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Investigation of Risky Behaviour Among Indonesian Riders in Motorcycle-to-Motorcycle Collisions

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ABSTRACT – *Motorcycle-to-motorcycle collisions are common, yet studies using video and questionnaire data are limited. This study analyzed 100 accident videos from social media and 100 questionnaire responses using crosstab and chi-square tests to identify patterns, key causal factors, and risky riding behaviors. Significant video variables ($p < 0.05$) included lighting (0.019), road category (0.034; 0.000), ignoring road markings (0.009), motorcycle brand (0.007), maneuvering (0.001), wrong-way riding (0.023), road width (0.032), traffic density (0.029), failure to use turn signals (0.007), high-speed riding (0.003), motorcycle type (0.011), intersections (0.045), and running red lights (0.031). Questionnaire data showed significant associations with failing to check mirrors (0.018), helmet use (0.043), age (0.005), and mechanical problems (0.001). The findings highlight the need for integrated prevention strategies, combining traffic discipline education with active safety technologies such as Anti-lock Braking System (ABS), Traction Control System (TCS), Forward Collision Warning (FCW), Lane Departure Warning/Lane Keeping Assist (LDW/LKA), Adaptive Cruise Control (ACC), Intelligent Speed Assistance (ISA), Traffic Sign Recognition (TSR), Driver Monitoring System (DMS), Blind Spot Monitoring, Automatic Headlamp On (AHO), Traffic Jam Assist (TJA), Intersection Assist/Cross Traffic Alert, and Automatic Turn Signal/Smart Indicators, as well as passive measures like wearable airbags and helmets with inner sun visors. By integrating these measures, the study suggests that such interventions can more effectively reduce motorcycle accident risks in Indonesia.*

KEYWORDS: Motorcycle-to-motorcycle accidents, risky riding behaviour, Chi-square test, active safety technology, traffic accident prevention

1. INTRODUCTION

Road traffic accidents are a major global health problem, causing injuries, deaths, and significant economic losses (Hermawan et al., 2024). World Health Organization (WHO) reports around 1.19 million deaths annually, making crashes the leading cause of death for people aged 5–29, with over 90% of fatalities occurring in low- and middle-income countries (WHO, 2023). These accidents result from complex interactions among human, vehicle, road, and environmental factors, which, from a macroergonomics perspective using the Haddon Matrix, can be seen as environment precrash controls that align people, technology, and organization to reduce risk (Nugroho, 2021).

Despite global efforts, road traffic crashes remain a serious issue, particularly in Indonesia, where motorcycles account for over 75% of accidents annually, making riders the most vulnerable group (IRSMS KORLANTAS POLRI). Figure 1 shows a steady increase in motorcycle accidents in Indonesia from 2020 to 2024. Although the 2024 data only cover the period up to August 5, the trend indicates that the number of accidents is expected to rise further by the end of the year. This trend suggests that motorcycle-related crashes remain a growing safety concern.

Building on these statistics, previous studies have consistently shown that risky riding behaviors, including helmet non-use, traffic violations, and distracted riding, are key contributors to motorcycle accidents, with naturalistic observations offering deeper insights into their causes (Panumasvivat et al., 2024; Arefin et al., 2025; Rasri et al., 2024).

In Indonesia, social media accident videos are underutilized in traffic safety research, despite their ability to show event chronology, rider interactions, and environmental context. This study addresses that gap by combining video and questionnaire data to analyze motorcycle-to-motorcycle crashes, identify key contributing factors, and propose targeted prevention strategies.

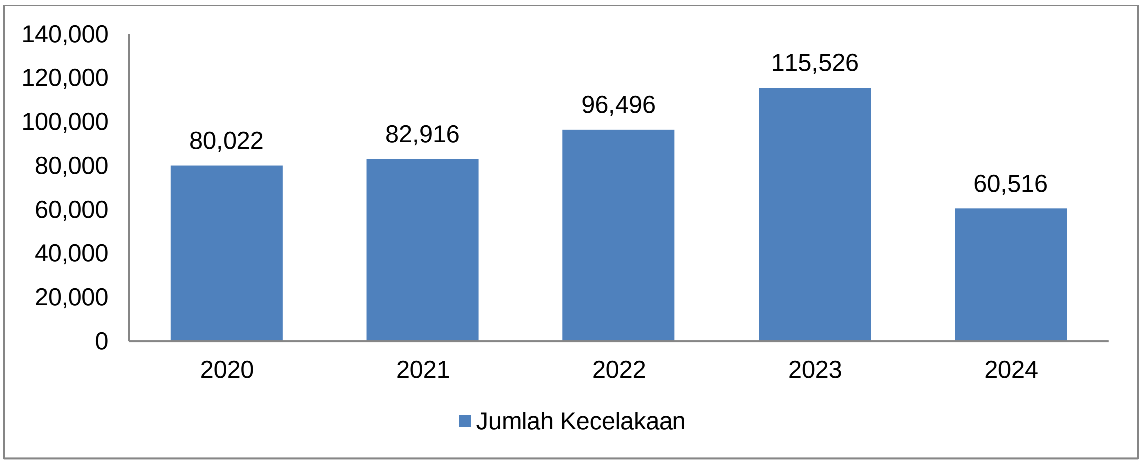

FIGURE 1: Graph of the number of motorcycle accidents in Indonesia (2020-2024)

