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Research Article

Assessing Significant Factors Affecting Risky Riding Behaviors of Vietnamese Motorcyclists Using a Contextual Mediated Model

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This study explores the significant factors affecting risky riding behaviors of Vietnamese motorcyclists using a contextual mediated model (CMM) in Hanoi, the capital of Vietnam, where motorcycle crashes are prevalent. The affecting factors include personality traits, riding self-confidence, riding attitude, and risk perception. Personality traits and riding self-confidence are distal factors of CMM that affect risky riding behaviors. On the other hand, riding attitude and risk perception are proximal factors in CMM. A survey was conducted to collect information on motorcyclists' risky riding behaviors related to the four factors mentioned through a self-reported questionnaire. Statistical Package Social Science (SPSS) and structural equation modeling (SEM) with analysis of moment structures (AMOS) are used to determine the effects of the factors on risky riding behaviors. The results discovered that riding attitude and risk perception were the intermediate variables of personality trait and riding self-confidence affecting the risky riding behaviors, and personality trait and riding self-confidence also affected the risky riding behaviors directly. Findings in the model also show that riding attitude was perceived to play a significant role in increasing risky driving behavior. The recommendation is to increase the safety education programs that reduce risky driving behavior.

1. Introduction

Many countries in Southeast Asia, including Vietnam, heavily rely on motorcycles for transportation. This is because motorcycles have several advantages over cars, such as being cheaper, easier to park, faster to navigate urban roads, and more fuel-efficient [1]. However, crashes and fatality rates on motorcycles are higher than in other transportation modes, primarily passenger cars. In Hanoi (Vietnam), there are over 700 registered motorcycles per 1,000 people, which account for more than 80% of the trips taken [2]. The World Health Organization (WHO) [3] reported that motorcycles are related to 43% of all road crash deaths in Southeast Asia. In Vietnam, road traffic accidents (RTAs) involving motorcycles account for over 66.7%, and human factors account for 71.6% [4]. Even in developed countries, motorcycle-related road crashes are still a recurring problem with no solution.

In contrast to passenger cars, motorcycles are less safe and vulnerable due to the absence of protective devices and the high number of motorcycles on the road in mixed traffic conditions. Motorcyclists are also considered to have more risk-taking and speeding behaviors [5], easily leading to road crashes. The previous studies found that road crashes related to motorcycles have been associated with risky behaviors and affecting factors of the risky behaviors of motorcyclists [1, 6]. It is essential to identify and understand riding behavior that helps predict motorcyclists' actions on the road, identify crash mechanisms and causes, and then control crashes to improve their health.

Contextual mediated model (CMM) using a self-reported questionnaire survey is an effective tool to explore effecting factors on riding behavior found in many studies related to car drivers. So far, research on the risky riding behaviors of motorcycles is still far from universal compared with other

road users such as cars and lacks general consideration of various contributing factors [7]. Most studies on motorcycle behavior using psychological factors are also mainly conducted in developed countries, where a few motorcycles with considerable power are used. There are limited studies on the riding behaviors of motorcyclists in developing countries like Vietnam [1].

Numerous factors can impact the risky behavior of motorcyclists. These may include inadequate motorcycle maintenance, insufficient motorcycle facilities, age group, lack of attention, careless riding, failure to follow traffic rules, riding attitude, self-confidence while riding, perception of risk, personal preferences, and personality traits. Exploring all the factors influencing driving behavior in a model would be more complicated and unnecessary than focusing on the key factors. Therefore, this study emphasizes Vietnamese motorcyclists' personality traits, riding self-confidence, riding attitude, and risk perception of self-reported performed risky riding behavior using the CMM model. Therefore, a complete understanding of the hazardous behaviors of motorcyclists is necessary to establish a plan for improving traffic safety.

The remainder of this study is structured as follows: Section 2 introduces the literature review, Section 3 presents the materials and methods utilized, Section 4 describes the study's results along with statistical testing and discussion, and Section 5 provides conclusions and future work.

2. Literature Review

Engaging in risky riding behavior, such as speeding, riding without a helmet, and other violations, is considered unacceptable in public due to the potential negative consequences of negligence [8, 9]. Since risky riding behavior is closely linked to motorcycle accidents, it is crucial to identify and comprehend the factors that contribute to such behavior. Studies have endeavored to define and recognize risky riding behavior by combining various elements and assessing their interactions, such as personality traits, riding self-confidence, riding attitude, and risk perception, among others, using different models, including the CMM model.

