



## Research article

# Unveiling the road to safety: Understanding the factors influencing motorcycle accidents among riders in rural Chiang Mai, Thailand

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## ABSTRACT

**Background:** Motorcycle accidents pose a significant threat to traffic safety in Thailand, particularly in rural areas where the severity of these accidents often results in prolonged medical treatment and a reduction in the quality of life of the affected individual.

**Objectives:** To investigate the prevalence and the factors associated with motorcycle accidents among motorcycle riders in rural areas in Chiang Mai, Thailand.

**Method:** A cross-sectional study was conducted from December 2022 to March 2023 via an anonymous survey in Chiang Mai, Thailand. A total of 308 participants engaged with the survey. The data about background information, motorcycle details, personal protective equipment, risky behaviors, attitude toward riding, and history of motorcycle accidents in the prior six months were collected and analyzed by binary logistic regression.

**Results:** Of 308 participants, the mean age was 56 years old (SD = 14.2), females were 56.8 % (N = 175), 51 % had co-morbidity, and 40.6 % were active alcohol drinkers. The prevalence of individuals who experienced a motorcycle accident within the previous six months was 57.1 %. Notably, the most unsafe riding behavior was not wearing a helmet while riding, which had a prevalence of more than 80 % in both the accident and non-accident groups. The study found significant associated factors for motorcycle accidents in rural communities, including the history of alcohol consumption (aOR 1.71, 95 % CI: 1.05,2.79), changing lanes without using turn signals (aOR 1.93, 95 % CI: 1.07,3.48) and those who strongly disagree with the notion that listening to music while riding is dangerous (aOR 2.80, 95 % CI: 1.06, 7.43).

**Conclusion:** Over half of motorcycle riders have been in accidents. These findings emphasize the need to enforce drunk-driving and traffic laws. Comprehensive motorcycle rider education and safety training are needed to encourage responsible riding.

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## 1. Introduction

Traffic accidents are considered a significant global issue [1]. The World Health Organization (WHO) has gathered data that estimates the annual death toll from traffic accidents to be 1.35 million, with the majority of deaths occurring in low-to middle-income countries. In 2018, the WHO ranked Thailand in the ninth place for countries with the highest number of deaths due to traffic accidents in the entire world and in first place in the Asian region with 33 deaths per 100,000 population [2,3]. It was discovered that motorcycle accidents had more serious injuries and required longer medical treatment than accidents involving other types of vehicles [4]. The increased occurrence of rural accident-related deaths can be attributed to factors such as decreased usage of safety measures including helmets and seat belts [5]. Moreover, rural areas had a higher severity of injury [6]. The negative impact of motorcycle accidents on the economy can be attributed to the disabilities inflicted on the victims, which can become a significant burden for their families and lead to a reduction in the overall quality of life of the affected people [7,8].

Three aspects of contributing variables to motorcycle accidents are vehicle factors [9–11] (engine capacity and vehicle visibility), environmental factors (road, weather, light, etc.), and personal factors [12–18] (risky behavior, attitude, gender, age, etc.). Risky driving behaviors and the rider's attitude towards riding behavior are among the main associated factors in motorcycle accidents, such as riding after alcohol consumption [14,16], not wearing a helmet [18], disobeying traffic signals [12–14,17], and mobile phone use while driving [15].

Alcohol use is one of the most recognized risks of traffic accidents [16]. A Norwegian study in 2015 also reported that 27.1 % of motorcycle riders who died in road crashes had alcohol or drugs in their blood samples, and among riders who lost their lives in single or multiple-vehicle accidents, alcohol was detected in 44.6 % [19]. Similarly, a study conducted in 2016 in Brazil found that 10.6 % of injured motorcycle riders in traffic accidents tested positive for alcohol [20]. Wearing a helmet is an important factor in reducing the severity of motorcycle accidents [21–24]. Helmet use is mandated by the Road Traffic Act, B.E. 2522 (1979) in Thailand; however, over half of Thai riders and passengers do not wear helmets while riding [18]. The significant factors contributing to non-wearing helmets were riding distance, riding status, helmet ownership, living in non-Bangkok regions, etc. [18,25]. The absence of wearing a helmet is associated with additional hazardous behaviors that significantly elevate the risk of motorcycle accidents, including engaging in alcohol consumption with elevated blood alcohol concentrations [25,26]. Distraction activities while riding lead to accidents too [27]. Engaging in distractions such as talking on a cell phone and listening to music while driving can lead riders to divert their focus from the road, thereby increasing the likelihood of accidents [28]. A study conducted in Vietnam found that 41 % of motorcyclists aged 18–25 and 34.8 % of car drivers aged 36–45 used their mobile phones while riding. The biggest influence on motorcycle riders' use of mobile phones while riding was their attitudes and beliefs [29].

