensive understanding of motorcyclist behavior within this specific context, it is essential to integrate these additional factors—currently not covered by the traditional MRBQ model. By incorporating elements like social media use, the research acknowledges the evolving nature of distractions that impact rider safety.

Furthermore, the adaptation of the MRBQ to include these dimensions provides valuable context-specific insights that can inform targeted policy interventions and safety programs tailored to the unique road conditions and traffic patterns in Thailand. This comprehensive approach not only enhances the assessment of risky riding behaviors but also lays the groundwork for future research to explore digital distractions in various geographic and cultural settings, thereby improving the generalizability and applicability of road safety measures across different populations.

The research process for this study, as illustrated in Figure 2, began with a comprehensive literature review to identify existing knowledge and gaps related to risky riding behaviors among food delivery motorcyclists. Following this, modifications were made to the questionnaire to ensure that it accurately captured the relevant behaviors and health beliefs of motorcyclists, integrating elements from the Motorcycle Rider Behavior Questionnaire (MRBQ) and the Health Belief Model (HBM). The modified questionnaire underwent evaluation through an Item-Objective Congruence (IOC) process, where experts assessed

each item for relevance and clarity. Next, a pilot test was conducted to further refine the questionnaire and confirm that it was suitable for the target population. After refining the questionnaire based on the pilot test feedback, the study received approval from the relevant Ethics Committee (EC), ensuring that the research adhered to ethical principles for studies involving human subjects. With ethical approval in place, data collection commenced, targeting food delivery motorcyclists across five regions in Thailand. Following data collection, a data preprocessing step was carried out to clean and prepare the data for analysis. Normality statistics were then calculated to verify that the data met the assumptions required for advanced statistical analysis. The next step involved Confirmatory Factor Analysis (CFA) to assess the validity and reliability of the measurement model, followed by Structural Equation Modeling (SEM) to examine the relationships between health beliefs, work-related factors, and risky riding behaviors. The findings were then synthesized in the results and discussion section, leading to the conclusion and recommendations, where practical insights and policy recommendations were provided to improve road safety among food delivery motorcyclists.

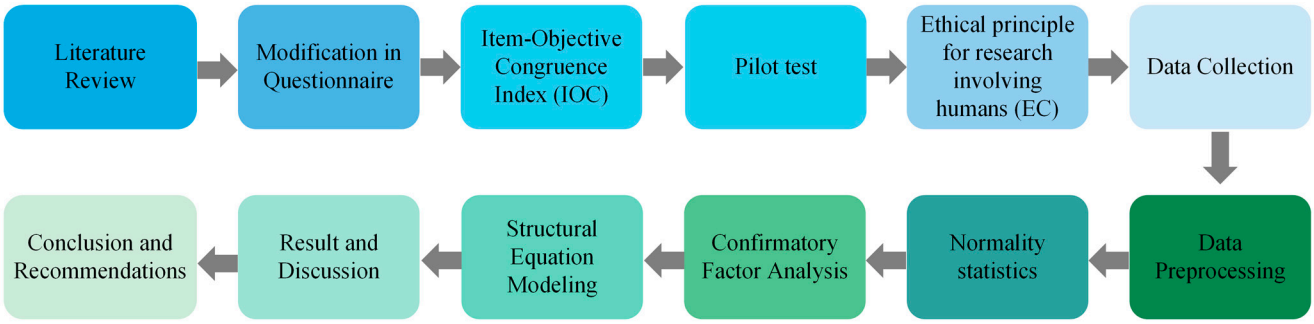

Figure 2. Research process.

3.1. Ethical Considerations

This study received ethical approval from the Human Research Ethics Office of Suranaree University of Technology, Thailand (Approval Code: COE No.139/2566). The questionnaire was meticulously designed to provide participants with a clear and detailed explanation of the study's purpose, procedures, and potential risks. All participants were informed of their rights, including the ability to decline participation or withdraw from the study at any time without any negative consequences. The study posed minimal risks, such as potential emotional discomfort from recalling accident experiences, concerns about privacy when sharing personal information, and slight inconvenience from allocating time to complete the questionnaire. These risks were mitigated by ensuring voluntary participation, offering the option to withdraw at any stage, and anonymizing data to protect participants' privacy. To further safeguard confidentiality, all collected data were kept strictly confidential, with personal identifiers removed to prevent any linkage to individual participants. Additionally, the study's findings are reported in an aggregated format to ensure that individual responses remain anonymous, thereby upholding the highest ethical standards in data handling and participant protection.

3.2. Data Collection and Questionnaire Survey

The data collection instrument utilized in this study was a questionnaire developed from the Motorcyclist Behavior Questionnaire (MRBQ) and the Health Belief Model (HBM). This questionnaire underwent rigorous assessment and validation through an index of item-to-objective congruence (IOC) process. In April 2024, a team of experts conducted data collection using a self-administered questionnaire specifically targeting food delivery motorcyclists. The data for this study were collected from food delivery motorcyclists. The collected data were analyzed using structural equation modeling (SEM), which suggests the appropriate number of the sample for maximum likelihood estimation, which should

have a value of at least 20 times the observed variables' number [63]. Therefore, the number of data samples to be used in fieldwork for the random collection was backed up at 5% to prevent mistakes or damage to data, and the total sample used was 2000 people. The questionnaire used in this study consists of general answerer information and the characteristics of social and economic indicators of motorcycle rider behavior from the MRBQ, food delivery motorcyclist behavior, and attitudes toward driving, using an HBM that considers the collected data in relation statistics for gross regional product and gross provincial product [64]. The territory of Thailand was divided into five regions, with 400 samples per region, as shown in Table 2.

Table 2. Fieldwork data collection divided by region and province.

Region	Province	Number (Set)	Total (Set)
Northern	1. Chiangmai	135	400
	2. Kamphaeng Phet	130	
	3. Nakhon Sawan	135	
Central	1. Bangkok	135	400
	2. Samut Prakan	135	
	3. Phra Nakhon Si Ayutthaya	130	
Northeastern	1. Nakhon Ratchasima	135	400
	2. Khon Kaen	135	
	3. Ubon Ratchathani	130	
Eastern	1. Chonburi	135	400
	2. Rayong	135	
	3. Chachoengsao	130	
Southern	1. Songkhla	135	400
	2. Nakhon Si Thammarat	135	
	3. Surat Thani	130	

Participants were recruited during their waiting times at common gathering spots, such as shopping malls, roadside restaurants, and designated waiting areas. These locations were strategically selected to ensure that respondents had adequate time to complete the questionnaire without disrupting their work responsibilities. Initially, potential respondents were asked if they were willing to provide information. Upon their agreement, they were approached to assess their willingness to participate in the study. Researchers clearly explained the study's objectives, emphasizing the focus on behaviors and factors related to accidents. Participants were also informed of their right to withdraw from the study at any time without facing any consequences, ensuring that their participation was both voluntary and fully informed.