2. METHODOLOGY

This study used a quantitative approach combining observations and surveys. Observations were conducted from motorcycle accident videos obtained from social media, while surveys were conducted via questionnaires with motorcyclists. This approach was used to analyze accident patterns, risky riding behaviors, and the potential adoption of active motorcycle safety technologies in Indonesia.

2.1 Research Population and Sample

The study population includes motorcycle accident videos from social media and motorcycle riders in Indonesia. The sample consists of 100 videos selected purposively based on eligibility criteria and 100 rider respondents determined using the Lemeshow formula.

2.2 Research Instruments

The research instruments include a video observation sheet to record accident-related variables and a respondent questionnaire covering demographics, experience, risky behaviors, and perceptions of accident risk.

2.3 Data Collection Techniques

Data were collected through the observation of accident videos on social media and online questionnaires to explore riders' risky behaviors and accident experiences.

2.4 Data Analysis Techniques

The data were analyzed using descriptive analysis to examine the frequency and distribution of variables, cross-tabulation analysis to identify relationship patterns among categorical variables, and the Chi-square (χ^2) test to assess the strength of associations between categorical variables at a 5% significance level, after the video observation and questionnaire data were numerically coded.

2.5 Research Variables

2.5.1 Research Variables Based on Video Observation

This study analyzed 100 video recordings to identify patterns and characteristics of motorcycle accidents, which were categorized by scenario variables presented in Tables 1-5.

TABLE 1: Human factors

No	Variable Code	Number of Samples
1	X1	Gender
2	X2	Carrying More Than One Passenger
3	X3	Helmet Use
4	X4	Riding Against Traffic
5	X5	Running a Red Light
6	X6	Using a Mobile Phone While Riding
7	X7	Turning on Turn Signals
8	X8	Overtaking from Left/Right
9	X9	Ignoring Road Markings
10	X10	Using Rearview Mirrors
11	X11	Riding at High Speed
12	X12	Maneuvering

TABLE 2: Vehicle factors

No	Variable Code	Number of Samples
1	X13	Motorcycle Type
2	X14	Motorcycle Brand

TABLE 3: Environmental factors

No	Variable Code	Number of Samples
1	X15	Weather Condition
2	X16	Lighting Condition
3	X17	Location

TABLE 4: Road factors

No	Variable Code	Number of Samples
1	X18	Road Category
2	X19	Intersection
3	X20	Road Signs or Markings
4	X21	Road Width
5	X22	Traffic Density
6	X23	Road Surface Condition

TABLE 5: Dependent variables (Y)

No	Variable Code	Number of Samples
1	Y1	Type of Accident
2	Y2	Type of Collision
3	Y3	Type of Injury
4	Y4	Impact on the Body
5	Y5	Vehicle Damage

2.5.2 Research Variables Based on Questionnaire

In addition to the video data, this study utilized 100 online questionnaires from motorcycle riders to describe the respondents' characteristics, with the results presented in Tables 6-10.

TABLE 6: Human factors

No	Variable Code	Number of Samples
1	X1	Gender
2	X2	Age
3	X3	Marital Status
4	X4	Education Level
5	X5	Occupation
6	X6	Working Hours
7	X7	Chronic Disease
8	X8	Diabetes
9	X9	Hypertension
10	X10	Mental Disorders
11	X11	Main Factors Causing Accidents
12	X12	Helmet Use
13	X13	Running Red Lights
14	X14	Riding Against Traffic
15	X15	Racing
16	X16	Misjudging Speed While Overtaking
17	X17	Entering the Wrong Lane
18	X18	Misjudging Turns
19	X19	Lack of Focus While Riding
20	X20	Not Checking Mirrors While Changing Lanes/Turning
21	X21	Using Mobile Phones While Riding
22	X22	Sudden Braking/Turning
23	X23	Riding Above Speed Limit
24	X24	Overtaking While Other Vehicles Signal a Turn
25	X25	Accidents in the Last 5 Years
26	X26	Number of Accidents in the Last 5 Years
27	X27	Situation During the Accident

TABLE 7: Vehicle factors

No	Variable Code	Number of Samples
1	X28	Vehicle Age
2	X29	Motorcycle Brand
3	X30	Motorcycle Type
4	X31	Part of Motorcycle Impacted
5	X32	Mechanical Problems of the Vehicle

TABLE 8: Environmental factors

No	Variable Code	Number of Samples
1	X33	Weather Condition
2	X34	Lighting Condition
3	X35	Accident Location
4	X36	Distance from Home to Accident Location

TABLE 9: Road factors

No	Variable Code	Number of Samples
1	X37	Road Condition at the Time of the Accident
2	X38	Road Category
3	X39	Intersection

TABLE 10: Dependent variables (Y)

No	Variable Code	Number of Samples
1	Y1	Severity Level
2	Y2	Impact on the Body

After the video and questionnaire data were presented in Tables 1–10, each variable was coded to facilitate statistical analysis. In video data, codes X1–X23 represent independent variables and Y1–Y5 represent dependent variables, while in the questionnaire data, codes X1–X39 represent independent variables and Y1–Y2 represent dependent variables.