The problem of traffic accidents among motorcycle riders is a serious public health concern worldwide, including rural areas in Thailand and Chiang Mai Province. Despite efforts to reduce the number of accidents, the rate of traffic injuries among motorcycle riders remains high. Therefore, it is crucial to identify the factors related to motorcycle accidents and to develop appropriate interventions to prevent and reduce these events. This study aimed to investigate the factors associated with motorcycle accidents among motorcycle riders in rural communities in Chiang Mai Province, Thailand, and the extent of the prevalence of traffic accidents and health problems among motorcycle riders. This study's findings can be used by policymakers to develop evidence-based interventions to improve the safety of motorcycle riders and reduce the burden of traffic injuries in rural communities.

## 2. Materials and methods

### 2.1. Study design and population

The research design was a cross-sectional study conducted among motorcycle riders living in rural areas in Chiang Mai, Thailand, from December 2022 to March 2023 via an anonymous survey. The inclusion criteria were age older than 18 years, currently living in Chiang Mai, being able to communicate, read, and understand the Thai language, and providing consent to participate in the project. The study was promoted with the help of community leaders, village health volunteers, and medical staff at the sub-district health-promoting hospital. Three hundred and eight participants accessed the survey.

### 2.2. Data collection

A convenient sampling method was used. Survey questionnaires were used to collect data from motorcycle riders who met the eligibility criteria. This questionnaire had a Cronbach's alpha of 0.7823. The participants were interviewed by the questionnaire, which was made up of six main parts:

- 1) Background information: This section collected age (years), sex (male/female), marital status (single/marriage/separate), and education level (no study/primary education/secondary education/bachelor's degree and above), income range, occupation status (full time/part-time/student/no job), co-morbidity (yes/no), sleeping status, (hour/day), smoking status (yes/no), alcohol drinking (yes/no), marijuana usage (yes/no), and accident insurance (yes/no).
- 2) Motorcycle information: This section collected characteristics of the motorcycle, such as the class, transmission, and riding habits including riding frequency, experience, distance, and speed. It also asked about the rider's motorcycle maintenance practices.
- 3) Personal Protective Equipment: This section used a Likert scale with five levels (always, often, sometimes, rarely, never) to assess the frequency of the rider's use of personal protective equipment during motorcycle riding.

- 4) Risky Riding Behavior: This section collected information about risky riding behaviors, mobile phone usage, and anxiety.
- 5) Accident Information: This section collected information on the number of accidents experienced by the rider in the past six months.
- 6) Beliefs and Attitudes: This section assessed participants' beliefs and attitudes about motorcycle riding, including helmet usage, compliance with traffic signs, listening to music, mobile phone usage, and alcohol consumption during motorcycle riding. The Likert scale with five levels (never, seldom, sometimes, usually, and always) was also used in this section.

2.3. Statistical and data analysis

Descriptive statistics were analyzed, including frequency (n), percentage (%), mean, median, standard deviation (SD.), percentile25th (P25th), and percentile75th (P75th). Inferential statistics, including the Fisher Exact test, Student t-test, and Mann-Whitney U test were also analyzed to compare all factors with the history of accidents. Binary logistic regression was analyzed to determine the factors associated with motorcycle accidents in a rural community.

Fisher's Exact Test was calculated as:  $p = \frac{(a+b)!(c+d)!(a+c)!(b+d)!}{(a!b!c!d!n!)};$  where p is exact probability; ! is factorial operator; n is total frequency; a,b,c, or d is individual frequencies of contingency table.

