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Unsafe Riding Behavior Among Adolescent Electric Bicycle Users in Semarang City

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The use of electric bicycles among adolescents has increased along with their growing popularity as an alternative mode of transportation. However, this trend raises concerns regarding riding safety. This study aimed to describe the riding behavior of adolescent electric bicycle users and to analyze the association between unsafe riding behavior with traffic incident history. Unsafe riding behavior was assessed based on speeding, helmet use, mobile phone use while riding, adult supervision, and riding in motor vehicle lanes. A quantitative descriptive-analytic study with a cross-sectional design was conducted in Semarang City. A total of 35 adolescent electric bicycle users were recruited using accidental sampling. Data were collected through a questionnaire and analyzed using univariate analysis and fisher's exact test. The results showed that more than half of respondents rode at speeds exceeding 25 km/h (54.3%), the majority did not use helmets (80.0%), frequently rode in motor vehicle lanes (74.2%), and were not consistently accompanied by adults. The mean riding speed was 30.03 km/h, with a maximum speed of 45 km/h. Regarding safety outcomes, 22.9% of respondents reported having experienced an accident, while 17.1% reported near-miss incidents. Unsafe riding practices were common among adolescent electric bicycle users in Semarang City. These findings suggest the importance of strengthening safety education and improving compliance with existing regulations governing electric bicycle use.

Keywords: Accident, Adolescents, Electric bicycle, Riding behavior, Traffic safety

INTRODUCTION

The adoption of electric vehicles has increased substantially in recent years. By 2024, nearly 300 million electric bicycles will be in use worldwide (Chafer, 2024). There were more than 280 million electric mopeds, scooters, motorcycles, and three-wheeled vehicles on the road in 2022 (The Conversation, 2023). Globally, road traffic crashes cause around 1.19 million deaths annually and leave an estimated 20–50 million individuals with non-fatal injuries. The growing use of electric-powered vehicles may also influence the occurrence of road traffic incidents. The number of injuries resulting from the use of e-bikes increased dramatically from 751 in 2017 to 23,493 in 2022. During that same period, injuries resulting from the use of electric scooters rose from 8,566 to 56,847. In total, there were almost 2.5 million bicycle-related injuries, over 304,000 scooter-related injuries, 45,586 e-bike-related injuries and around 189,517 e-scooter-related injuries in the United States (ScienceDaily, 2024).

According to Statistics Indonesia, the number of reported traffic accidents rose from 103,645 cases in 2021 to 139,258 cases in 2022 (BPS Indonesia, 2024). This represents an increase of 35,613 cases, equivalent to a growth of 34.36% over the one-year period. Data from the Integrated Road Safety Management System (IRSMS) of the National Police Traffic Corps (Korlantas Polri) indicates that there were 107 electric bicycle accidents on public roads across Indonesia between June and August 2023 (pusiknaspolrigoid, 2023). Furthermore, according to data from the Indonesian National Police Traffic Corps (Korlantas), there were a total of 647 accidents involving electric bicycles from January to June 2024 in Indonesia (Pratama et al., 2025).

According to data from the Central Java Provincial Central Statistics Agency (BPS), there were 30,493 traffic accidents in 2022 (BPS Jawa Tengah, 2023). A total of 31,425 traffic accidents were recorded in 2023 (BPS Jawa Tengah, 2024). The number of traffic accidents in Central Java increased by 3.06% or by 932 accidents in 2023 compared to 2022. The number of traffic accidents in the city of Semarang in 2022 was 1,116 (BPS Jawa Tengah, 2023). Then, in 2023, there were 1,339 traffic accidents in Semarang City (BPS Jawa Tengah, 2024). This represented an increase of 19.98% from 2022 to 2023, with the number of accidents rising by 223. Some of these accidents involved electric vehicles.

Recently, a new type of traffic accident involving children riding light private vehicles and low-speed electric

vehicles has emerged, characterised by specific types of trauma and injuries (Shkatula et al., 2024).A viral video on social media showed three children riding electric bicycles involved in an accident in Semarang (Tribun Jawa Tengah, 2023). Additionally, a young child riding an electric bicycle caused a pile-up in Genuk, Semarang City, on February 18, 2024 (Muntoha, 2024). Findings from a study indicate that adolescents commit a higher rate of traffic violations compared to adults and middle-aged individuals across all types of traffic violations (Lady & Umyati, 2021).