The questionnaire required participants to complete the MRBQ, specifically adapted to assess risky riding behaviors among food delivery motorcyclists. To capture the unique work environment of these riders, the questionnaire included three work-related factors: fatigue, time pressure, and aggressive riding behavior. Each item was rated on a 6-point Likert scale, from 1 ("never") to 6 ("always"), allowing respondents to indicate the frequency of their engagement in each behavior, with higher scores indicating a greater frequency of risky behaviors. Additionally, the questionnaire incorporated the HBM framework to explore six constructs related to health beliefs and perceptions that may influence risky riding behaviors. This section was rated on a 7-point Likert scale, ranging from 1 ("Strongly Disagree") to 7 ("Strongly Agree"), enabling participants to express nuanced levels of agreement regarding their health and safety beliefs. This comprehensive approach provides valuable insights into the factors influencing the risky riding behaviors of food delivery motorcyclists.

3.3. Data Analysis

The model specification for this research concept is drawn from the results of a literature review to show the relationship between the latent variables and between indicative variables and latent variables according to theoretical considerations or related research, as shown in Table 3, which consists of six HBM factors in total: health motivation, perceived susceptibility, perceived severity, perceived benefits, perceived barriers, and cues to action. The three factors considered in this study were time pressure, exhaustion, and aggressive driving behavior. These factors were analyzed using SEM to verify the complicated relationship between the observed variables and the latent ones, including testing hypotheses concerning the relationships in the theoretical model, including direct and indirect influence. Confirmatory factor analysis and measurement models are part of SEM, which has a role in verifying the correctness of the observed variables to explain the latent structure and can verify correctness and the complete causal analysis of the theoretical model before verifying the relationship of SEM. Moreover, the sufficiency evaluation for the SEM adopted accepted sufficiency criteria suggested by Browne and Cudeck [65], namely, a root mean square error of approximation (RMSEA) lower than 0.07; Steiger [66] suggested that the standardized root mean square residual (SRMR) be lower than 0.08, as seen in the data of Hu and Bentler [67]. It was suggested that the comparative fit index (CFI) value be more than 0.95, and Hooper et al. [68] suggested that the that the Tucker–Lewis index (TLI) value should be higher than 0.80 to indicate that the model is harmonic with the empirical data in acceptable criteria.

The basic statistical data processing and model analysis were performed using SPSS Software Version 20.0 and Mplus 7.1.

Table 3. The construct and measurement items.

Indicators		**References**
Speed violations		Krishnakishore and Othayoth [69]
SV1	Driving beyond the legal speed limit	
SV2	Disregarding the speed limit late at night or in the early morning.	
SV3	Driving over the speed limit in a community or village area.	
Traffic errors		Krishnakishore and Othayoth [69]
TE1	You exited the alley without reducing your speed and failed to check if other cars were coming or not.	
TE2	You disregard “give way” signs when you need to enter a narrow lane and give way to vehicles that have the right of way.	
TE3	You drive without noticing that there is a car cutting in front of your vehicle.	
TE4	Driving so closely behind the vehicle in front that it would be difficult to stop in an emergency.	
TE5	If the road is empty, you disregard the fact that the traffic light on your side is red and proceed to drive immediately.	
TE6	You attempt to overtake someone in front and you did not care to turn on your signal lights before doing so.	
Stunts		Krishnakishore and Othayoth [69]
ST1	You attempt to do a wheelie on a motorcycle.	
ST2	Pull away too quickly and your front wheel lifted off the road.	
ST3	Get involved in racing other riders or drivers.	
ST4	Intentionally do a wheel spin.	
Control errors		Krishnakishore and Othayoth [69]
CE1	You do not slow down or reduce your speed when entering a curve or intersection.	
CE2	You deliberately drive in the wrong direction or intentionally enter roads marked as “one way.“	
CE3	You often park in areas where parking is not allowed.	

Table 3. *Cont.*

Indicators		References
Social media		Jomnonkwao et al. [20]
SM1	Typing or reading messages on smartphones while driving.	
SM2	While driving, I looked at the map on my smartphone simultaneously.	
SM3	Use social media platforms (Facebook, Twitter, Instagram, Line) while driving.	
Alcohol		Jomnonkwao et al. [20]
AL1	Driving after drinking alcohol.	
AL2	During important festivals such as New Year, Songkran, or social gatherings, you often drink alcohol and drive.	
AL3	Driving after taking medicines that cause drowsiness.	
Time Pressure		Zheng et al. [10]
TP1	You frequently consider the penalties for late delivery.	
TP2	You often worry about late delivery while working because of the time limit for each order.	
TP3	You endeavor to process as many orders as possible to increase your compensation.	
TP4	You are concerned about providing food pick-up and delivery services during rainy weather.	
Fatigue		Zheng et al. [10]
FA1	You have trouble sleeping (such as difficulty falling asleep, waking up frequently at night, or waking up earlier than usual).	
FA2	You feel tired while working.	
Aggressive Driving		Zheng et al. [10]
AD1	You drive with aggressive behavior during work hours (such as following closely behind other vehicles, honking at vehicles in front)	
AD2	You often drove in competition with others and always thought that other cars prohibit overtakinge me.	
AD3	You drive without looking in the side mirror to see cars approaching from behind before turning, overtaking, or changing lanes.	
Health Motivation		Ambak et al. [33]
HM1	Road accidents caused by vehicle riding are the most dangerous ones.	
HM2	Health and the physical body are the most important factors when riding vehicles.	
HM3	Proper rest is the most important thing for vehicle riding.	
HM4	You pay attention to safety when riding a vehicle.	
Perceived Susceptibility		Razmara et al. [41]
PSU1	You know that lack of driving experience poses a high risk of accidents.	
PSU2	You know that drinking alcohol and driving can lead to accidents.	
PSU3	You understand that using a mobile phone or playing social media while driving may cause you to have an accident.	
Perceived Severity		Razmara et al. [41]
PSE1	If you do not wear a helmet, you may die if you get into an accident.	
PSE2	If an accident is caused by riding, it may cause death or disability, which requires long-term treatment.	
PSE3	Vehicle accidents would highly affect your study/work.	
PSE4	Accidents would affect your life and network, e.g., immediate family, friends, relatives, etc.	
PSE5	Each accident causes death, mental illness, and loss of time and money.	