Student t-test was calculated as:  $t = \frac{(X1-X2)}{\sqrt{\frac{(S1)^2}{n1} + \frac{(S2)^2}{n2}}};$  where X1 is mean of sample1; S1 is standard deviation of sample1; n1 is

sample size of sample1; X2 is mean of sample2; S2 is standard deviation of sample2; n2 is sample size of sample2.

Mann-Whitney U test was denoted U and was the smaller of U1 and U2, is calculated as:

$$U1 = n1n2 + \frac{n1(n1 + 1)}{2} - R1$$

$$U2 = n1n2 + \frac{n2(n2 + 1)}{2} - R2$$

where U1 is U test of group1; U2 is U test of group2; n1 is sample number of group1; n2 is sample number of group2; R1 is sum of the ranks for group1; R2 is sum of the ranks for group2.

Binary logistic regression was calculated as :  $p(x) = \frac{1}{1 + e^{-(\beta0 + \beta1x)}}$

**Table 1**  
Socio-demographic characteristics and information of motorcycle use.

Characteristics	Total	Accident within the previous six months		P value	
		Yes	No		
Age (years.), Mean + SD.	56.0 ± 14.2	54.1 ± 15.4	57.5 ± 13.2	0.054	
Gender, n(%)	Male	133 (43.2)	68 (51.5)	65 (36.9)	0.015*
	Female	175 (56.8)	64 (48.5)	111 (63.1)	
Occupation, n(%)	Full time	102 (33.1)	48 (36.4)	54 (30.7)	0.556
	Part time	119 (38.6)	49 (37.1)	70 (39.8)	
	Student	9 (2.9)	5 (3.8)	4 (2.3)	
	No job	78 (25.3)	30 (22.7)	48 (27.3)	
Education, n(%)	No study	51 (16.6)	25 (18.9)	26 (14.8)	0.201
	Primary education	222 (72.1)	94 (71.2)	128 (72.7)	
	Secondary education	23 (7.5)	6 (4.5)	17 (9.7)	
	Bachelor's degree and above	12 (3.9)	7 (5.3)	5 (2.8)	
Co-morbidity, n(%)	157(51.0)	66 (50.0)	91 (51.7)	0.818	
Smoking status, n(%)	45 (14.6)	19 (14.4)	26 (14.8)	0.530	
Alcohol drinking, n(%)	125 (40.6)	65 (49.2)	60 (34.1)	0.010*	
Use of Marijuana, n(%)	34 (11.0)	14 (10.6)	20 (11.4)	0.857	
Accident insurance, n(%)	106 (34.4)	48 (36.4)	58 (33.0)	0.547	
Sleeping status, (hr./day), Mean + SD.	7.7 ± 1.6	7.8 ± 1.8	7.7 ± 1.4	0.159	
Frequency of motorcycle riding (hr./week), Median (25th,P75th)	7 (5,48.8)	7 (7,70)	7 (3.5,30)	0.015*	
Experience in motorcycle riding, yrs. Median (25th,P75th)	35 (25.5, 40)	35 (25,44.8)	36 (27.3,40)	0.641	
Distance of riding (km/day), Median (25th,P75th)	4 (2, 8)	3 (2,10)	3 (1,6)	0.007**	
Driving license, n(%)	137 (44.5)	67 (50.8)	70 (39.8)	0.064	
Owner of motorcycle, n(%)	253 (82.1)	109 (82.6)	144 (81.8)	0.882	
Capacity engine, n(%)	≤110 cc	249 (80.8)	99 (75.0)	150 (85.2)	0.028*
	>110 cc	59 (19.2)	33 (25.0)	26 (14.8)	
Type of gear, n(%)	Auto	78 (25.3)	37 (28.0)	41 (23.3)	0.357
	Clutch	230 (74.7)	95 (72.0)	135 (76.7)	
Maintenance of motorcycle, n(%)	258 (83.8)	105 (79.5)	153 (86.9)	0.088	

\*\*P value < 0.05; \*P value < 0.01.

where  $p(x)$  is the probability of the dependent variable;  $\beta_0$  is the intercept from the linear regression equation;  $\beta_1x$  is regression coefficient multiplied by some value of the predictor.