In addition to traffic accidents, near-miss events are increasingly recognized as important indicators of road safety. A near-miss refers to an event that almost occurs and has the potential to result in injury, damage, or loss, but does not develop into an actual accident because certain contributing factors or causal mechanisms are absent (Al Shaaili et al., 2023). Although they do not result in injury or damage, the reporting and analysis of near-miss events can help identify risk factors and support the development of more effective accident prevention strategies (Hashmi et al., 2024).

Electric vehicles have higher accident rates than traditional vehicles (McDonnell et al., 2024). Injuries involving electric bicycles among children increased between 2011 and 2020, while bicycle-related injuries decreased (Goodman, 2019). Children typically sustain upper extremity injuries, whereas adults mostly suffer lower extremity injuries (Büyükceran et al., 2023). Compared to fatalities from other modes of transportation, those killed in electric scooter accidents are younger and more likely to be male (Karpinski et al., 2023). A study confirms the high prevalence of single-vehicle accidents involving e-bikes (Hertach et al., 2018).

E-bike riders involved in accidents sustain more severe injuries, are more likely to suffer multiple injuries, and experience more severe head injuries compared to conventional cyclists (Poos et al., 2017). Major factors contributing to e-bike accidents include violations of traffic signs or signals, careless riding, speeding, and riding in the wrong lane (Zhang et al., 2018). Additionally, answering or making phone calls and not wearing a helmet while cycling increase the risk of e-bike traffic injuries (Zhong et al., 2022). Furthermore, there is a higher likelihood of e-bike accidents occurring near city administrative centers and along arterial roads (Zhuang et al., 2024). The Sustainable Development Goals (SDGs), particularly Target 3.6, aim to substantially reduce road traffic deaths and injuries by 2030. Achieving this target requires not only preventing traffic crashes but also identifying traffic safety incidents, including near-miss events, which provide valuable insights into hazardous riding behaviors before serious injuries occur.

Although studies have examined risk factors associated with electric bicycle injuries and crashes, most evidence comes from countries such as China and the United States. Evidence regarding unsafe riding behaviors among adolescent electric bicycle users in Indonesia remains limited. Although several studies on electric bicycles have been conducted in Indonesia, most have focused on legal and regulatory aspects. The available literature on safety has included descriptive and qualitative investigations; however, few studies have specifically examined both accidents and near-miss experiences as indicators of traffic safety outcomes (Istiyanto et al., 2025).

The increasing use of electric bicycles among adolescents raises concerns regarding compliance with safety regulations and the potential occurrence of safety incidents. Therefore, this study aims to describe unsafe riding behaviors among adolescent electric bicycle users, evaluate their compliance with selected safety provisions stipulated in the Regulation No. PM 45 of 2020 issued by the Minister of Transportation of the Republic of Indonesia, and examine the association between unsafe behavior and the history of accidents and near-miss incidents in Semarang City.

METHODS

This study employed a quantitative approach with a cross-sectional design. The research was conducted in the city of Semarang from June to August 2025. The study population consisted of adolescents aged 10–18 years who use electric bicycles. A total of 35 were included in the city of Semarang from June to August 2025. The study population consisted of adolescents aged 10-18 years who use electric bicycles. Participants were recruited using accidental sampling at several public locations and several schools in Semarang city during the study period. Individuals who used electric bicycles, met the inclusion criteria, and voluntary agreed to participate were enrolled in the study.

Information was collected through a structured questionnaire covering respondent characteristics, riding practices, and previous experiences of accidents or near-miss events while using electric bicycles. The questionnaire was based on the Regulation of the Minister of Transportation of the Republic of Indonesia No. PM 45 of 2020 and supported by previous studies on electric bicycle safety. The questionnaire consisted of factual and behavioral items rather than psychometric scales. Therefore, the unsafe riding behavior score was constructed by combining five observable safety-related behaviors. Data were obtained based on respondents' self-reports of their experiences using electric bicycles.

Prior to analysis, all collected data were reviewed, coded, and entered the database for processing. Data processing was conducted using a quantitative approach, where each variable was categorized according to the indicators established in the research questionnaire. Unsafe riding behavior was assessed using a composite score derived from five behavioral indicators. The indicators included riding speed, helmet use, mobile phone use while riding, adult supervision, and riding in motor vehicle lanes. Each indicator was assigned a score according to the level of unsafe behavior, with higher scores representing greater engagement in unsafe riding practices. The total unsafe behavior score ranged from 0 to 9, with higher scores indicating a higher level of unsafe riding behavior. The participants were categorized using the sample median score (5). Scores of 1–4 were classified

as low unsafe behavior, whereas scores of 5–9 were classified as high unsafe behavior. The scoring system used to classify unsafe riding behavior is presented in Table 1.