Table 3. *Cont.*

Indicators		References
Perceived Benefits		Razmara et al. [41]
PBE1	You believe that if you wear a helmet and an accident occurs, you will not be injured much.	
PBE2	You feel that driving without wearing a helmet is unsafe.	
PBE3	You feel safe when driving cautiously or driving under the speed limit.	
PBE4	You think that following traffic rules will make you safe.	
Perceived Barriers		Razmara et al. [41]
PBA1	Wearing a helmet makes you feel uncomfortable.	
PBA2	You witness other people breaking traffic laws without facing prosecution, so you imitate their behavior.	
Cues to Action		Razmara et al. [41]
CTA1	You often encounter campaigns or public relations efforts about safe riding, which makes you always aware of this.	
CTA2	Your organization/company pays attention to safe riding/has a safe riding campaign.	
CTA3	You saw that polices are strict with regard to traffic discipline and that makes you pay more attention to driving safely.	
CTA4	You feel that there is an offense when driving faster than the legal limit.	

4. Results

4.1. Descriptive Statistics

The initial questionnaire results were obtained from 2000 participants from five regions of Thailand (North, Central, Northeastern, Western, and South), 400 respondents per region. As shown in Table 4, the survey found that most respondents were male (86.15%), most were 30–44 years old (56.25%), and most were single (50.35%). A plurality had graduated from high school/vocational certificate (37.65%). Notably, 75.10% of respondents are full-time food delivery motorcyclists, dedicating their primary work hours to this role, while 24.55% engage in food delivery part-time alongside other occupations. Although part-time riders share some job-related experiences, they differ from full-time riders in terms of road risk exposure, daily riding hours, and pressure to meet tight deadlines. This distinction is important because part-time riders may not exhibit the same frequency or intensity of risky behaviors as full-time riders, whose work demands and pressures significantly influence their on-road behavior.

Table 4. Socio-economic data of respondents.

Variables	Description	Frequency	Percentage (%)
Gender	Male	1723	86.15
	Female	277	13.85
Marital status	Single	1007	50.35
	Married	940	47.00
	Divorce	53	2.65
Age (years)	18–29	477	23.85
	30–44	1125	56.25
	45–59	390	19.50
	more than 60	8	0.40
Education Level	Primary school	89	4.45
	Junior high school	243	12.15
	Senior high school/Vocational certificate	753	37.65
	Diploma/High vocational certificate	433	21.65
	Bachelor's degree	476	23.80
	Master's degree	6	0.30

Table 4. *Cont.*

Variables	Description	Frequency	Percentage (%)
Average household income (THB/month)	<25,000	241	12.05
	25,001–50,000	1187	59.35
	50,001–75,000	395	19.75
	75,001–100,000	123	6.15
	>100,000	54	2.70
Profession	Rider	1509	75.45
	Student	51	2.55
	Government/stat enterprise	43	2.15
	Private company	145	7.25
	Farmer	50	2.50
	General employee	135	6.75
	Own business/trade	54	2.70
	Butler/housekeeper	1	0.05
	Other	12	0.60

Table 5 provides a demographic and work-related profile of food delivery motorcyclists in Thailand, with several variables displaying skewed distributions that reflect the unique demands of this occupation. The majority of riders work full-time (75.10%), likely because the gig economy's payment structure requires substantial hours to ensure adequate income. Income distribution is also skewed, with most riders earning 10,000–20,000 THB monthly. Higher income brackets are less common, as achieving them requires extended hours and access to high-demand areas. Almost all riders (99.70%) have a driver's license, primarily the 5-year type (94.55%), which aligns with legal requirements for commercial motorcycle operation in Thailand.

Table 5. Respondents' work information.

Variables	Description	Frequency	Percentage (%)
Job type	Part-time	498	24.90
	Full-time	1502	75.10
Average personal income from rider occupation (THB/month)	<10,000	247	12.35
	10,000–15,000	522	26.10
	15,001–20,000	829	41.45
	20,001–25,000	277	13.85
	>25,000	125	6.25
Motorcycle driver's license	Yes	1994	99.70
	No	6	0.30
Types of motorcycle driving licenses	2-years (temporary)	65	3.25
	5-years	1891	94.55
	For life	38	1.90
	No	6	0.30
Motorcycle riding experience (years)	<1	1	0.05
	1–2	18	0.90
	3–5	261	13.05
	>5	1720	86.00
Experience working in food delivery (years)	<1	173	8.65
	1–2	451	22.55
	3–4	959	47.95
	>4	417	20.85
Working hours for food delivery (not including rest hours during work) (hr./day)	1–4	64	3.20
	5–8	488	24.40
	9–12	1133	56.65
	>12	315	15.75

Table 5. *Cont.*

Variables	Description	Frequency	Percentage (%)
Break time during work (average per day)	Not resting	102	5.10
	<30 min	413	20.65
	30 min–1 h	1114	55.70
	>1 h	371	18.55

Most riders are experienced motorcyclists, with 86% having over 5 years of riding experience, suggesting that the job's demands favor those with advanced riding skills. The industry's recent growth, especially post-COVID-19, has led to an influx of newer riders, reflected in the fact that nearly half have only 1–3 years of experience in food delivery. Working hours are skewed towards 9–12 h daily (56.65%), as riders are incentivized to complete more deliveries to increase earnings. Similarly, break times are short; over half (55.7%) take only 30 min to 1 h, while a quarter take less than 30 min or do not rest at all, indicating the high-pressure environment that discourages extended breaks. These skewed distributions highlight the challenging and demanding nature of food delivery work in Thailand's gig economy.

The data shown in Table 6 provide the basic statistical analysis results for the indicators in the SEM of the risky riding behavior of food delivery staff, and it was found that the mean and standard deviation for the observed variables had the average high for PSE5 (accident as cause of death, mental effects, and loss of money and time), with a mean of 6.17 (SD = 1.195), followed by HM4 (giving priority to safety when driving), with a mean of 6.10 (SD = 1.167). The observed variable had an average low of ST4 (tire burning) and a mean of 1.15 (SD = 0.435). The test of normal distribution taking skewness into account had a value between −1.827 and 2.836, and the kurtosis value was between −1.015 and 8.833. The skewness and kurtosis values fell within accepted criteria, as the skewness value was not greater than 3, and the kurtosis value was not over 10, indicating that the data had a normal distribution [70,71].

Table 6. Mean, standard deviation, skewness, and kurtosis values of variables used in the model.