The contextual mediated model (CMM) of risky behavior was first proposed by Elander et al. [10] and generalized by Sümer [11] based on the horizontal model of Lajunen [12]. The CMM points out that the combination of various distal and proximal contextual factors in certain conditions can lead to risky behaviors and crashes. The proximal factors mainly emphasize the factors that directly contribute to risky behaviors or accidents. The distal factors mainly emphasize social background, lifestyle, daily habits, and other factors. Elander et al. [10] described a relationship among personality traits, driving behaviors, and crash risk using CMM. Iversen and Rundmo [13] found that risky behaviors (e.g., speeding) partially mediated the impacts of personality on accident involvement in Norway. Sümer [11] proposed an indirect connection between distal factors (e.g., demographic traits and individual differences) and outcomes (e.g., accidents) through the proximal environment (e.g., driver actions). Zhang et al. [14] investigated a relationship among driving anger, aberrant behaviors, and crash risk based on CMM. According to the study, abnormal behaviors were found to be the main factor that caused an increase in the risk of crashes due to driving anger. Just like the risk of crashing or getting into an accident, aggressive driving can also be considered an outcome in the absence of a crash [15]. According to Ullerberg and Rundmo [6], distal factors affect the outcomes of a CMM involving personality, attitude, and behavior. Several studies have used or expanded the model of Ullerberg and Rundmo, and their results indicated that the framework of road traffic safety was helpful from a CMM model [16–20]. The CMM can describe a relation between distal factors, proximal factors, and outcomes. We can easily increase variables and change the roles of variables in different CMM models. Analyzing shows that previous studies often use only a few latent variables in the CMM models in various areas with different study samples under traffic flow conditions predominated by cars. Thus, in the context of Vietnam's transportation, it is vital to construct a CMM model that suits motorcycles for better analysis of motorcycle accidents, training behavior of motorcyclists, and intervention.

There have been limited studies in Vietnam that focus on the behaviors of motorcyclists and the factors that affect them. For instance, Trinh and Vo [21] used a combination of the theory of planned behavior and the health belief model to explain the relationship between drunk driving, illegal changing of direction, and speeding, but they did not focus on motorcyclists. However, Trinh and Le [22] found a significant link between speeding and helmet-wearing among motorcyclists using the theory of planned behavior. Truong et al. [23] examined the relationship between phone use while riding and other risky behaviors among university students on motorcycles, with calling while riding being the most common risky behavior. Nguyen-Phuoc et al. [24] investigated the risky behaviors of app-based motorcycle taxi riders. They found that phone use while riding was the most frequent, followed by failing to use turn signals, encroaching on car lanes, exceeding speed limits, running red lights, and carrying more than one passenger. Meanwhile, Luot et al. [25] found no correlation between risk behaviors and risk perception among Vietnamese motorcyclists. Li et al. [26] conducted a cross-sectional study in Ho Chi Minh City and found an increase in the use of improper and poor-quality helmets, which is one of four main issues (i.e., drink-driving, motorcycle helmets, seat belts, and speed management) implemented by road safety projects in 10 low- and middle-income countries [27]. Bui et al. [28] provided a Motorcycle Rider Behavior Questionnaire (MRBQ) with 36 items adapted from the original MRBQ of Elliott et al. However, they did not consider the factors influencing risk behavior in a given model. Nguyen-Phuoc et al. [29] investigated the factors that affect the frequency of turn signals at intersections, such as environmental characteristics, perceived risk, and beliefs. In addition, Nguyen-Phuoc et al. [30] examined the factors related to the risk-taking attitude and road safety compliance of motorcycle delivery riders, such as job demands and resources. Vuong et al. [4] explored riding attitudes and attempted to explain the relationship between

the detected factors and the riding attitudes of motorcyclists. Lastly, Can et al. [31] considered the reliability and validity of a risk perception scale of motorcyclists in Vietnam. Generally, in recent years, some scholars have been interested in and tried to discover the risky behaviors of motorcyclists in Vietnam. However, they mainly focused on given violations and have not provided comprehensive models or a general picture of the risky riding behaviors of motorcyclists in the transport context of Vietnam.

In our study, we utilized a deductive approach by leveraging the results of prior research [15, 32] and engaging with industry experts through qualitative interviews to construct a theoretical framework using the CMM model. This model significantly emphasizes five key elements—personality traits, riding attitudes, risk perception, and riding self-confidence—to comprehensively analyze the effects of risky riding behaviors on road traffic safety in developing nations like Vietnam. Our ultimate objective is to propose effective safety measures and interventions that can meaningfully reduce the incidence of dangerous riding practices among motorcyclists.

3. Materials and Methods

3.1. Formulation of the Theoretical Model. In this study, the proposed theoretical model using CMM considers personality traits, riding self-confidence, riding attitude, and risk perception as factors contributing to risky riding behaviors among motorcyclists. The first two factors (i.e., personality traits and riding self-confidence) are distal factors, and the remaining factors (i.e., riding attitude and risk perception) are proximity factors of the proposed CMM, as shown in Figure 1. We review the considered factors and propose the research hypotheses of the proposed model as follows:

3.1.1. Personality Trait. The most studied personality traits are those that cause individuals to disregard or underestimate the dangers of the road, leading to reckless and unsafe behavior. These traits are characterized by an increased probability of engaging in risky riding practices and being involved in accidents. Several scales of personality traits are used in the context of risky behaviors, such as the Revised NEO Personality Inventory [33], the Big Five Questionnaire [34], the Zuckerman-Kuhlman Personality Questionnaires Cross Cultural [35], and normlessness [36]. For instance, personality traits in the Big Five Questionnaire have comprised extraversion, neuroticism, agreeableness, openness to experience, and conscientiousness; the NEO Personality Inventory measures excitement-seeking, anxiety, and aggression. In addition, many scales of personality traits have combined and developed from the abovementioned scales [6, 16, 37–40].

Previous studies have indicated that certain individual characteristics can significantly encourage unsafe motorcycling behaviors [41, 42]. These traits can exert both a direct and indirect influence on risk perception [43] and riding attitudes. Our current study postulates that personality traits can impact hazardous riding conduct among motorcyclists via both direct and indirect routes, encompassing risk perception and riding attitudes.