The variables that had a P value < 0.05 were included in the model and a backward model was used. Adjusted odds ratio (aOR) and 95 % confidence interval (95 % CI) were presented. The significance level was set at  $P < 0.05$ .

### 2.4. Ethical considerations

The study was approved by the Research Ethics Committee of the Faculty of Medicine, Chiang Mai University. (Approval ID 446/2565 Research ID COM-2565-09332).

### 3. Results

This survey received 308 responses for analysis from Thai motorcycle riders living in Chiang Mai. More than half of the participants (57.1 %) had experienced a motorcycle accident within the previous six months.

Among individuals with a prior history of motorcycle accidents, the mean age was 54.1 years (SD = 15.4). Roughly half of these participants reported having a chronic medical condition, while 49.2 % reported current alcohol consumption. Current smoking and cannabis use were reported by approximately 10.6 % and 14.4 % of participants, respectively. The participants reported frequent riding, averaging approximately 7 h per week and covering approximately 3 km per day. Approximately half of the participants possessed a valid driver’s license, while 75 % reported owning a motorcycle with an engine size of less than 110 cc. Furthermore, almost 80 % of the participants reported regular vehicle maintenance practices (Table 1).

Among individuals without a prior history of motorcycle accidents, the mean age was 57.5 years (SD = 13.2). More than half (51.7 %) of these participants reported having a chronic medical condition, while 34.1 % reported current alcohol consumption. Current smoking and cannabis use were reported by approximately 14.8 % and 11.4 % of participants, respectively. The participants reported frequent riding, averaging approximately 7 h per week and covering approximately 3 km per day. Forty percent of the participants possessed a valid driver’s license, while 85.2 % reported owning a motorcycle with an engine size of less than 110 cc. Furthermore, almost 87 % of the participants reported regular vehicle maintenance practices (Table 1).

As shown in Fig. 1, local Thai motorcycle drivers utilized various forms of personal protective equipment (PPE) while riding. The most employed PPE was a mask, which was worn by 91.6 % of the participants. This was followed by long trousers (68.8 %) and long-sleeved shirts (67.5 %). Other forms of PPE utilized by the participants included helmets (30.8 %), boots (26.3 %), glasses (16.9 %), and gloves (12.0 %). Notably, knee pads and earplugs were not utilized by any of the motorcycle riders who participated in the study.

Table 2 shows the association between hazardous behaviors in motorcycle riding and accidents. Six behaviors were associated with increased risk of having motorcycle accidents in the community including suddenly changing riding lanes (OR = 2.0, 95 % CI 1.01,3.98), riding with one hand only (OR = 2.2, 95 % CI 1.34,3.66), tailgating the vehicle in front at close range while riding (OR = 2.84, 95 % CI 1.32,6.12), turning or changing lanes without using indication lamp (OR = 2.12, 95 % CI 1.23,3.63), cutting in front of other vehicles while riding (OR = 3.74, 95 % CI 1.30,10.76), and riding at a speed exceeding the legal limit (90 km/h) (OR = 2.79, 95 % CI 1.25,6.23).

Fig. 2 displays the comparison between participants who have had previous accidents and those who have not, regarding their attitude toward motorcycle riding and accidents in a rural community. The results revealed a statistically significant difference in perceived risk related to listening to music while riding between both groups (p-value 0.044). However, no significant differences were observed in other aspects such as the necessity to adhere to traffic signs, wearing a helmet regardless of distance, and the dangers of drinking alcohol or using a mobile phone while riding.