Indicators	Mean	S.D.	SK	KU
Speed violations				
SV1	2.63	1.215	0.382	−0.520
SV2	2.36	1.255	0.679	−0.287
SV3	2.17	1.127	0.781	0.089
Traffic errors				
TE1	2.10	0.995	0.831	0.725
TE2	1.88	1.012	1.480	2.723
TE3	1.92	1.096	1.340	1.563
TE4	1.83	1.033	1.549	2.744
TE5	1.95	1.119	1.196	1.256
TE6	2.24	1.227	0.721	−0.247
Stunts				
ST1	1.24	0.500	2.408	7.747
ST2	1.27	0.620	2.438	5.764
ST3	1.25	0.486	1.970	4.788
ST4	1.18	0.457	2.836	8.833
Control errors				
CE1	2.08	1.020	0.773	0.209
CE2	2.60	1.132	0.684	0.595
CE3	2.27	1.332	0.935	0.166

Table 6. *Cont.*

Indicators	Mean	S.D.	SK	KU
Social media				
SM1	3.20	1.554	0.273	−0.989
SM2	4.04	1.496	−0.463	−0.732
SM3	2.66	1.746	0.666	−0.989
Alcohol				
AL1	1.62	0.970	1.703	2.603
AL2	1.92	1.097	1.212	1.363
AL3	1.56	0.949	2.030	4.567
Time pressure				
TP1	4.09	1.478	−0.268	−1.015
TP2	4.35	1.420	−0.640	−0.453
TP3	4.49	1.446	−0.785	−0.306
TP4	4.29	1.532	−0.568	−0.700
Fatigue				
FA1	2.50	1.328	0.554	−0.552
FA2	3.07	1.306	0.119	−0.470
Aggressive driving				
AD1	1.71	1.069	1.764	2.898
AD2	1.51	0.943	2.388	6.172
AD3	1.73	1.170	1.949	3.537
Health motivation				
HM1	5.91	1.181	−0.880	0.028
HM2	5.96	1.224	−1.267	1.191
HM3	5.97	1.168	−1.049	0.603
HM4	6.10	1.167	−1.602	2.797
Perceived susceptibility				
PSU1	5.83	1.396	−1.295	1.107
PSU2	5.98	1.318	−1.440	1.841
PSU3	5.83	1.411	−1.241	0.950
Perceived severity				
PSE1	5.82	1.222	−0.890	0.397
PSE2	6.12	1.187	−1.743	3.281
PSE3	5.96	1.354	−1.435	1.569
PSE4	5.95	1.321	−1.393	1.665
PSE5	6.17	1.195	−1.827	3.549
Perceived benefits				
PBE1	5.49	1.193	−0.782	0.737
PBE2	5.43	1.365	−1.016	0.737
PBE3	5.62	1.237	−0.892	0.645
PBE4	5.70	1.437	−1.019	0.304
Perceived barriers				
PBA1	2.08	1.416	1.309	1.043
PBA2	2.19	1.542	1.285	0.766

Table 6. *Cont.*

Indicators	Mean	S.D.	SK	KU
Cues to action				
CTA1	5.23	1.448	−0.551	−0.333
CTA2	5.44	1.117	−0.502	0.223
CTA3	5.43	1.338	−0.827	0.270
CTA4	5.07	1.524	−0.616	−0.217

4.2. Measurement Model Evaluation

Cronbach's alpha was used to evaluate the reliability of the questionnaire and variable structure, and the factor loadings, construct reliability (CR), and average variance extracted (AVE) were also investigated in the test, as shown in Table 7. The questionnaire was initially developed by integrating items from the Motorcycle Rider Behavior Questionnaire (MRBQ) [43 items], the Health Belief Model (HBM) [35 items], and work-related factors (e.g., time pressure, fatigue, and aggressive driving behaviors) [14 items], resulting in a total of 92 items targeting various risky riding behaviors. To ensure reliability and validity, all items were first included in the analysis, and Construct Reliability (CR) and Average Variance Extracted (AVE) were calculated for each construct. Items that did not meet the acceptable factor loading threshold of 0.3 (or the item with the lowest factor loading within a construct) were iteratively removed. Specifically, the item contributing the least to CR and AVE was excluded, followed by recalculating these metrics after each removal. This iterative process continued until all remaining items satisfied the standard criteria for both CR and AVE, resulting in a final set of 53 items. This refinement enhanced the questionnaire's clarity and reliability, ensuring that each factor consistently measured the intended underlying constructs.

Table 7. Structural equation modeling.

Indicators	Standardized Estimates	Standard Error (S.E.)	Cronbach's Alpha	CR	AVE
Speed violations			0.770	0.985	0.438
SV1	0.569	0.019			
SV2	0.563	0.019			
SV3	0.821	0.021			
Traffic errors			0.822	0.994	0.440
TE1	0.641	0.015			
TE2	0.618	0.016			
TE3	0.695	0.014			
TE4	0.685	0.014			
TE5	0.719	0.013			
TE6	0.614	0.017			
Stunts			0.734	0.989	0.429
ST1	0.634	0.017			
ST2	0.808	0.017			
ST3	0.561	0.015			
ST4	0.588	0.024			
Control errors			0.625	0.988	0.524
CE1	0.676	0.018			
CE2	0.626	0.018			
CE3	0.850	0.020			
Social media			0.794	0.984	0.612
SM1	0.533	0.021			
SM2	0.885	0.029			
SM3	0.877	0.035			

Table 7. *Cont.*

Indicators	Standardized Estimates	Standard Error (S.E.)	Cronbach's Alpha	CR	AVE
Alcohol			0.678	0.990	0.468
AL1	0.839	0.010			
AL2	0.650	0.015			
AL3	0.526	0.016			
Time pressure			0.825	0.991	0.574
TP1	0.795	0.018			
TP2	0.842	0.017			
TP3	0.729	0.015			
TP4	0.652	0.031			
Fatigue			0.619	0.972	0.431
FA1	0.645	0.024			
FA2	0.668	0.025			
Aggressive driving			0.742	0.989	0.466
AD1	0.658	0.017			
AD2	0.701	0.016			
AD3	0.688	0.015			
Health motivation			0.857	0.995	0.576
HM1	0.795	0.010			
HM2	0.758	0.011			
HM3	0.825	0.009			
HM4	0.645	0.014			
Perceived susceptibility			0.773	0.992	0.542
PSU1	0.651	0.015			
PSU2	0.758	0.012			
PSU3	0.793	0.010			
Perceived severity			0.868	0.996	0.565
PSE1	0.654	0.014			
PSE2	0.754	0.011			
PSE3	0.801	0.010			
PSE4	0.802	0.010			
PSE5	0.736	0.012			
Perceived benefits			0.800	0.993	0.509
PBE1	0.605	0.016			
PBE2	0.780	0.014			
PBE3	0.572	0.016			
PBE4	0.856	0.012			
Perceived barriers			0.675	0.984	0.506
PBA1	0.631	0.017			
PBA2	0.784	0.016			
Cues to action			0.807	0.992	0.552
CTA1	0.757	0.016			
CTA2	0.575	0.016			
CTA3	0.613	0.018			
CTA4	0.964	0.019			
Risky riding behavior				0.994	0.473
Speed violations	0.484	0.023			
Traffic errors	0.847	0.011			
Stunt	0.713	0.019			
Control errors	0.818	0.021			
Social media	0.160	0.007			
Alcohol	0.826	0.013			