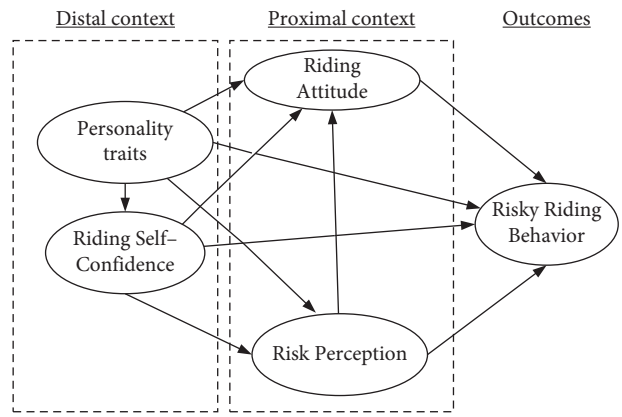

Figure 1: Theoretical model of motorcyclists' risky behaviors using CMM.

3.1.2. Riding Self-Confidence. Wong et al. first proposed the riding self-confidence scale for motorcyclists [37–39, 44]. It expresses the individuals' judgment of their riding ability. In [45, 46], the scale is expanded and expressed in terms of motorcyclists' technical capacity and judgment ability. Compared with other scales, this scale is still less applicable when studying the riding behaviors of motorcyclists.

3.1.3. Riding Attitude. A positive safety mindset is essential for riders to prioritize traffic safety while on the road. This mindset encompasses their thoughts, emotions, and cognitive processes [47], significantly impacting their riding behaviors. Riders who engage in risky behaviors often hold negative attitudes towards traffic safety. To assess a rider's attitude towards riding, various scales such as Ulleberg and Rundmo's scale (which evaluates traffic flow and rule obedience, speeding, and enjoyment of riding) [6, 16] and Iversen and Rundmo's scale (focusing on attitude towards rule violations and speeding, careless driving by others, and drinking and driving) are utilized [47].

3.1.4. Risk Perception. Risk perception is "the subjective experience of risk in potential traffic hazards" [48]. Therefore, risk perception is considered a precursor to actual driving behavior and is also commonly examined concerning traffic safety. Risk perception can be assessed using several scales. For example, the scale of Rundmo and Iversen consists of three different dimensions (i.e., worry and insecurity, probability assessments, and concern) [49]. The scale of Machin and Sankey is compacted into three subfactors (i.e., worry and concern, the likelihood of a crash, and aversion to risk-taking) [42, 48]. The scale of Wang et al. includes three different subfactors (i.e., level of danger, worry, and probability assessments) [45, 46].

3.1.5. Risky Riding Behavior. In 2004, Sexton et al. [50] employed a 24-item Motorcycle Rider Behavior Questionnaire (MRBQ) to evaluate the dangerous behaviors exhibited by motorcyclists, which were classified into four distinct categories: traffic errors, speeding, stunts, and control errors.

Later, Elliott et al. [51] expanded on the original MRBQ, drawing on Reason et al.'s [52] research to identify the various factors that influence motorcyclist behavior in Great Britain. These factors were categorized into five groups, including traffic errors, control errors, speed violations, performing stunts, and the use of safety equipment. Subsequent studies have also used the MRBQ to explore the risky behaviors of motorcyclists. For example, Motevalian et al. [53] developed the MRBQ for Persian motorcycle riders, which included six subscales (i.e., speed violations, traffic errors, safety violations, traffic violations, stunts, and control errors). In their model, some items related to protective clothing, as in Elliot's MRBQ, were deleted to match Persian motorcycle riders. Besides, some items were also added, such as helmet use, red light running, etc. Özkan et al. [54] deployed the MRBQ for Turkish people with factors similar to those of Elliott et al. According to researchers, the correlation between rider accidents and offenses and annual mileage was significant, while rider age had a comparably more minor influence. Stunts were identified as the primary cause of accidents and offenses, whereas traffic violations were primarily caused by speeding. In a study of Australian riders, Sakashita et al. [55] used the MBRQ to identify four important factors: control errors, speeding violations, stunts, and protective gear. Similarly, Uttra et al. [56] studied Thai riders and found that traffic errors, control errors, stunts, and safety equipment were critical factors. Stephens et al. [57] also analyzed the correlation between the MBRQ and traffic accidents in Australia. They discovered that while speeding violations and control errors were uncommon, they still increased the likelihood of an accident. Furthermore, stunts raise the chance of an accident. Bui et al. [28] investigated the factors of the MRBQ for Vietnamese motorcyclists. Their scale included 36 items, which were arranged into four dimensions in terms of previous studies on the factors influencing riding behaviors. Some studies considered either four factors [28, 50, 55, 56], five factors [51, 54, 57], or six factors [53]. From there, the consideration of factors is not consistent, depending on the traffic characteristics of each region. Besides, most of the above studies have been conducted in a traffic environment with predominantly cars, which differs from the mixed traffic flow that depends on motorcycles, like in Vietnam. Besides, several items related to the use of safety equipment and safety devices, such as protective clothing, are unsuitable for Vietnamese traffic conditions due to the lack of regulations and traffic culture. Therefore, they are not considered in this study.

3.1.6. Research Hypotheses. Based on the abovementioned discussions, ten hypotheses are proposed to formulate the theoretical model for this study as follows:

H1a: Personality traits significantly have a positive direct effect on riding attitude.