2.6 Research Steps

This study collected motorcycle-to-motorcycle accident videos from social media and rider questionnaires, then analyzed them statistically to examine the relationships between risky behaviors, causal factors, and accident characteristics, and to provide recommendations for implementing active safety technologies.

3. RESULTS AND DISCUSSION

3.1 Analysis of the Relationship Between Independent Variables (X) and Dependent Variables (Y) in Video Data

3.1.1 Analysis of the Relationship Between Variable X and Type of Accident (Y1)

Based on the results of the chi-square test, several variables were significantly related to the type of accident (Y1). The detailed results of this analysis are presented in Table 11.

TABLE 11: Variables (X) in relation to Type of Accident (Y1)

No	Variable	Sig. Value	Description
1	Lighting condition	0.019	Significant
2	Road category	0.034	Significant
3	Ignoring road markings (rider 1)	0.009	Significant

Based on Table 11, three variables are significantly associated with the type of accident (Y1) and will be further analyzed to understand their influence on accident patterns and risk levels. Visualizations of these relationships are presented in Figures 1-3.

Figure 1 shows that most accidents occur during daytime, when traffic activity and density are higher. Bright conditions increase riders' confidence and speed, while heat and glare from the sun reduce visibility, increasing collision risk. This aligns with Salsabila et al. (2025), who noted that bright conditions often lead to overconfidence and less cautious behaviour.

Figure 2 shows that most accidents occur at intersections with high vehicle interaction and limited maneuvering space, especially during peak hours. These conditions increase the risk of conflict when riders turn, cross, or change lanes. This aligns with Fauzan et al. (2024), who found that road function and classification influence accident severity, with major roads carrying dense, high-speed traffic posing greater risks due to complexity and reduced reaction time.

Based on Figure 3, two-vehicle collisions were most common among riders who followed and ignored road markings, but violations of road markings increased chain collision risk. This underscores the importance of road markings for maintaining safe distances and traffic order, as ignoring them can prompt sudden lane changes. Sukmayasa et al. (2022) similarly note that markings guide distance and speed, with neglect increasing the risk of chain collisions, especially on high-speed roads.