In particular, the value of Cronbach's alpha was used to specify internal alignment between compositions. The analysis showed that all Cronbach's alpha values were between

0.619 to 0.868, meeting the criterion, as per Pallant [72], who considered that Cronbach's alpha values greater than 0.60 had high reliability and were acceptable [73]; likewise, Van Griethuijsen et al. [74] indicated that Cronbach's alpha values above 0.60 were acceptable. The values of factor loadings, CR, and AVE were verified to confirm convergent validity between the questions that were measured in the related structure. Table 7 shows that 53 lists of factor loadings have values exceeding 0.50 and were led to be tested in the model. The values for all CR were greater than 0.70, with a lowest value was 0.972, confirming that the factor had good convergent validity, and the values of AVE were between 0.429 and 0.612, meeting the lower criterion of 0.40 [75]. When comparing the values with the suggested criteria, it was found that all values met the criteria, which shows that the indicators were standard and appropriate for the measurement model.

According to the factor-finding analysis of effects on the risky riding behavior of food delivery staff through SEM, the chi-square/df = 4.118, $p < 0.001$, CFI = 0.949, TLI = 0.925, SRMR = 0.039, and RMSEA = 0.062, as shown in Figure 3, and all values were in the criteria, showing that the SEM has an alignment with the empirical data. Taking all measurement models into consideration, 15 compositions found that all 53 indicators could be confirmed to be a composition of each latent variable at statistical significance ($p < 0.001$).

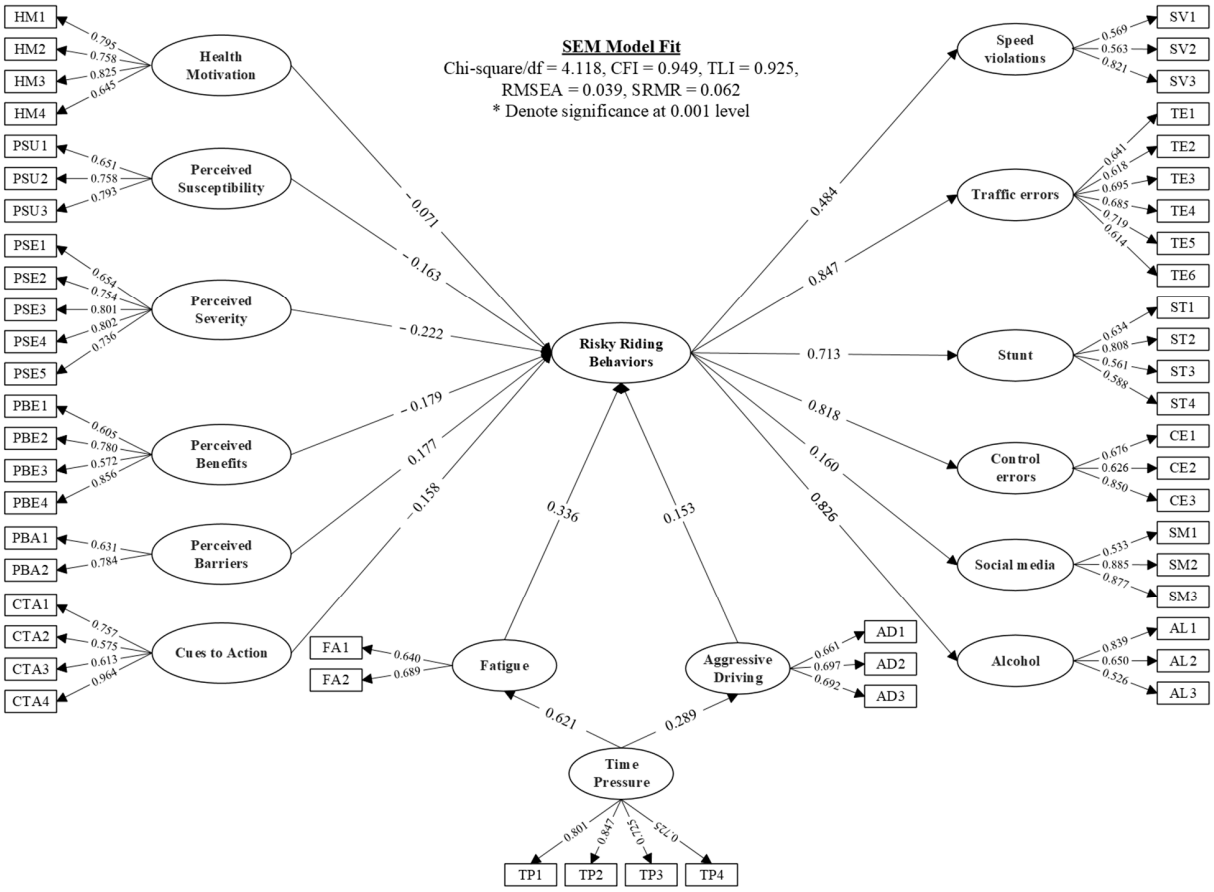

Figure 3. Result of SEM.

This study evaluated risky riding behavior of food delivery motorcyclists using 22 variables derived from MRBQ theory, grouped into six categories: speed violations (SV1–SV3), traffic errors (TE1–TE6), stunts (ST1–ST4), control errors (CE1–CE3), social media use (SM1–SM3), and alcohol use (AL1–AL3). The analysis indicated that the measurement model for risky riding behavior included six significant factors: traffic error, alcohol, social media, control error, and stunt, with a significance level of 0.001.