H1b: Personality traits significantly have a positive direct effect on risk perception.

H1c: Personality traits significantly have a positive direct effect on risky riding behavior.

H1d: Personality traits significantly have a positive direct effect on riding self-confidence.

H2a: Riding self-confidence significantly has a positive direct effect on riding attitude.

H2b: Riding self-confidence significantly has a negative direct effect on risk perception.

H2c: Riding self-confidence significantly has a negative direct effect on risky riding behavior

H3: Riding attitude significantly has a positive direct effect on risky riding behavior.

H4a: Risk perception has a positive direct effect on risky riding behavior.

H4b: Risk perception significantly has a negative direct effect on riding attitude.

The mediated effect through riding attitude and risk perception of the theoretical model is significant when the product of paths is significantly different from zero [58, 59].

3.2. Methods of Data Collection and Analysis

3.2.1. Data Collection. To match the theoretical model proposed in Sub-section 3.1, we designed a structured three-section questionnaire as a self-reported questionnaire. For the first section, we gathered socio-demographic information from the participants, such as their age, gender, and riding experience. The second section was dedicated to analyzing trip patterns, such as the purpose and frequency of rides. Lastly, in the third section, we sought to collect data on personality traits, riding attitude, self-confidence, risk perception, and any risky riding behavior.

The research analyzed personality traits (PT) through five subfactors that comprised a total of 24 items. These subfactors were anxiety (AN, four items), anger (AG, five items), sensation-seeking (SS, five items), altruism (AL, six items), and normlessness (NL, four items), which were sourced from materials such as [6, 16, 38, 40]. Participants were assigned a rating on a five-point Likert-type scale, with responses ranging from "strongly disagree (1)" to "strongly agree (5)." A higher score indicated a greater level of the personality traits under examination.

Riding self-confidence (RC) was evaluated utilizing seven items adapted from [45, 46] (except "I can judge the speed of a motor vehicle accurately"). All items were evaluated based on a 5-point scale from low to high (strongly disagree (1) to strongly agree (5)). The higher the score, the higher the self-confidence.

To assess one's riding attitude (RA), we analyzed three key components as a set of subfactors. These subfactors included attitudes towards traffic flow (AT), consisting of three distinct items; attitudes towards rule adherence and speeding (AR), consisting of nine items; and attitudes towards enjoying the ride (AF), consisting of three items. These were sourced from [4, 16, 60]. The quantitative items

were evaluated on a 5-level scale, ranging from strongly disagree (1) to strongly agree (5). A higher score indicates a more negative attitude, indicating a greater inclination towards disregarding traffic laws and regulations [4].

Risk perception (RP) was considered using three aspects as three subfactors, including worry and concern (WC, four items), probability assessments (PA, four items), and cognition of danger level (WC, six items), as modified from [45, 46, 49]. Quantitative items were assessed on a 5-level scale from low to high (strongly disagree/no danger (1) to strongly agree/very dangerous (5)). The higher the score, the more worried you are about traffic risks and feelings. The higher the risk of behavior is subjective, the greater the perceived consequences [31].

Risky riding behavior (RB) was measured through four subfactors of 28 items. The first three subfactors, including ordinary violations (OV, eight items), speed and riding violations (SV, six items), and lapses and errors (LE, six items), were modified from [37, 38, 51, 53–55, 61–63]. The last subfactor, aggressive violations (AV, eight items), was adapted from [45, 61, 62, 64]. The items were established based on a Likert 5-point scale (1 = never; 2 = hardly ever; 3 = occasionally; 4 = often; 5 = very often).

The questionnaire used for the official survey was initially written in English and later translated into Vietnamese. Pilot tests were conducted to finalize the questionnaire before data collection began in Hanoi, Vietnam's largest city by area and second-largest by population, from January to March 2019. Before participation, all participants were informed of the survey's purpose and gave their consent.

After collecting 750 responses, we carefully screened for incomplete and unreliable responses, resulting in a final sample of 716 participants to test the proposed model. Of those participants, 52.5% were male, and 50% were between the ages of 16 and 25. About 33.2% had a college or intermediate-level education, while 66.8% had a university degree or higher. In terms of income, 42.8% earned 5–10 million VND per month, 51.7% earned below 5 million VND per month, and 5.9% earned over 10 million VND per month.

3.2.2. Analytical Method. The model underwent rigorous testing and validation using structural equation modeling (SEM), a widely accepted analytical technique for discovering patterns and relationships among variables and parameters across various fields, such as traffic behavior modeling [65, 66]. To execute SEM, this study employed two key stages, namely, confirmatory factor analysis (CFA) for measurement models and SEM for a structural model, with the aid of SPSS software and the AMOS tool.

Several goodness-of-fit statistics are used to test the hypothesis, as well as to judge the fit and validity of the measurement model and structural model, as follows:

(i) Factor loading is not less than 0.5 for CFA [67, 68]. In addition, to ensure reliability and convergence, average variance extracted (AVE) is not less than 0.5 [67], and the composite reliability index (CRI) is not less than 0.6 [69, 70].