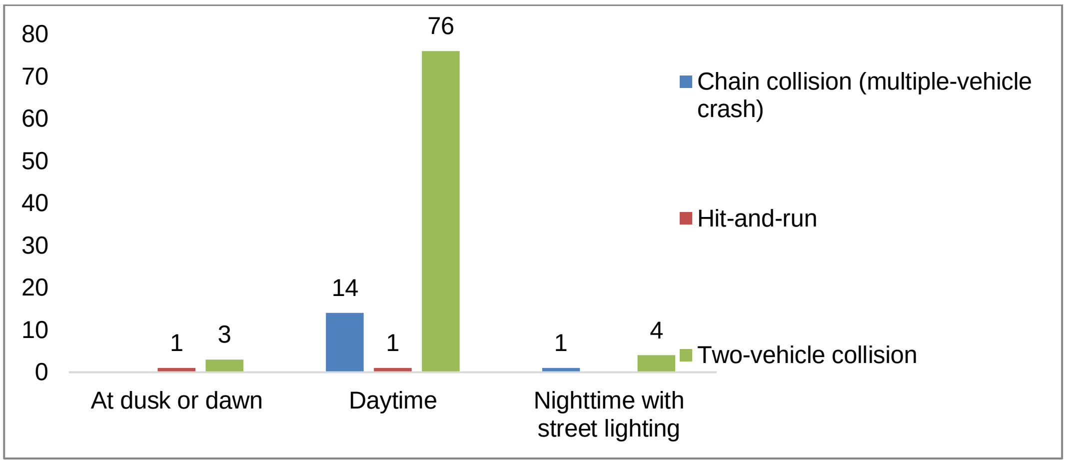

FIGURE 1: Graph of lighting condition versus type of accident

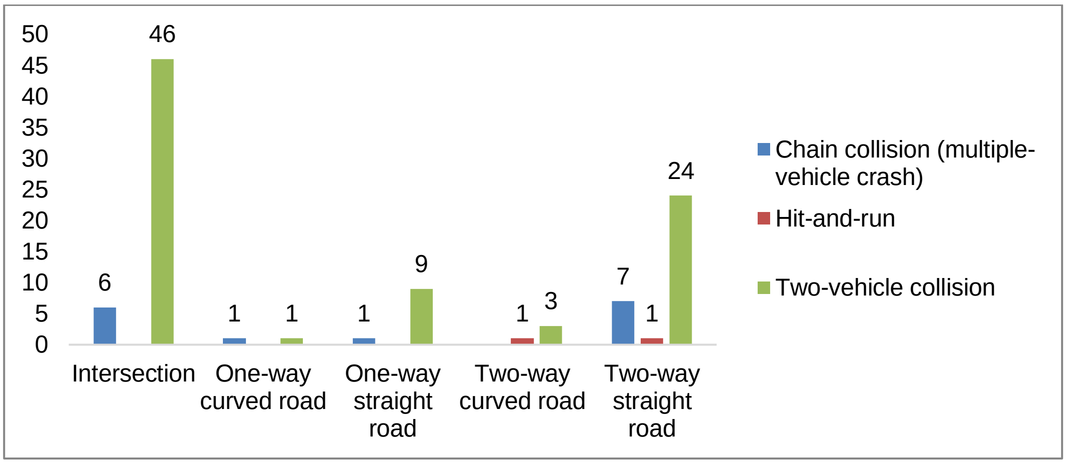

FIGURE 2: Graph of road category versus type of accident

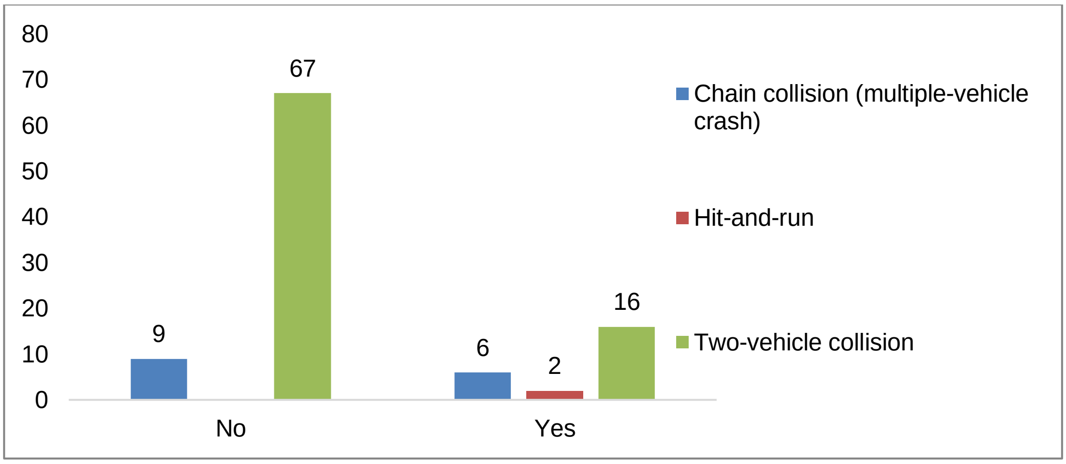

FIGURE 3: Graph of ignoring road markings versus type of accident

3.1.2 Analysis of the Relationship Between Variable X and Type of Collision (Y2)

Chi-square test results indicate that several variables are significantly associated with collision type (Y2). Detailed results are presented in Table 12.

TABLE 12: Variables (X) and Type of Collision (Y2)

No	Variable	Sig. Value	Description
1	Road Category of Rider 1	0.000	Significant
2	Road Category of Rider 2	0.015	Significant
3	Maneuvering of Rider 1	0.001	Significant
4	Maneuvering of Rider 2	0.000	Significant
5	Maneuvering of Rider 3	0.007	Significant
6	Wrong-Way Riding by Rider 1	0.023	Significant
7	Road Width	0.032	Significant
8	Traffic Density Level	0.029	Significant
9	Turn Signal Use by Rider 2	0.007	Significant

Table 12 shows that nine variables are significantly associated with collision type (Y2) and will be further analyzed to assess their influence on accident patterns and risk levels. Visualizations of these relationships are presented in Figures 4-12.

Figures 4 and 5 show that road type affects the location of vehicle impacts: frontal and side collisions occur more frequently at intersections and on two-way roads due to risky maneuvers and right-of-way violations, while rear-end collisions are common on one-way roads due to unsafe following distances. This emphasizes the need for location-specific interventions such as traffic management, clearer markings, and safe-distance campaigns, consistent with Fauzan et al. (2024), who found that road function and classification significantly affect accident severity.

Figures 6–8 show that straight-line riding is the main cause of collisions, driven by inattention, unsafe distances, or high speed. Turns and lane changes also pose risks, but less frequently. Rider negligence and poor anticipation play a larger role than maneuver complexity (Saputra et al., 2025).