The factor that was most closely related to the risky riding behavior of food delivery motorcyclists was traffic errors, for which the factor value was 0.847. The next most

important factors were alcohol, social media use, control errors, and stunts, in that order. This result aligns with the study of Naderpour et al. [76], who identified that traffic errors were significantly related to accidental experience. This study result echoes the findings of Topolšek and Dragan [23] to identify that traffic error was an important variable for predicting the trend of motorcyclist accidents in India and England. In addition, Chouhan et al. [28] indicated that the MRBQ factor was significant for the study of the risky riding behavior relationship. Sunmud et al. [77] found that traffic error can be used as a variable for indicating the risky riding behavior in a survey of the middle-aged such as that investigated by Chouhan et al. [28]; Chouhan et al. [78] also identified that the traffic error factor is the most important predictor of risk for accidents.

Alcohol has emerged as the next most important factor for risky riding behavior. Previous research by Setyowati et al. [79] found that the riding behavior of those who were under the influence of alcohol tended to show speed without fear of prosecution and being an illegal part of road competition. Moreover, driving after having alcohol always leads to erroneous decisions when faced with urgent situations, such as the response-ability in the mentioned situation, which gradually aligns with the study of Bui et al. [29], who found a positive relationship between driving under the influence of alcohol and risky behavior for accidents, such as fast driving and breaking of the traffic rules; the mentioned findings were approved from the previous research as well [20].

Unfortunately, social media was found to be a less influential factor in assessing risky riding behaviors among food delivery motorcyclists. This variable, newly introduced to the traditional MRBQ framework, showed a broader range of mean values (2.66–4.04) for each observed indicator, as shown in Table 6. This variability suggests less consistency within the social media construct compared to traditional MRBQ factors, which have undergone more rigorous validation in the literature, impacting its overall factor loading in the measurement model. However, despite the lower factor loadings, social media indicators remained statistically significant in measuring risky behaviors ($p < 0.01$). The widespread use of smartphones and social media introduces new distractions for riders, contributing to unsafe behaviors. Therefore, including social media in the model reflects the evolving nature of these distractions, offering a more comprehensive understanding of factors affecting rider safety.

5. Discussion

In this study, it was found that the following factors affect the risky riding behavior of food delivery staff, as shown in Table 8: health motivation, perceived susceptibility, perceived severity, perceived benefits, and cues to action directly negatively influenced the risky riding behavior of food delivery staff, while perceived barriers positively influenced the risky riding behavior of food delivery staff at a significance level of 0.001.

Table 8. Parameter estimates of the structural model.

Hypothesis	Standardized Estimates	Standard Error (S.E.)	*p*-Value	Conclusion
Health Motivation → Risky Riding Behavior	−0.071	0.002	<0.001	Supported
Perceived Susceptibility → Risky Riding Behavior	−0.163	0.004	<0.001	Supported
Perceived Severity → Risky Riding Behavior	−0.222	0.005	<0.001	Supported
Perceived Benefits → Risky Riding Behavior	−0.179	0.004	<0.001	Supported
Perceived Barriers → Risky Riding Behavior	0.177	0.005	<0.001	Supported
Cues to Action → Risky Riding Behavior	−0.158	0.005	<0.001	Supported
Time Pressure → Fatigue	0.673	0.053	<0.001	Supported
Time Pressure → Aggressive Driving	0.290	0.012	<0.001	Supported
Fatigue → Risky Riding Behavior	0.260	0.012	<0.001	Supported
Aggressive Driving → Risky Riding Behavior	0.123	0.004	<0.001	Supported

5.1. Health Motivation

The negative relationship observed between health motivation and risky riding behavior ($\beta = -0.071$) suggests that as food delivery motorcyclists' motivation to maintain their health increases, their propensity to engage in risky riding behaviors decreases. Specifically, riders who prioritize their health or who have experienced accidents are more likely to adopt safer riding practices, such as reducing speed and avoiding traffic violations like running red lights. This inverse relationship indicates that high health motivation individuals are more aware of the potential consequences of risky riding, including accidents, injuries, and long-term health issues. Consequently, these riders tend to exhibit more cautious and responsible behaviors on the road.

In the context of our study, motorcyclists with heightened health motivation recognize the risks associated with dangerous riding and are therefore motivated to mitigate these risks through safer behaviors. Additionally, prior experiences with accidents may reinforce their health motivations, further discouraging engagement in risky behaviors.

The implications of this relationship are significant for developing targeted interventions aimed at reducing risky riding behaviors among food delivery motorcyclists. Enhancing health motivation through awareness campaigns, education on the consequences of unsafe riding, and providing support for accident survivors could foster a culture of safety within this high-risk group.

5.2. Perceived Susceptibility

This study found a negative relationship between perceived susceptibility and risky riding behavior ($\beta = -0.163$), indicating that as food delivery motorcyclists' perception of their vulnerability to accidents and injuries increases, their engagement in risky behaviors decreases. Riders who recognize a higher likelihood of experiencing negative outcomes are more inclined to adopt safer practices, such as reducing speed and avoiding traffic violations. This finding aligns with the Health Belief Model (HBM), which suggests that individuals who perceive greater susceptibility to health threats are more motivated to take preventive actions. Morowatisharifabad [39] also highlighted that perceived susceptibility fosters reasonable decision-making in groups prone to risky behaviors. For food delivery motorcyclists, heightened awareness of their vulnerability leads to more cautious and responsible riding.

These insights have important implications for developing targeted interventions. Educational campaigns and safety training programs that enhance riders' awareness of their susceptibility to accidents can encourage safer riding practices. Additionally, integrating strategies that boost perceived susceptibility within broader safety initiatives can effectively reduce risky behaviors and, consequently, motorcycle-related accidents and injuries.

5.3. Perceived Severity

This study found a significant negative relationship between perceived severity and risky riding behavior ($\beta = -0.222$). This indicates that as food delivery motorcyclists' perception of the severity of potential risks increases, their engagement in risky behaviors decreases. In other words, riders who recognize the serious consequences of risky riding are more likely to adopt safer riding practices [80]. These findings underscore the crucial role of perceived severity in influencing behavior and highlight the importance of risk awareness.

Factors that enhance perceived severity, such as increased awareness of the potential for accidents, injuries, and long-term health issues, encourage riders to prioritize safety over speed and efficiency. Riders who understand the severe outcomes of risky behaviors are more inclined to ride cautiously and avoid actions like speeding or running red lights [42]. Enhancing riders' awareness of the severe consequences of risky riding can effectively promote safer behaviors and reduce the incidence of motorcycle-related accidents and injuries among food delivery motorcyclists in Thailand.