(ii) The goodness-of-fit index (GFI) and the root mean square error of approximation (RMSEA) are evaluated as absolute fit measures. The comparative fit index (CFI) [71] and incremental fit index (IFI) are taken as incremental fit indexes. Besides, some other indexes are also used to test the hypothesis, such as the value of Chi-square/df and the Tucker-Lewis index (TLI). In general, 3 to 4 relevant indicators are present for each study, and the evidence is sufficient to provide the appropriateness of the model without considering all other indicators [67]. The CFI, TLI, IFI, and GFI values are between 0 and 1, and close to 1 is better [72]. The value of Chi-square/df should be smaller than 5 [73, 74]. RMSEA should be smaller than 0.08 [73]. TLI should be equal to or larger than 0.80 [75].

4. Results and Discussion

4.1. Results of the CFA. We employed the CFA method to evaluate the reliability of measurement items and confirm the suitability of the factorial structure. Through this process, we pinpointed key personality traits such as riding self-confidence, risk perception, riding attitude, and risky riding behavior. We eliminated items that exhibited low loading values, as determined by the multiple goodness-of-fit statistics discussed earlier.

First, we obtained four dimensions for personality traits, including anger (AG, five items), sensation-seeking (SS, four items), normlessness (NL, three items), and altruism (AL, two items). Secondly, riding self-confidence was extracted from one dimension of six items. There are three subscales for riding attitude: attitude towards traffic flow (3 items), attitude towards rule obedience and speeding (6 items), and attitude towards fun-riding (2 items). After that, risk perception consisted of three dimensions: worry and concern (WC, four items), probability assessments (PA, four items), and cognition of danger level (CD, six items). Finally, we achieved the scale of risk-riding behavior with four subscales: ordinary violations (OV, four items), speed and riding violations (SV, four items), lapses and errors (LE, five items), and aggressive violations (AV, seven items). The items of the factors are shown in Table 1.

4.2. Results of SEM. This study tested the theoretical model using SEM to analyze the factors that affect risky riding behaviors among motorcyclists. In the first analysis of the theoretical model, the goodness-of-fit statistics met the requirements. However, we did not see a significant relationship between personality traits (PT) and riding self-confidence (RC) (Sig. = 0.122), as well as between personality traits (PT) and risk perception (RP) (Sig. = 0.931). This means that hypotheses H1b and H1d have been rejected. After removing the insignificant relationships from the theoretical model, we achieved a final model, as shown in Figure 2. The model had the value of Chi-square/df = 2.454 < 5; RMSEA = 0.045 < 0.08. In addition, the GFI, CFI, IFI, and TLI values were all greater

Table 1: The structures of factor scales measured.

Factor		Item	Factor loading	AVE	CRI
Personality trait (PT)	Anger (AG)	Keep my cool	0.956	0.65	0.90
		Rarely complain	0.771		
		Get irritated easily	0.72		
		Get upset easily	0.8		
		Get angry easily	0.761		
	Sensation-seeking (SS)	Love excitement	0.612	0.52	0.81
		I am willing to try anything once	0.762		
		Act in direct way	0.691		
	Normlessness (NL)	Would never go hang gliding or bungee jumping	0.795	0.51	0.75
		It is OK to get round laws and rules as long as you don't break them directly	0.665		
		If something works, it is less important whether it is right or wrong	0.813		
		Some things can be wrong to do even though it is legal to do it	0.648		
	Altruism (AL)	I am indifferent to the feelings of others	0.774	0.52	0.68
		Take no time for others	0.667		
Riding self-confidence (RC)		Ability to deal with unexpected situations on unfamiliar roads	0.633	0.51	0.86
		Riding skills will help me get out of trouble when in danger	0.688		
		I am a good rider so i can ride exceeding the speed limits	0.615		
		I am familiar with the roads around me and everything is under my control	0.816		
		I can often judge whether my riding behavior is dangerous or not based on my experience	0.791		
		I can accurately judge the movement of nearby vehicles	0.699		
Riding attitude (RA)	Attitude towards rule obedience and speeding (AR)	Sometimes it is necessary to break the traffic rules in order to get ahead	0.759	0.52	0.87
		Sometimes it is necessary to take chances in the traffic	0.687		
		Sometimes it is necessary to bend the traffic rules to arrive in time	0.765		
		A person who take chances and violate some traffic rules is not necessary a less safe driver	0.628		
		If you have good skills, speeding is OK	0.74		
		I think it is OK to speed if the traffic conditions allow you to do so	0.745		
	Attitude towards traffic flow (AT)	There are many traffic rules which cannot be obeyed in order to keep up the traffic flow	0.739	0.55	0.78
		Sometimes it is necessary to bend the rules to keep traffic going	0.821		
		It is more important to keep up the traffic flow rather than always follow the traffic rules	0.646		
	Attitude towards fun-riding (AF)	Riders may be increase fun and excitement in traffic	0.735	0.53	0.70
		Speeding and excitement belong together when you are riding	0.726		

Table 1: Continued.