Figure 9 shows that most accidents occur in normal lanes due to traffic density, insufficient following distance, and speed differences, even among rule-abiding riders. Riders traveling in the opposite direction are fewer but face a higher risk. Thus, frequent accidents in normal lanes stem mainly from dense traffic rather than risky behaviour, consistent with Yulyanti et al. (2022), who found that riding against traffic on two-way roads without a median greatly increases the risk of frontal collisions.

Figure 10 shows that not using turn signals makes maneuvers unpredictable, increasing the risk of frontal and side collisions, especially in heavy traffic. Many riders skip signaling when quickly changing lanes on familiar roads. Adib et al. (2024) found that turn-signal negligence is a major cause of accidents, with 98% supporting automatic turn-signal systems. Consistent, timely signaling is therefore essential to prevent accidents from unpredictable maneuvers.

Figure 11 shows that narrow, single-lane, one-way roads and high traffic increase the risk of frontal collisions, worsened by risky overtaking, poor lighting, and poor markings. Improving road design, adding separators, and promoting driver safety awareness can reduce accidents (Sârbescu & Maricuţoiu, 2019).

Figure 12 shows that quiet roads encourage higher speeds and overconfidence, leading to longer braking distances, delayed reactions, and increased risk of frontal or side collisions. Low traffic combined with reduced alertness makes these conditions particularly dangerous (Zheng et al., 2024).