Table 1

Scoring System for Unsafe Riding Behavior

Variable	Response	Score
Average Riding Speed	≤25 km/h	0
	>25 km/h	1
Helmet Use	Always	0
	Sometimes	1
	Never	2
Mobile Phone Use While Riding	Never	0
	Sometimes	1
	Often	2
Riding in Motor Vehicle Lanes	Never	0
	Sometimes	1
	Often	2
Adult Supervision While Riding	Always	0
	Sometimes	1
	Never	2

The collected data were analyzed through both descriptive and inferential statistical approaches. Descriptive analysis was applied to summarize the characteristics of respondents and patterns of electric bicycle use, while bivariate analysis was performed to examine the association between unsafe riding behavior and the history of safety incidents among adolescent electric bicycle users. Statistical significance was determined through the Fisher's Exact Test, applying a significance threshold of $p < 0.05$. All statistical procedures were carried out using IBM SPSS Statistics. Ethical clearance for this research was granted by the Health Research Ethics Committee, Faculty of Medicine, Universitas Negeri Semarang (Approval No. 1042/KEPK/FK/KLE/2025).

RESULTS AND DISCUSSION

The results of the study show that the majority of respondents were in the 13–15 age group, with the highest proportion being 14-year-olds (31.4%), followed by 15-year-olds (28.6%) and 13-year-olds (20.0%). Respondents aged 12 and 16 each accounted for 5.7%, while those aged 11 accounted for 8.6%. The mean age of the respondents involved in this study was 13.83 years, with a standard deviation of 1.317. By gender, the majority of respondents were female (62.9%), while males accounted for 37.1%. These findings are similar to those of Plazier (2020), who found that women were 1.99 times more likely than men to own an electric bicycle (Plazier et al., 2023).

Table 2.

Characteristics of Respondents

No	Characteristics	Categories	n	(%)
1	Age	11 years	3	8.6
		12 years	2	5.7
		13 years	7	20.0
		14 years	11	31.4
		15 years	10	28.6
		16 years	2	5.7

No	Characteristics	Categories	n	(%)
2	Gender	Male	13	37.1
		Female	22	62.9
3	Duration of Electric Bicycle Use	≤1 year	18	51.4
		>1 year	17	48.6
4	Primary Purpose of Use	Transportation to School	14	40.0
		Recreation	21	60.0

In terms of the duration of electric bicycle use, 51.4% of respondents had been using electric bicycles for ≤1 year, and 48.6% had been using them for >1 year. The most commonly reported purpose of use was for recreation (60.0%), while 40.0% of respondents stated that they more often used electric bicycles as transportation to school.

The distribution of electric bicycle usage behavior shows that more than half of the respondents (54.3%) ride electric bicycles at an average speed of >25 km/h, while 45.7% ride at a speed of ≤25 km/h. Respondents reported a mean riding speed of 30.03 km/h (median = 30 km/h), ranging between 17 km/h and 45 km/h, indicating variation in speed among teenage electric bicycle users. Regarding protective gear, many respondents (80.0%) stated they never wear a helmet while riding, and only 20.0% wear a helmet occasionally. No respondent reported always wearing a helmet. Regarding the use of cell phones while riding, the majority of respondents (82.9%) never use a cell phone, while 17.1% reported occasionally using a cell phone while riding.

Table 3.

Distribution of Riding Behaviors and Crash History Among Adolescent Electric Bicycle Users

No	Variables	Categories	n	(%)
1	Average Riding Speed	≤25 km/h	16	45,7
		>25 km/h	19	54,3
2	Helmet Use	Sometimes	7	20,0
		Never	28	80,0
3	Mobile Phone Use While Riding	Never	29	82,9
		Sometimes	6	17,1
4	Riding in Motor Vehicle Lanes	Never	9	25,7
		Sometimes	20	57,1
		Often	6	17,1
5	Adult Supervision While Riding	Sometimes	19	54,3
		Never	16	45,7
6	Crash History	Experienced a Crash	8	22,9
		Experienced a Near-Miss Incident	6	17,1
		Never	21	60,0

Most respondents also admitted to having driven in the motor vehicle lane, with 57.1% stating they do so sometimes and 17.1% stating they do so frequently; only 25.7% have never used the motor vehicle lane. In

addition, more than half of the respondents (54.3%) stated that they were only occasionally accompanied by an adult while riding, and 45.7% were never accompanied. Regarding the history of incidents, 22.9% of respondents had experienced a minor accident, 17.1% had experienced a near miss, and 60.0% stated they had never experienced such incidents. The accidents experienced by respondents were classified as minor. A total of 22.9% of respondents had experienced a minor accident, and 17.1% had experienced a near miss. These findings suggest that approximately two-fifths of adolescent riders had experienced a safety-related incident while operating an electric bicycle, with limitations on generalizability.