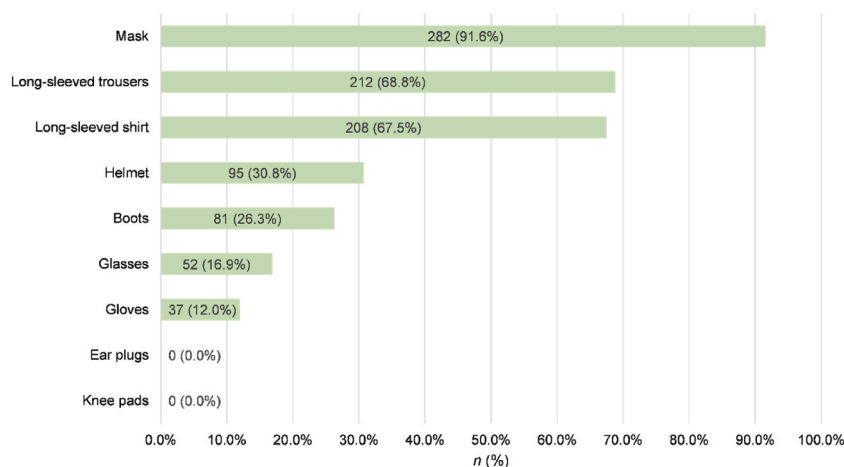
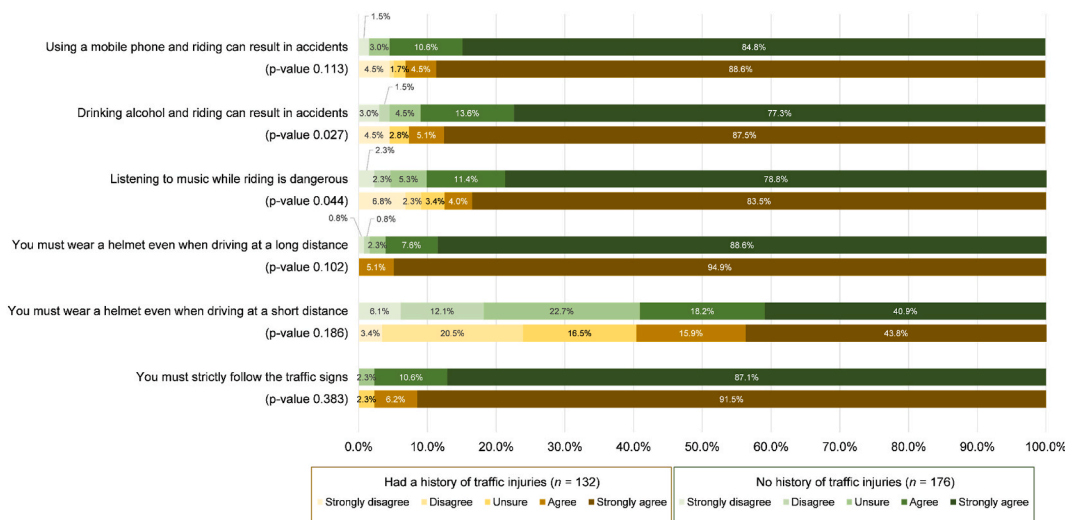


Fig. 1. Percentage of personal protective equipment (PPE) usage among motorcyclists residing in rural areas of Chiang Mai.

**Table 2**  
Relationship between hazardous behaviors in motorcycle riding and accidents within the previous six months in the rural Thai community.

Factors	Total	Accident within the previous six months		Crude OR	95 % CI
		Yes	No		
1. Not wearing a helmet	267 (86.7)	118 (89.4)	149 (84.7)	1.527	0.767,3.043
2. Driving on the walkway	9 (2.9)	7 (5.3)	2 (1.1)	4.872	0.995,23.848
3. Not stopping the vehicle for people who want to cross the zebra crossing	23 (7.5)	13 (9.8)	10 (5.7)	1.813	0.769,4.274
4. Suddenly change lane	38 (12.3)	22 (16.7)	16 (9.1)	2.000	1.005,3.980*
5. Riding with one hand only	88 (28.6)	50 (37.9)	38 (21.6)	2.214	1.340,3.660**
6. Tailgating the vehicle in front at close range while riding	32 (10.4)	21 (15.9)	11 (6.2)	2.838	1.316,6.118**
7. Riding in reverse	34 (11.0)	20 (15.2)	14 (8.0)	2.066	1.002,4.263
8. Riding through a red light	22 (7.1)	12 (9.1)	10 (5.7)	1.660	0.694,3.968
9. Turning or changing lanes without using indication lamp	70 (22.7)	40 (30.3)	30 (17.0)	2.116	1.232,3.633**
10. Turning into an alleyway without slowing down	19 (6.2)	11 (8.3)	8 (4.5)	1.909	0.746,4.888
11. Cutting in front of other vehicles while riding	18 (5.8)	13 (9.8)	5 (2.8)	3.736	1.298,10.758**
12. Riding at a speed exceeding the legal limit (90 km/h)	29 (9.4)	19 (14.4)	10 (5.7)	2.791	1.251,6.225*
13. Using a mobile phone while riding	31 (10.1)	18 (13.6)	13 (7.4)	1.980	0.933,4.201
14. Making a call while riding	21 (6.8)	12 (9.1)	9 (5.1)	1.856	0.758,4.544
15. Chatting or texting while riding	11 (3.6)	5 (3.8)	6 (3.4)	1.115	0.333,3.737
16. Using a mobile phone as a navigation tool while riding	14 (4.5)	7 (5.3)	7 (4.0)	1.352	0.462,3.953
17. Listening to music while riding	13 (4.2)	5 (3.8)	8 (4.5)	0.827	0.264,2.587