5.4. Perceived Benefits

Perceived benefits have negative relationships to risky riding behavior in food delivery motorcyclists ($\beta = -0.179$). Negative relationships between perceived benefits and risky riding behavior show that if perceived benefits increase, the chance of performing risky behavior tends to be decreased, which aligns with the findings of Morowatisharifabad [39], who found, in Yazd, Iran, that the perceived benefits of observance of traffic rules have a negative relationship with risky riding behavior. Mazengia et al. [36] found that perceiving benefits has a negative relationship with unsafe riding behavior. Conversely, Refs. [41,42] demonstrated that perceived benefits positively predict safe riding behavior, indicating that riders who believe in the advantages of adhering to traffic regulations, such as wearing helmets and maintaining appropriate speeds, are more likely to adopt safer practices. Therefore, enhancing riders' perception of the benefits associated with safe riding can effectively decrease risky behaviors among food delivery motorcyclists, contributing to improved road safety [80].

5.5. Cues to Action

This study found a significant negative relationship between cues to action and risky riding behavior among food delivery motorcyclists ($\beta = -0.179$). Cues to action, such as safety campaigns, educational materials, and promotional initiatives, play a crucial role in encouraging safer riding practices. Ali et al. [81] identified cues to action as fundamental predictors of safe riding behavior, emphasizing their ability to motivate individuals to adopt safety measures. Similarly, Quine et al. [82] demonstrated that increased exposure to cues to action led to a 60% rise in helmet usage, highlighting the effectiveness of these interventions. Odoom et al. [43], further supported these findings by showing that riders who adhere to safety measures, prompted by cues to action, experience a significant reduction in accident rates. These studies collectively underscore the importance of integrating robust cues to action within road safety programs. By continuously reinforcing safe riding practices through targeted campaigns and educational efforts, it is possible to significantly decrease the incidence of risky behaviors and enhance overall road safety among food delivery motorcyclists.

5.6. Perceived Barriers

The Health Belief Model (HBM) posits that perceived barriers significantly influence behavior change. In this study, perceived barriers were found to have a positive relationship with risky riding behavior ($\beta = 0.177$), indicating that higher perceived barriers are associated with an increase in such behaviors. This suggests that even when food delivery motorcyclists recognize the dangers and health risks of risky riding, they may still disregard legal measures, rules, and regulations, continuing to engage in unsafe practices. According to HBM, overcoming these barriers is essential for promoting health-supportive behaviors, which may involve enhancing perceived severity or emphasizing potential income loss to motivate safer riding. However, our findings contrast with those of Mazengia et al. [36], who reported a significantly negative relationship between perceived barriers and risky riding behavior. This discrepancy may stem from contextual differences or variations in how barriers are perceived and addressed among different rider populations. Further research is needed to explore the underlying reasons for this difference and to identify effective strategies to reduce perceived barriers and encourage safer riding practices among food delivery motorcyclists.

5.7. Time Pressure

Time pressure is a critical factor influencing risky riding behavior among food delivery motorcyclists. The business model of food delivery services emphasizes speed and efficiency, rewarding rapid deliveries with higher compensation and better rankings. This creates an environment of intense pressure, as riders must meet strict delivery times to increase their income and maintain their job status. Consequently, riders often feel com-

pelled to violate traffic regulations to deliver orders on time, engaging in behaviors such as speeding, ignoring traffic signals, and riding against traffic flow.

Our analysis revealed a significant positive relationship between time pressure and aggressive riding behavior (β = 0.290), indicating that increased time pressure is associated with higher instances of risky riding. This finding is consistent with that of Dong et al. [44], who also reported a positive correlation between time pressure and aggressive riding behavior. Furthermore, previous studies [45,46] have similarly found that food delivery staff exhibit more aggressive riding behaviors under time constraints.

Time pressure not only diminishes safe riding practices but also heightens stress levels, adversely affecting decision-making and situational responses. Additionally, the constant demand for rapid delivery leads to exhaustion among riders, as they have limited time to rest and must work longer hours to earn sufficient income. This exhaustion further exacerbates the likelihood of engaging in risky behaviors. Abd Murad [83] corroborates these findings, noting that work pressure, long hours, and financial responsibilities significantly stimulate risky behavior in riders, thereby increasing the risk of accidents. Implementing measures such as realistic delivery timeframes, stress management programs, and incentives for safe riding could help mitigate the adverse effects of time pressure, promoting safer riding practices and reducing accident rates among this high-risk group.

5.8. Fatigue

Fatigue significantly impairs cognitive functions and decision-making processes, leading to unsafe riding behaviors (coefficient = 0.260). Exhausted riders exhibit reduced alertness and slower response times, increasing the likelihood of traffic violations and accidents [10]. Lakhan et al. [84] established a direct relationship between fatigue and unsafe riding behaviors, further linking fatigue to a higher incidence of accidents [85]. For food delivery motorcyclists, income is directly tied to the number of deliveries completed, necessitating long working hours to earn sufficient income. This prolonged work period induces fatigue, which in turn promotes risky behaviors such as speeding, ignoring traffic signals, and impaired maneuvering. Consequently, fatigue emerges as a critical factor contributing to the heightened risk of accidents among food delivery motorcyclists. Addressing fatigue through measures such as regulated working hours, mandatory rest periods, and fatigue management training could mitigate these unsafe behaviors and enhance overall road safety.

5.9. Aggressive Driving

Aggressive driving behaviors among food delivery motorcyclists encompass dangerous actions such as riding at high speeds, tailgating, and frequently and abruptly changing lanes. This study identified a positive relationship between aggressive riding behavior and risky behaviors in food delivery motorcyclists (β = 0.123). These behaviors are driven by both internal and external pressures. Internal pressures include the necessity to adhere to tight delivery schedules and maximize income, while external pressures stem from the competitive nature of the job, where numerous riders vie for the same deliveries, leading to increased haste and competition on the road.

Research by Mohammadpour et al. [86] and Zheng et al. [10] supports the finding that aggressive driving significantly heightens the risk of accidents. For instance, riding at high speeds reduces the time available to respond to unexpected events [87]. Pervez et al. [30] identify speeding as a high-risk behavior that not only contributes to accidents but also heightens the risk of fatality. Additionally, sudden lane changes can surprise other drivers, resulting in more severe accidents [88]. Similarly, Pervez et al. [4] found that speeding and overtaking considerably raise fatality risks in motorcycle crashes. Additionally, aggressive riding behavior not only endangers the rider but also poses significant risks to other road users. The interplay of these factors underscores the critical need for interventions aimed at mitigating aggressive driving behaviors to enhance overall road safety among food delivery motorcyclists.