Factor		Item	Factor loading	AVE	CRI
Risk perception (RP)	Cognition of danger level (CD)	Violating red lights	0.659	0.55	0.88
		Riding after drinking alcohol beyond the legal limit	0.605		
		Riding faster than surrounding riders	0.736		
		Going in the opposite direction	0.846		
		Getting into the wrong lane	0.803		
		Using a cell phone whilst riding	0.761		
	Probability assessments (PA)	How probable do you think it is for yourself to be involved in a traffic accident	0.906	0.73	0.91
		How probable do you think it is for yourself to be injured in a traffic accident	0.959		
		How probable do you think that you are more likely to have a traffic accident than others?	0.855		
		How probable do you think that riding a motorcycle in a traffic accident is higher than that of other vehicles	0.662		
	Worry and concern (WC)	Feeling unsafe that you yourself could be injured in a traffic accident while riding	0.716	0.62	0.87
		Worried for yourself being injured in a traffic accident	0.782		
		Feeling unsafe that persons could be injured in a traffic accident	0.853		
		Concerning about a traffic accidents and thinking that you yourself could be victimized	0.784		
Risky riding behavior (RB)	Aggressive violations (AV)	Get angry at other rider and try to give chase with the intention of letting them know what you mean	0.694	0.60	0.91
		Running through an intersection that causes riders of the same direction to stop and yield to you	0.777		
		Horn (verbally) to indicate your discomfort with other riders	0.817		
		Racing away from a traffic light with the intention of passing the vehicle ahead	0.841		
		Riding too close to rider in front ignoring safe gap	0.795		
		Riding very close to the rider in front as a signal to its rider to go faster or get out of the way	0.772		
	Lapses and errors (LEs)	Getting involved in unofficial races with other riders	0.724	0.57	0.87
		Not paying attention to observe should almost collide with pedestrians (traffic equipment and objects)	0.754		
		Not paying attention or misjudging the speed of the vehicle in front, but running too close	0.766		
		Do not pay attention to the “give way yield ” signs or signal lights	0.833		
		Brake too quickly	0.711		
	Ordinary violations (OVs)	Maneuver (including turn movement) without checking mirror	0.698	0.58	0.85
		Going in the opposite direction or forbidden road	0.753		
		Getting into the wrong lane	0.777		
		Riding without helmet-wearing	0.762		
		Using a cell phone whilst riding	0.761		
	Speed and riding violations (SVs)	Accelerating into an intersection when the traffic light is changing from yellow to red	0.633	0.56	0.83
		Exceeding the speed limit on a road	0.769		
		Illegal overtaking	0.829		
		Riding between bigger vehicles to go faster	0.742		

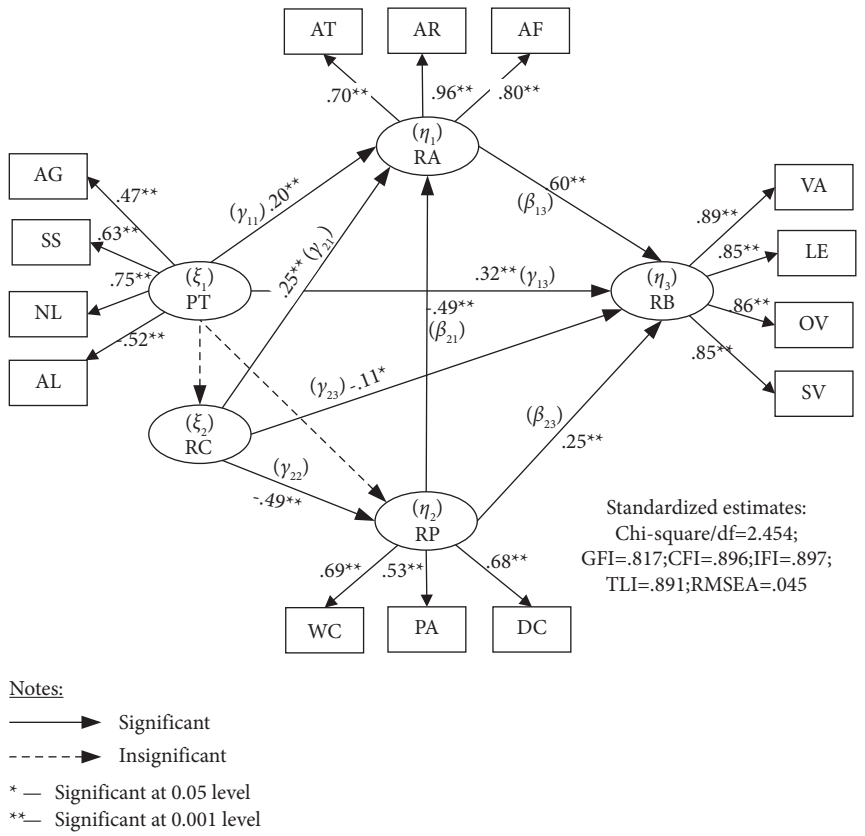

Figure 2: Results of the final estimating model.

than 0.8, close to 1.0, indicating that the model had a reasonable fit. In the model, only the relationship between riding self-confidence (RC) and risky riding behaviors (RB) was accepted with a significance of 0.05 (Sig. = 0.024), and other links were accepted with a significance of 0.001. Since then, we have obtained the results of the research hypotheses, as shown in Table 2.

The direct and indirect effects of various factors, such as riding self-confidence, personality traits, risk perception, and riding attitude, are listed in Table 3.

After considering both direct and indirect effects, it was found that the most influential factors on risky riding behavior were one's riding attitude ($\beta = 0.60$) and one's personality traits ($\beta = 0.44$). Factors that had less impact included risk perception ($\beta = -0.04$) and riding self-confidence ($\beta = 0.06$).