\*\*P value < 0.05; \*P value < 0.01.



**Fig. 2.** Motorcycle riding attitudes among residents of rural Chiang Mai.

The factors associated with motorcycle accidents in a rural community are presented in Table 3. Participants who reported a history of alcohol consumption (aOR = 1.71, 95 % CI 1.05–2.79), those who turned or changed lanes without using indication lamp (aOR = 1.93, 95 % CI 1.07–3.49), and those who strongly disagreed with the notion that listening to music while riding is dangerous (aOR =

**Table 3**  
Factors associated with motorcycle accidents in rural community by binary logistic regression.

Factors	Adj. OR	95 %CI
Alcohol drinking	1.707	1.046,2.785*
Capacity engine (<=110 cc as ref.)	1.807	0.987,3.311
Tailgating the vehicle in front at close range while riding	2.315	0.983,5.453
Turning or changing lanes without using indication lamp	1.929	1.068,3.487*
Attitude- Listening to music while riding is dangerous	Strongly agree (Ref.)	
	Agree	0.261, 0.066,1.026
	Unsure	0.620, 0.122,3.157
	Disagree	1.063, 0.320,3.532
	Strongly disagree	2.804, 1.058,7.427*

\*P value < 0.01.

2.80, 95 % CI 1.06–7.43) were found to be more likely to experience motorcycle accidents in rural areas.

#### 4. Discussion

This survey revealed that more than half of the participants (57.1 %) had experienced a motorcycle accident within the previous six months. A developing country's rural areas had a prevalence of motorcycle accidents between 28.2 and 50 % [30,31]. However, this study indicated a grossly greater incidence compared to an 87,134-participant cohort study in Thailand [32], which found just 8.4 % of transport accidents (6.04 % from motorcycle accidents) within the previous 12 months. The study found significant associated factors for motorcycle accidents in rural communities, including the history of alcohol consumption, changing lanes without using turning signals, and those who strongly disagree with the notion that listening to music while riding is dangerous.

##### 4.1. Alcohol drinking

Alcohol use is one of the most recognized risks in traffic accidents. According to meta-analysis research by Kassyn L. et al. [16], alcohol intake among injured drivers was most common in Asia (30.6 %, 95 % CI: 24.6–36.5 %). The prevalence of alcohol intake in this study was higher than the results of the meta-analysis. In Thailand, the proportion of injured drivers who had consumed alcohol before the accident was 36.3 % [33] and the northern region reported the highest drinking rates, which were more common in rural areas [34]. Based on two studies [35,36] that included both cars and motorcycle riders, the prevalence of alcohol use among motorcycle riders was greater and was associated with more accidents. Drinking alcohol considerably and favorably increased the probability of road injuries by 1.68–2.83 times [21,32,35] and increased the severity of injuries [35]. Among injured motorcycle riders in traffic accidents, 10.6–27.1 % of them had alcohol or drugs in their blood samples, with alcohol being the most frequently found substance [19,20].