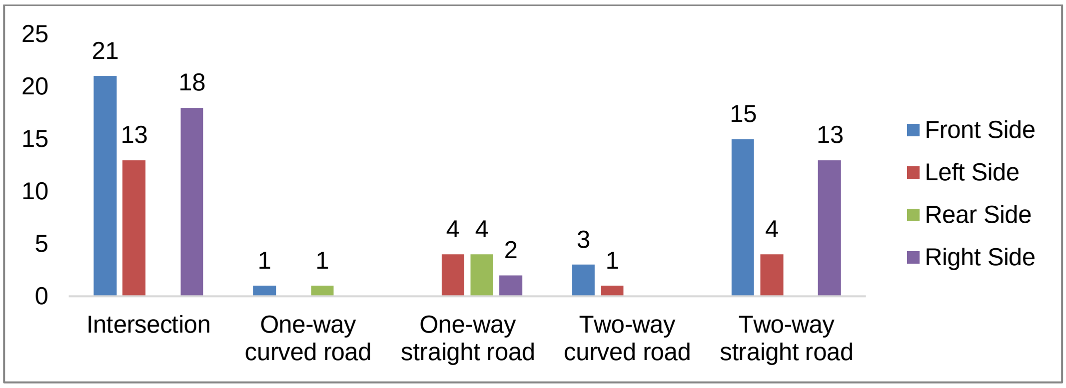

FIGURE 4: Graph of road category versus type of collision for rider 1

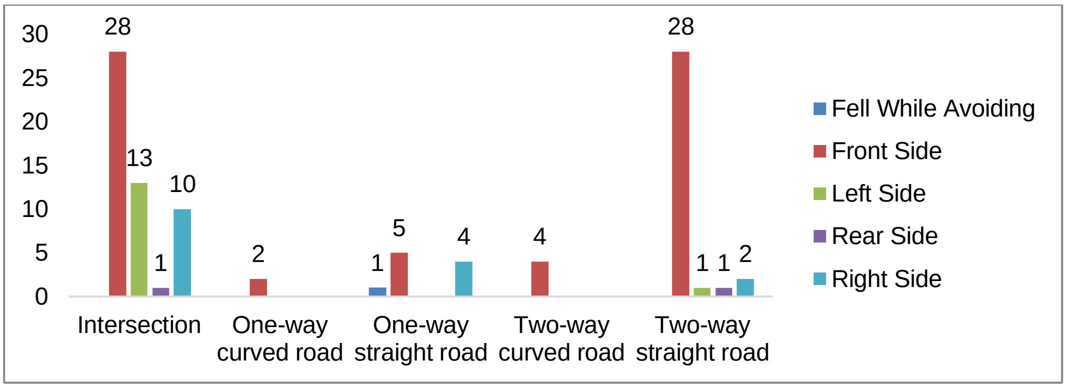

FIGURE 5: Graph of road category versus type of collision for rider 2

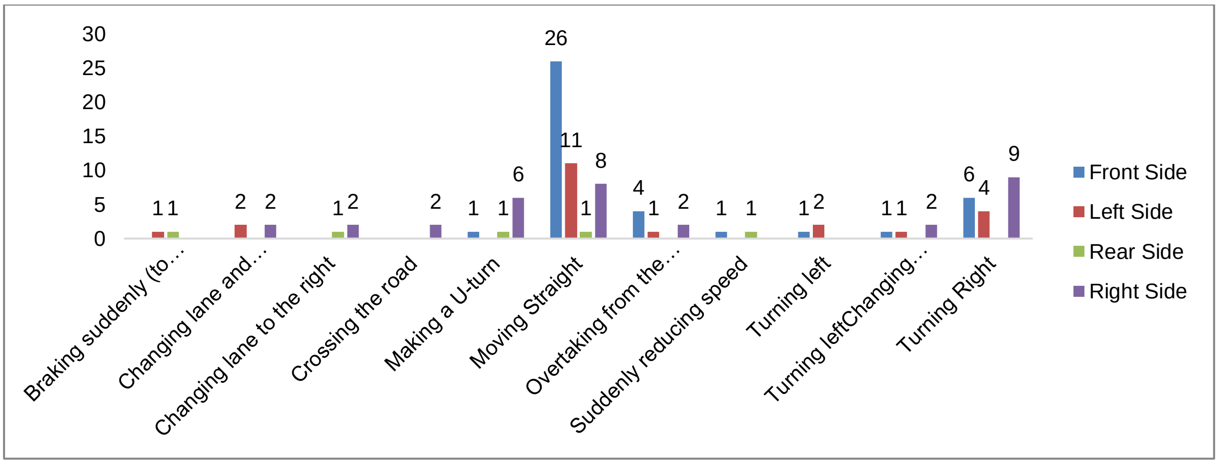

FIGURE 6: Graph of manoeuvring versus type of collision for rider 1

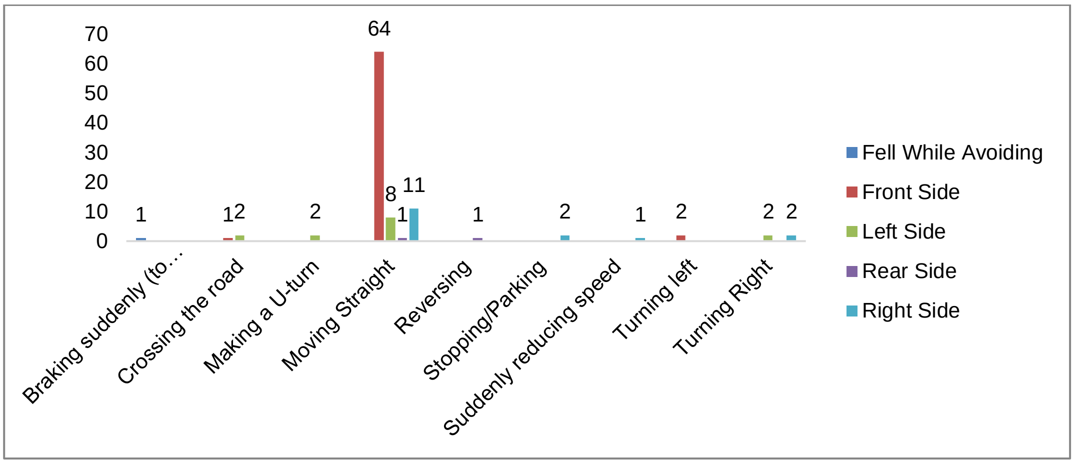

FIGURE 7: Graph of maneuvering versus type of collision for rider 2

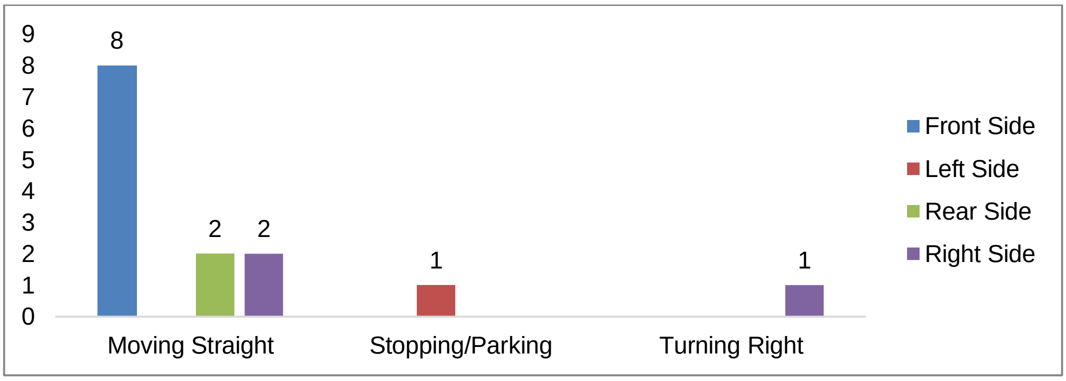

FIGURE 8: Graph of maneuvering versus type of collision for rider 3

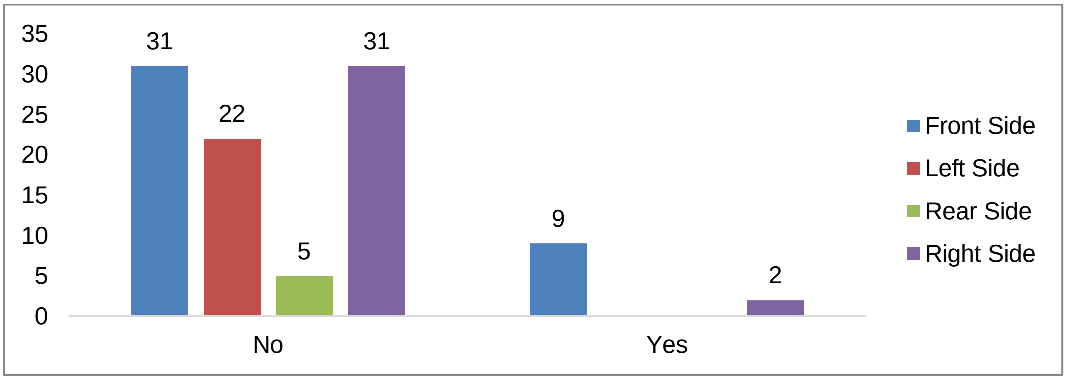