Bivariate analysis results show that in the group with low levels of unsafe behavior, 33.3% had experienced an accident or near miss, while 66.7% had never experienced such an incident. In the group with high levels of unsafe behavior, 45.0% had experienced an incident and 55.0% had never experienced one. Traffic incident history comprised both near-miss events and traffic crashes. These outcomes were combined because near misses are recognized as surrogate indicators of crash risk and to improve statistical stability in this relatively small sample.

Table 4

Association Between Unsafe Riding Behavior and Incident History Among Adolescent Electric Bicycle Users

Unsafe Riding Behavior	Incident History		Total	*p-value*	PR (95% CI)
	Ever*	Never			
	n (%)	n (%)	n (%)		
High	9 (45.0)	11 (55.0)	14 (100.0)	0.728	1.350 (0.569-1.407)
Low	5 (33.3)	10 (66.7)	21 (100.0)		

A fisher's exact statistical test yielded a p-value of 0.728 ($p > 0.05$), indicating that there was no significant association between the level of unsafe behavior and the history of accidents and near misses among adolescent electric bicycle users in this study. This finding should be interpreted cautiously because the small sample size may have limited the statistical power to detect a significant association. In addition, traffic incidents may be influenced by various factors beyond riding behavior, including environmental conditions, traffic density, road infrastructure, and the behavior of other road users. In addition, traffic incident history was self-reported, introducing the possibility of recall bias, particularly for near-miss events. Unsafe riding behavior was assessed at the time of the survey, whereas incidents may have occurred earlier, creating the potential for exposure misclassification. Furthermore, the cross-sectional design precludes establishing temporal relationships, and adolescents who had previously experienced traffic incidents may have subsequently adopted safer riding behaviors.

The study findings indicate that some adolescents still exhibit riding behaviors that do not comply with safety principles, such as riding at speeds exceeding 25 km/h, not wearing helmets, riding without adult supervision between the ages of 12 and 15, and riding in motor vehicle lanes. These findings warrant attention because Regulation No. PM 45 of 2020 issued by the Minister of Transportation of the Republic of Indonesia stipulates that electric bicycles have a maximum speed limit of 25 km/h, require the use of helmets, mandate that riders aged 12–15 be accompanied by an adult, and may only be operated on designated lanes and/or specific areas (Kementerian Perhubungan, 2020). Thus, the riding practices identified in this study indicate non-compliance with applicable safety regulations.

Regulations in Indonesia state that children under 12 are not permitted to ride electric bicycles (Azzahra et al., 2025). The results show that three respondents aged 11 (under 12) still ride electric bicycles. Furthermore, none of the respondents are consistently supervised by an adult, even though those aged 12 to 15 are required to be accompanied by an adult. The use of electric bicycles can be influenced by various factors, including perceptions of their benefits (Rahmadani, 2023). Respondent ownership of electric bicycles indicates parental involvement in access to these vehicles. According to Nguyen's 2024 research, teenagers are more likely to use electric bicycles and are supported in this choice when their parents believe electric bicycles are beneficial and safe (Nguyen et al., 2024). The research results show that none of the respondents were consistently accompanied by an adult while riding electric bicycles. These findings suggest that the respondents generally use electric bicycles without continuous adult supervision.

Beyond describing unsafe riding behaviors, these findings provide an initial assessment of adolescents' compliance with national safety regulations governing electric bicycle use. The high prevalence of non-compliance with helmet use, speed limits, lane restrictions, and adult supervision indicates that unsafe riding practices remain common among adolescent electric bicycle users in Semarang City. These findings provide baseline evidence to support the development of targeted safety education programs and future initiatives to improve compliance with existing regulations. This finding is consistent with previous studies showing that the improper use of motor vehicle lanes and speeding are among the

risky behaviors commonly found among electric bicycle users (Qin et al., 2021).