Driving after drinking behavior might be associated with social norms, peer influence, knowledge and awareness of adverse outcomes, and laws [37,38]. Alcohol consumption has a direct dose-response association with the ability to drive safely. It causes reduced attention, delayed reactions, impaired decision-making, and vision impairment [33,39]. According to a study done on drunk riders and drivers, these individuals are more likely to lose vehicle control (such as deviations in vehicle position, centerline crossings, and edge crossings of the road) and take part in risky riding behaviors (such as disobeying traffic signals and running off the road) [33, 40].

The WHO recommended setting blood alcohol concentration (BAC) limits of 0.05 g/dL for general drivers and 0.02 g/dL for young and novice drivers as a best practice [3]. The legal blood alcohol content in Thailand is 0.05 g/dL for drivers with general licenses and 0.02 g/dL for drivers below 20 years old or who have temporary permits, both of which adhere to WHO best practices. Even though it is the law, testing for alcohol levels was more common in urban than rural areas [34]. We suggest that the drink-driving prohibition needs to be effectively enforced at all levels of authority, including national, regional, and municipal.

##### 4.2. Helmet use

In this study, the risky riding behavior was not wearing a helmet while riding, which had a prevalence of more than 80 % in both the accident and non-accident groups. Additionally, this study only found that 30.8 % of participants regularly used helmets. The prevalence decreased in comparison to cohort research conducted in Thailand, which revealed that 65 % of Thai motorcyclists wore helmets [41]. Compared to other middle-income Southeast Asian countries like Malaysia and Indonesia, which reported helmet-wearing rates of 80–90 %, the prevalence of helmet use in this study was lower [17]. A systematic review conducted in Thailand [18] showed that rural areas were associated with non-helmet wearing due to poorer police enforcement of helmets. Other associated factors with non-helmet use were young females, a lower degree of road safety, barriers to helmet use, and a lack of knowledge of risks from motorbike use. Many previous studies [21–24] highlighted that motorcycle helmets reduced the risk of death and head injury in crashed motorcyclists. Helmets reduced the incidence of fatal injuries by 37–42 % and head injuries by 56–69 % [23, 24]. According to research conducted in Alabama [21], riding without a helmet increased the probability of serious injuries in motorcycle accidents in rural areas.

This study, however, did not identify an association between motorcycle accidents and helmet use. To explain the findings, it might be discussed that wearing a helmet was considered protective equipment or a safety item intended to reduce accident severity, disability, and mortality rather than reduce incidence. Riding without a helmet can reflect other risky behaviors. The absence of helmet usage is notably linked to other risky behaviors, such as driving under the influence of alcohol, texting while driving, and red-light running, which are associated with accidents [25,26].

Additionally, non-helmeted riding burdens the country's finances. A meta-analysis study found that hospital expenses for each patient who experiences a non-helmeted injury were \$12,239 and more [42].

It's interesting to note that non-helmeted riders have acceptable knowledge about the advantages and protective functions of helmets as well as the importance of wearing them [9]. It is challenging for authorities to enforce helmet use when riding since people often have acceptable knowledge and awareness. Several factors were found to positively influence helmet usage, such as riding on highways, long distances, helmet ownership, larger engine sizes, helmet prices, and the legal regulations [9,30]. To increase the use of helmets, public policy may therefore begin by focusing on those protective factors. It is possible to increase the awareness of motorcycle riders concerning the advantages of wearing helmets by creating safety education programs or campaigns.

### 4.3. Other risky behaviors and attitudes

Between the accident and non-accident groups, many risky riding behaviors differed for them, such as turning on the indicator lamp when turning, lane changing suddenly, one-hand control, and stunts. However, after adjusting, only one factor that significantly increased the risk of an accident was not turning on the indication lamp when turning. The prevalence of not turning on the indication lamp when turning was higher in this study than in the research conducted in Indonesia, which had a 10 % prevalence [17]. Several studies have identified differences in risky behaviors that are associated with accidents, such as stunts [43], speed-related violence [12, 13], running red lights [14], and mobile phone use while riding [15]. The difference in associated risky behavior could be based on variations in driving culture, law enforcement, and driving habits.