FIGURE 9: Graph of wrong-way riding versus type of collision

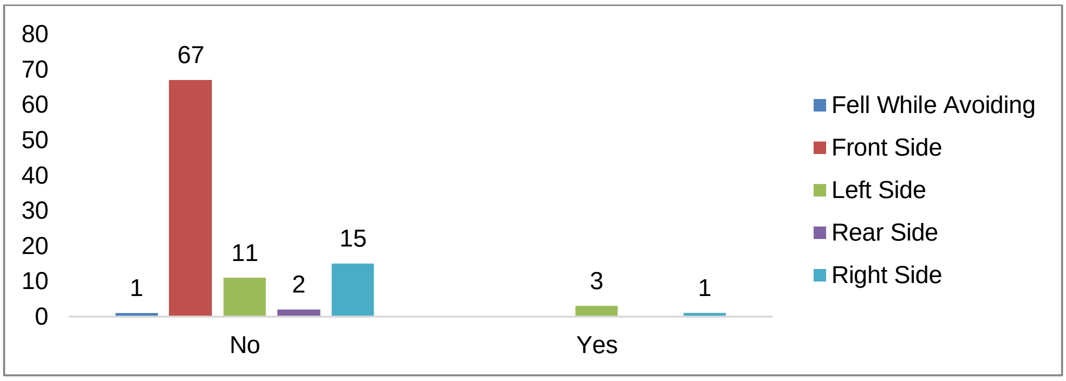

FIGURE 10: Graph of turn signal usage versus type of collision for rider 2

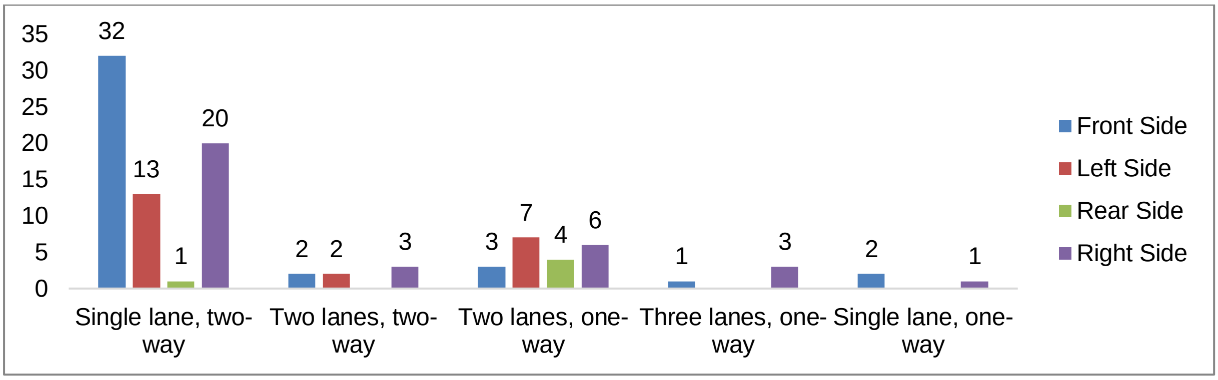

FIGURE 11: Graph of road width versus type of collision for riders

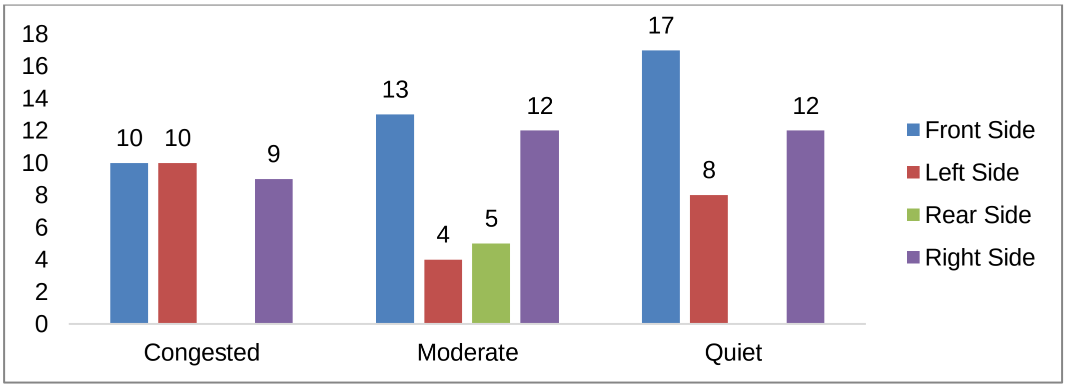

FIGURE 12: Graph of traffic density versus type of collision

3.1.3 Analysis of the Relationship Between Variable X and Type of Injury (Y3)

Chi-square test results indicate that several variables are significantly associated with injury type (Y3). Detailed results are presented in Table 13.