The substantial number of adolescents who reported not wearing helmets raises important concerns regarding riding safety. Failure to wear protective equipment may increase the severity of injuries should a crash occur. An encouraging finding was that most respondents reported refraining from mobile phone use while riding. Safety studies have shown that wearing a helmet significantly reduces the likelihood of fatal or disabling outcomes in the event of a collision, making it a critical safety measure for riders (Li et al., 2022; Wang et al., 2024). The proportion of respondents who do not wear helmets in this study aligns with previous findings indicating that younger riders with relatively limited riding experience are more likely to not wear helmets.

Unsafe behaviors such as speeding, reckless driving, and failure to use safety equipment have been reported in previous studies to contribute to child traffic fatalities (Suparmanta, 2019). These non-compliance factors are reported to be linked to safety education and weak supervision and enforcement of traffic rules (Gebru et al., 2025). Interestingly, the majority of respondents did not use mobile phones while driving, indicating that not all aspects of risky behavior have a high prevalence. This may suggest partial awareness of the risks of distraction while driving. Non-compliant practices require attention because they are normatively and conceptually categorized as risky behaviors within the traffic safety system.

The occurrence of near-miss events observed in this study may provide valuable insight for preventive traffic safety strategies. Near-miss incidents have proven effective as indicators for assessing driving risks (Sun et al., 2024). In both occupational and transportation safety fields, near-miss events are commonly regarded as early indicators of underlying hazards within a system, that have not yet resulted in injury but have the potential to escalate into more serious incidents if no intervention is taken. Near misses, minor or major accidents, and even fatalities are often linked to a lack of adherence to traffic safety principles (Ray Sarkar, Ramachandra Rao, & Chatterjee, 2024). Therefore, continuous monitoring and enhanced safety education programs for adolescent electric bicycle riders are warranted. Knowledge and attitudes are linked to safe riding behavior; therefore, improving these aspects has the potential to support safer riding practices (Mirfan, Putri, & Rahman, 2021).

Statistically, the findings of this study indicate that the levels of risky behavior measured in this study cannot yet be proven to be associated with the occurrence of events. However, several factors need to be considered when interpreting these results. First, the relatively small sample size limits the statistical power to detect potential relationships. Second, the cross-sectional design cannot establish the temporal sequence between behavior and events, so a causal relationship cannot be inferred. Third, self-report-based measurements allow for potential information bias regarding both accident occurrences and risky behaviors.

Although no statistically significant association was found between unsafe behavior and accident history, non-compliant practices still warrant attention because they are normatively and conceptually categorized as risky behavior within the traffic safety system. These findings hold significant value as a foundation for developing preventive interventions in the context of public health as well as occupational safety and health.

An important finding of this study is the occurrence of near-miss incidents among adolescent electric bicycle users. Although near misses do not result in actual injuries, they represent warning signals of unsafe traffic situations and may precede future crashes. The presence of near-miss experiences among respondents suggests that adolescents are already exposed to traffic hazards associated with unsafe riding practices. From a public health perspective, near-miss events should not be overlooked because they provide opportunities to identify risks and implement preventive measures before more severe injuries occur.

Several limitations should be acknowledged, particularly the cross-sectional nature of the study, which prevents causal inference, a relatively small sample size with accidental sampling that limits generalizability, and the use of self-reported data that may introduce reporting bias. Additionally, the composite categorization of unsafe behaviors may oversimplify variations in risk levels among respondents. Despite these limitations, the study contributes preliminary empirical evidence regarding electric bicycle riding practices among adolescents, which to date have been limited in local-level transportation safety research. These findings can serve as a foundation for further research with broader designs and scope, as well as provide input for formulating promotional and preventive measures regarding the safe use of electric bicycles among adolescents.

CONCLUSION

Several unsafe riding behaviors were identified among adolescent electric bicycle users participating in this study. The unsafe behaviors include failing to adhere to rules on age limits, helmet use, speed limits, adult supervision, and lane usage. Although no significant association was found between unsafe behavior and incident history, the observed prevalence of near-miss events and accidents highlights ongoing safety concerns requiring preventive interventions. These findings contribute to the evidence on adolescent electric bicycle safety by providing empirical information on unsafe riding behaviors and incident history, which may inform preventive practices, safety policies, and future research on adolescent electric bicycle use.

SUGGESTION

Given the high prevalence of unsafe riding practices observed in this study, schools should provide regular education on electric bicycle safety as part of student health promotion activities. Parents are encouraged to supervise adolescent riders and reinforce compliance with traffic safety rules, including helmet use

and appropriate riding practices. Local authorities should strengthen public awareness campaigns and consistently enforce existing regulations governing electric bicycle use. Future studies should involve larger and more representative samples to better understand the factors associated with safety incidents among adolescent electric bicycle users.

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