Attitude toward riding is also associated with accidents. This study revealed that even though the prevalence of riders who listened to music while riding was only 13 %, there was a significant association between motorcycle accidents and attitudes that disagreed with "listening to music while riding was dangerous". One of the distractions that might affect driving performance and cause accidents is listening to music. The most distracting activities for motorcyclists [27] were utilizing map navigation, listening to music, and adjusting mirrors or other vehicle devices. Not only increasing motorcycle accidents by 1.53 times (1.29–1.80), but listening to music while driving has also been linked to attention-related driving errors (Spearman 0.16,  $p$  0.01) [17].

### 4.4. Vehicle factors

Although there was a difference in engine capacity between the accident and non-accident groups, this difference was not substantially connected with accidents when confounders were adjusted. Even larger engines were protective variables for wearing helmets [9], but several studies revealed that heavy engines were related to more incidence and serious crashes [10,11]. It can be due to the heavier weight, larger size, and greater potential power, speed, and momentum [44].

### 4.5. Chronic medical conditions

Our study reported no association between the presence or absence of chronic medical conditions and motorcycle accidents in rural areas. This outcome contrasts with a previous study by Turrado et al., which reported a documented association between chronic medical conditions and an increased risk of accidents. These conditions included hearing difficulties (with an aOR of 1.19 and a 95 % CI of 1.06–1.34), joint disorders (with OR of 1.17 and a 95 % CI of 1.06–1.30), as well as depression, anxiety, and stress (with OR of 1.23 and a 95 % CI of 1.01–1.49) [45]. Therefore, individuals with a history of hearing difficulties, joint disorders, or mental health conditions should consider managing their conditions before engaging in motorcycle riding.

### 4.6. Strengths and limitations

To our knowledge, this study revealed characteristics and reflected motorcycle accidents in rural areas that might differ from urban areas. Even though many safety drive policies have been developed, they still involve risky driving, especially for alcoholic drinks. Attitude about listening to music while riding was a unique associated factor in this study, which should be explored more in the future. However, there are some limitations to this study. First, a cross-sectional design makes it difficult to determine how contributing factors and accidents relate to each other. Second, survival bias and recall bias occurred because self-report questionnaires were collected from only non-fatal accident participants. Lastly, the study was conducted only in Chiang Mai, Thailand, so generalizability appears somewhat limited. We suggest doing a prospective study to establish a causal relationship. Additional significant information might be retrieved via more comprehensive data collection from medical records (ER visits, hospitalization rates, death cases, etc.) and traffic injury reports from the police information report. The blood alcohol level and history of alcohol consumption before driving (quantity, time, and duration) were also suggested. In future research, conducting an in-depth analysis of a range of factors associated with motorcycle accidents in rural areas, such as law enforcement, public policies (e.g., alcohol consumption, helmet usage, risky behaviors), possession of a driver's license, and motorcycle maintenance, could offer a more comprehensive insight into the causes of motorcycle accidents among motorcycle drivers in rural communities.

## 5. Conclusion

Over half of motorcycle riders have encountered accidents while on the road, signifying the serious issue of motorcycle accidents. This study has provided evidence that risky behaviors, including alcohol consumption, failure to use turn signals, and listening to music, can contribute to motorcycle accidents in rural areas. The helmet-wearing rate among riders is less than one-third. Furthermore, riders' attitudes toward riding are correlated with accident rates. These results emphasize the importance of continued and enhanced enforcement of laws related to drunk driving and traffic regulations. To address these concerns in rural communities, stakeholders should integrate elements of social norms, peer influence, and awareness of adverse outcomes. Additionally, there is a need for comprehensive motorcycle rider education and safety training to promote responsible riding behaviors.

### Data availability statement

The data that support the findings of this study are available from the corresponding author, [AK], upon reasonable request.

## CRediT authorship contribution statement

**Jinjuta Panumasvivat:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Amornphat Kitro:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Yanisa Samakarn:** Writing – original draft, Data curation. **Kavee Pairojtanchai:** Writing – original draft, Data curation. **Wachiranun Sirikul:** Writing – review & editing, Writing – original draft, Visualization, Formal analysis. **Tharntip Promkutkao:** Writing – original draft, Supervision, Data curation. **Ratana Sapbamrer:** Writing – review & editing, Writing – original draft, Supervision, Formal analysis.

## Declaration of competing interest

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

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