6. Conclusions and Implementation

The gig economy and the increasing demand for food delivery service is bringing about new challenges to road safety. One such challenge is the risky riding behavior of food delivery motorcyclists, which has created a serious problem. Although models and theories have been developed to understand these behaviors, a literature review found that there are important gaps in the study of riding behavior in food delivery motorcyclists. This research applied the MRBQ, the HBM, and factors related to working, namely, time pressure, fatigue, and aggressive riding behavior. The main objective of this study was to identify factors influencing the risky riding behaviors of food delivery motorcyclists in Thailand. The results of the study will lead to building efficient methods and measures for decreasing accidents and increasing the safety riding of food delivery staff.

The research results show that health motivation, perceived susceptibility, perceived severity, perceived benefits, and cues to action have a negative influence on the risky riding behavior of food delivery staff. In other words, increasing awareness and health and safety motivations can affect food delivery motorcyclists to reduce risky behavior. These factors play an important role in specifying the ways in which food delivery staff respond to risky motorcycle riding. By contrast, perceived barriers are a factor that has a positive influence on risky riding behavior. The perceived barriers with respect to food delivery staff indicate that following the protection measure is difficult or inconvenient and causes them to go back to riding without safety. Moreover, this study produced the important finding that the factors related to work have a significant relationship with risky riding behavior in food delivery motorcyclists. Time pressure has a positive influence on fatigue and aggressive riding behavior in the work of food delivery staff. Fatigue and aggressive riding behavior while working also have a positive influence on risky riding behavior of food delivery motorcyclists.

Therefore, to decrease unsafe riding behavior in food delivery staff, the government and the private sector (service platforms) should assign precedence to the mentioned factors to promote the safety of riding through building awareness of health motivation to maintain health and prevent an accident, increasing the perceived severity and perceived risk from the accident, including supporting perceived benefits to following safe riding measures in a group of food delivery motorcyclists while decreasing perceived barriers or difficulty to action to encourage safe riding behavior. This study makes the following practical suggestions:

(1) Targeted Training and Education Programs: Implementation: Develop comprehensive training programs focused on accident prevention, safe riding techniques, and the importance of adhering to traffic rules. These programs should be tailored to address the specific challenges faced by food delivery motorcyclists, such as managing time pressures and coping with fatigue. Challenges and Solutions: Implementing these programs requires collaboration between government agencies, delivery platform companies, and rider associations. To overcome resistance from companies, safety training can be integrated into the recruitment and ongoing training processes mandated by law. Additionally, leveraging existing interactions with riders, such as during driving license renewals or through on-road police enforcement, can facilitate the inclusion of safety education.

(2) Revised Compensation and Incentive Structures: Implementation: Modify compensation models to prioritize safety over speed. Introduce bonuses for consistent safe riding records and limit the number of deliveries to prevent excessive working hours. Challenges and Solutions: Ensuring compliance with revised compensation models may necessitate clear legal frameworks governing the gig economy. Advocating for legislation that restricts excessive working hours and incentivizes safe behavior can compel companies to adopt these changes. Government intervention is crucial to enforce such regulations and ensure fair compensation practices.

(3) Enhanced Safety Awareness Campaigns: Implementation: Launch safety awareness campaigns that emphasize the importance of health motivation, such as the long-

term health risks associated with risky riding. Utilize various media platforms to disseminate information and reinforce safe riding practices. Challenges and Solutions: Identifying and reaching the appropriate target groups, including riders and their families, can be difficult. Collaboration with delivery companies and local communities can help effectively disseminate safety messages. Police involvement in monitoring and providing immediate feedback during traffic violations can also enhance the reach and impact of these campaigns.

(4) Implementation of Rest and Break Policies: Implementation: Establish mandatory rest periods and limit continuous working hours to combat fatigue. Encourage the use of designated rest areas and provide incentives for adhering to break schedules. Challenges and Solutions: Enforcement of rest and break policies requires regulatory support. Introducing policies that mandate maximum working hours and require delivery platforms to monitor and enforce compliance can mitigate the risk of rider fatigue.

(5) Provision of Safety Equipment and Technology: Implementation: Ensure that all food delivery motorcyclists are equipped with standard safety gear, such as helmets and reflective clothing. Additionally, integrate technology like speed limiters and GPS-based monitoring systems to track and manage riding behaviors. Challenges and Solutions: Providing safety equipment may involve initial costs, which can be offset by bulk purchasing agreements or subsidies from the government. Integrating technology requires cooperation from delivery platforms and could be incentivized through regulatory requirements.

While this study focuses on Thailand, the proposed countermeasures hold potential applicability in other countries with similar urban delivery ecosystems and high rates of motorcycle-related accidents. Cultural and infrastructural differences should be considered when adapting these strategies to different contexts. For instance, safety awareness campaigns should be culturally tailored to resonate with local values and norms regarding road safety and occupational behaviors. Governments in other countries can integrate revised compensation models and safety regulations into existing labor laws to support safe riding practices among delivery workers. Partnerships between governments, delivery platforms, and rider associations can facilitate the implementation of comprehensive safety programs and incentive structures.

7. Limitations and Future Research

Like any study, this research has several limitations. Firstly, the use of a self-administered questionnaire based on the MRBQ and the HBM relies on participants' self-reported behaviors and perceptions. This approach is susceptible to biases such as social desirability bias and recall bias, where respondents may underreport risky behaviors or overstate their adherence to safety practices. Consequently, caution should be exercised when interpreting the results. Secondly, the study focuses exclusively on food delivery motorcyclists in Thailand, a country characterized by unique road conditions, traffic patterns, and cultural behaviors. As a result, the findings may not be directly generalizable to other countries with different traffic laws, infrastructure, and rider behaviors. Additionally, while the study offers recommendations based on its findings, it does not test or evaluate the effectiveness of these proposed interventions. Future research could address these limitations by implementing and evaluating targeted interventions, such as safety training programs or revised compensation models, to assess their impact on reducing risky behaviors in real-world settings. Furthermore, conducting similar studies in different geographic or cultural contexts would help validate the findings and enhance their generalizability.

Another alternative approach to data collection is online surveying. However, reaching respondents with relevant resources may be challenging through online platforms, potentially affecting their psychological states and the accuracy of their responses. Future studies could compare results obtained from online surveys with those from traditional data collection methods to explore potential differences in responses and perceived be-

haviors. Such comparisons would provide valuable insights into the most effective data collection strategies for studying risky riding behaviors.

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