4.3. Discussion, Findings, and Implications. This study first described the relationship between personality traits, riding self-confidence, riding attitude, and risk perception related to risky riding behaviors in Vietnamese motorcyclists using the CMM. After that, we estimated the effects of these factors on risky riding behaviors using a path analysis of SEM. The factors were considered in many aspects, so they were also appropriate to human behavior.

Our research reveals fascinating insights into the intricate relationship between a rider's personality, confidence level, attitude, and risk perception and how they impact the likelihood of engaging in risky riding behavior. We observed that a positive riding attitude, strong self-confidence, and certain personality traits were associated with an increased likelihood of engaging in risky behavior, both directly and indirectly. Conversely, a negative perception of risk was linked to a decreased likelihood of such behavior. Moreover, we found that riding attitude and risk perception partially mediated the relationship between behavior, personality traits, and riding self-confidence. Particularly, riding attitude partially mediated the association between risk perception and risky riding behavior. Our study uncovers the intricate interplay between these factors and their impact on risky riding behavior.

For personality traits, there was a direct positive causal relationship ($\gamma_{13} = 0.32$) between personality traits and risky riding behaviors. Similarly, a positive causal relationship ($\gamma_{11} = 0.20$) was also found between personality traits and riding attitudes. This was also found in [16, 76]; therefore, the results of this study reinforce the statement related to personality traits. Hence, personality traits may be mitigated to address risky riding behaviors.

Multiple studies have indicated a favorable connection between risk perception and a reduction in risky behavior [8, 43, 77]. This implies that an individual who perceives a particular behavior as hazardous is less likely to partake in it. Nonetheless, this association is sometimes not as strong as anticipated. Moreover, some research suggests that risk perception might be an effect rather than a causal factor. In other words, there was no cause of risky behavior by risk

Table 2: Results of the research hypotheses.

No.	Hypothesis	Symbol	Effect (±)	State
1	Personality traits significantly have a positive direct effect on riding attitude	H1a	(+)	Accepted
2	Personality traits significantly have a positive direct effect on risk perception	H1b	(+)	Rejected
3	Personality traits significantly have a positive direct effect on risky riding behavior	H1c	(+)	Accepted
4	Personality traits significantly have a positive direct effect on riding self-confidence	H1d	(+)	Rejected
5	Riding self-confidence significantly has a positive direct effect on riding attitude	H2a	(+)	Accepted
6	Riding self-confidence significantly has a negative direct effect on risk perception	H2b	(−)	Accepted
7	Riding self-confidence significantly has a negative direct effect on risky riding behavior	H2c	(−)	Accepted
8	Riding attitude significantly has a positive direct effect on risky riding behavior	H3	(+)	Accepted
9	Risk perception has a positive direct effect on risky riding behavior	H4a	(+)	Accepted
10	Risk perception significantly has a negative direct effect on riding attitude	H4a	(−)	Accepted

Table 3: Results of direct and indirect effects.

Paths			Effects				
			Direct	Indirect 1	Indirect 2	Indirect 3	Total (β)
RA	<--	PT	0.20^{**} (γ_{11})				0.20
RB	<--	PT	0.32^{**} (γ_{13})	0.12 ($\gamma_{11} \times \beta_{13}$)			0.44
RP	<--	RC	-0.49^{**} (γ_{22})				−0.49
RA	<--	RC	0.25^{**} (γ_{21})	0.24 ($\gamma_{22} \times \beta_{21}$)			0.49
RB	<--	RC	-0.11^{*} (γ_{23})	0.15 ($\gamma_{21} \times \beta_{13}$)	−0.12 ($\gamma_{22} \times \beta_{23}$)	0.14 ($\gamma_{22} \times \beta_{21} \times \beta_{13}$)	0.06
RA	<--	RP	-0.49^{**} (β_{21})				−0.49
RB	<--	RP	0.25^{**} (β_{23})	−0.29 ($\beta_{21} \times \beta_{13}$)			−0.04
RB	<--	RA	0.60^{**} (β_{13})				0.60

Notes. *— significant at 0.05 level; **— significant at 0.001 level.

perception [6, 25] or only an indirect effect on risky behavior via riding attitude [78] or a negative relationship on reduction of risky behavior [8, 77, 78]. Hence, risk perception was found to influence risky riding behaviors in both positive and negative, depending on the traffic characteristics and culture. This study found a positive direct relationship ($\beta_{23} = 0.25$) between risk perception and risky riding behavior, suitable for the results found in [8, 78, 79]. This result can be described when motorcyclists perceive and behave consistently with those perceptions while riding on the road. It stands to reason that one's likelihood of a potential crash influences one's driving habits. Individuals who engage in riskier driving behaviors may see themselves as more susceptible to a collision, which may result in further risky driving behavior [42]. Moreover, a few motorcyclists could accept a certain risk when riding to unaffect their enjoyment and may take risky actions [80]. Many motorcyclists believe that they are immune to accidents [46]. However, our research revealed a negative correlation (estimated at −0.29) between risk perception and risky riding behaviors, primarily influenced by riding attitude. This indirect impact is more significant than the direct impact. Therefore, our findings indicate that risk perception has a negative impact on risky riding behavior. Simply put, the higher an individual's risk perception score, the lower their score in risky riding behavior. As a result, it is crucial to educate motorcyclists about the dangers of reckless behavior and the severity of traffic accidents through laws and awareness campaigns.

There was a positive correlation (0.60) between risky behavior and unsafe riding attitudes found in this study and sources [37, 76, 81, 82]. It found that high scores of riding attitudes indicated negative attitudes towards traffic safety, leading to a positive relation to risky behaviors. In other words, participants who reported unsafe attitudes towards riding also reported more risky behaviors. Besides, there was an association between riding attitudes and risk perception, as well as the affecting riding behaviors [6, 81]. We found a negative relationship ($\beta_{21} = -0.49$) between risk perception and riding attitudes. It revealed that a high-risk perception score indicated a negative attitude towards risk-taking behaviors, i.e., a positive attitude towards traffic safety. This was consistent with the results in [37]. These results reinforced the direct effect of risk perception on riding attitudes. Therefore, strategies intended to change riding behaviors will be effective only by changing riding attitudes towards unsafe behaviors. In other words, traffic laws and education programs are necessary to improve safety-riding attitudes.

Regarding riding self-confidence, there was a positive effect of riding self-confidence on riding attitude towards risk-taking behavior found in [37, 39]. At the same time, there was a negative relationship between it and risk perception [45, 46]. This study also found these results, i.e., riding self-confidence increased attitudes toward unsafe behaviors and decreased perceived risk. However, we found a negative direct relationship ($\gamma_{23} = -0.11$) between riding self-confidence and risky riding behavior, the same as in [76]. Experienced motorcyclists often exhibit greater self-assurance while on the

road, which can reduce the likelihood of accidents for themselves and others [76]. Moreover, there are indirect correlations between self-confidence and risky behavior, as evidenced by risk perception (with an estimated value of −0.12), riding attitudes (with an estimated value of 0.15), and the combination of both (with an estimated value of 0.14). In general, the advantages of riding self-confidence outweigh the disadvantages. To sum up, riding self-confidence positively impacts risky riding behavior. Nonetheless, it is worth noting that excessive confidence can result in increased risk-taking and a greater chance of accidents. Improving the traffic infrastructure for motorcycles is necessary to increase new riders' confidence on the road. In addition, stronger law enforcement is needed to address motorcyclists who exhibit excessive confidence.

For risky riding behavior, as presented in Table 1, 20 items of the riding behavior scale were found to result from complex traffic conditions and the limitations of safety legislation in Vietnam. Several behaviors (e.g., SV04 "Illegal overtaking," OV04 "Get into the wrong lane," and SV03 "Exceed the speed limit on a road," OV06 "Use a cell phone while riding," etc.) need to be prioritized for handling. Furthermore, aggressive violations (AV) were also identified as important risky behaviors that impact the crash risk of motorcyclists. Aggressive violations have been associated with personality traits of motorcyclists, such as anger. They also reflect the low culture of a part of motorcyclists.

Based on the abovementioned discussions, the controlling measures and changes in risky behaviors of Vietnamese motorcyclists are proposed as follows:

(i) Motorcycles will still be the primary means of transportation people choose in the long term, but facilities (e.g., motorcycle lanes, signal lights, etc.) for motorcycles are still limited. The facility is a key part of riding behaviors, and it impacts the behaviors of the motorcyclist. It is necessary to increase facilities for motorcycles.

(ii) Strengthening and consistency in enforcing road traffic rules and laws can increase awareness and result in a change in riding behaviors.

(iii) Installing surveillance cameras at intersections and road sections will make motorcyclists pay attention to their surveillance, thereby helping to control risky behaviors related to violations.

(iv) To enhance road safety in crucial zones, it is imperative to adopt effective measures that cover various aspects such as speed control, enforcement, and communication. Strategies such as imposing higher penalties, introducing a license point system, and defining speed limits can be employed [27]. It is also vital to regularly conduct awareness campaigns to educate motorcyclists on safe riding practices and risk perception. Furthermore, imparting safety education can positively influence the personality traits of motorcyclists, particularly in managing anger and avoiding sensation-seeking behavior.

(v) Analyzing the causes of motorcycle crashes to increase public awareness is necessary.

This study has the following implications:

(i) This study can help policymakers introduce a riding behavior test in training.

(ii) We can predict future behavior tendencies of motorcyclists, as well as determine how to relate to motorcycle crashes through the affecting factors, including personality traits, riding self-confidence, riding attitude, risk perception, and so on.

(iii) The study's findings can inform road safety measures and programs for motorcyclists.

(iv) This study also provides future scholars with new insights into exploring the riding behaviors of motorcyclists in developing countries like Vietnam.

5. Conclusions

A CMM model study explored how personality traits, riding self-confidence, riding attitude, risk perception, and risky riding behavior were interrelated among motorcyclists in Hanoi, Vietnam. The findings indicated that these factors played a significant role in shaping the risky riding behavior of the participants. Both personality traits and riding self-confidence directly and indirectly affect risky riding behavior, mediated by riding attitude and risk perception. The study revealed that riding attitude and personality traits were the most influential factors, whereas risk perception and riding self-confidence had a comparatively lower impact. These results align with earlier research and establish the validity of the measurement scales for varying traffic cultures. The study provides crucial groundwork for developing strategies to mitigate risky riding behavior among motorcyclists.

The study's data collection scope was confined to urban areas of Hanoi, Vietnam, which could potentially limit its ability to represent riding behaviors in other areas accurately. Moreover, the study did not incorporate controlling factors for risky behaviors. These constraints will be thoroughly scrutinized in forthcoming studies.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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