TABLE 13: Recapitulation of variables significant to Type of Injury (Y3)

No	Variable	Sig. Value	Description
1	Maneuvering of Rider 1	0.003	Significant

Table 13 shows that one variable is significantly associated with injury type (Y3) and will be further analyzed to assess its influence on accident patterns and risk levels. Visualizations of this relationship are presented in Figure 13.

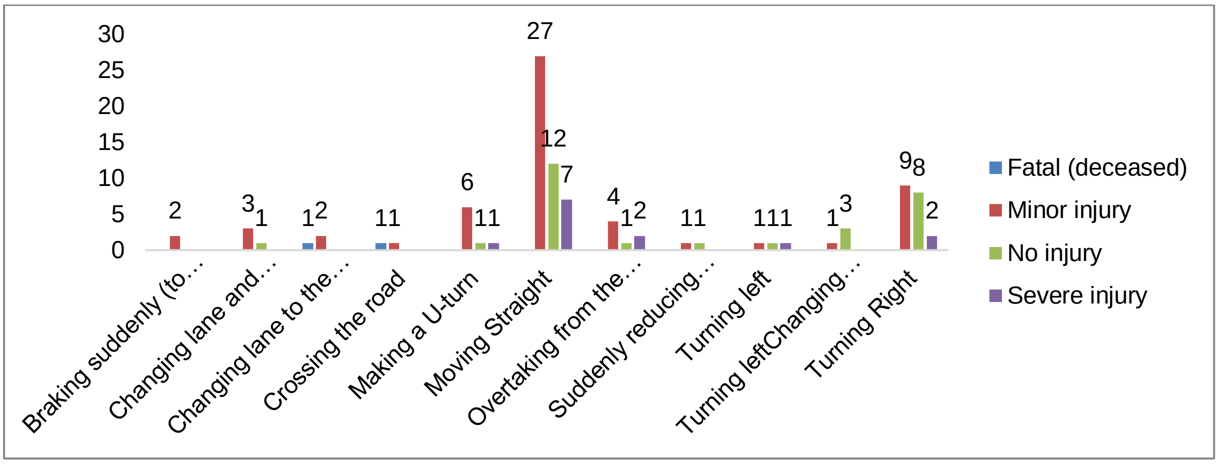

FIGURE 13: Graph of rider 1 maneuvering versus type of injury

Figure 13 shows that most accidents occur during straight-line riding, as this maneuver is more frequent and prolonged, increasing crash likelihood. Collisions are typically front–rear or side impacts, resulting in minor injuries, though traffic density and overconfidence can lead to chain collisions. High-risk maneuvers such as U-turns, overtaking, or crossing roads often result in more severe injuries due to greater speed differences (Saputra et al., 2025).

3.1.4 Analysis of the Relationship Between Variable X and the First Impact on the Body (Y4)

Chi-square test results indicate that several variables are significantly associated with the first impact on the rider's body (Y4). Detailed results are presented in Table 14.

TABLE 14: Recapitulation of variables significant to the first impact on rider's body (Y4)

No	Variable	Sig. Value	Description
1	Intersection Impact on Rider 1	0.020	Significant
2	Intersection Impact on Rider 3	0.027	Significant
3	Lighting Condition Impact on Rider 2	0.006	Significant
4	Traffic Density Impact on Rider 2	0.008	Significant

Table 14 shows that four variables are significantly associated with the first impact on the body (Y4) and will be further analyzed to assess their influence on accident patterns and risk levels. Visualizations of these relationships are presented in Figures 14-17.

Figures 14 and 15 show that most injuries occur on straight, busy roads where riders speed, ignore safe distances, and react slowly, leading to high-energy collisions. Road monotony and reduced alertness further increase risk, consistent with Syarifudin et al. (2022) and the SSD concept.

Figure 16 shows that most injuries occur during daytime, when traffic volume and public activity are high. Speed differences, sudden braking, abrupt maneuvers, and heat-induced fatigue increase collision risk. This aligns with Salsabila et al. (2025), who noted that bright conditions often lead to overconfidence and less cautious behaviour.

Figure 17 shows that collision severity varies with traffic: low in heavy traffic, moderate on empty roads, and high at moderate density with limited space. Speed and traffic density increase accident risk, highlighting the need for traffic engineering and safety technologies (Zheng et al., 2024).

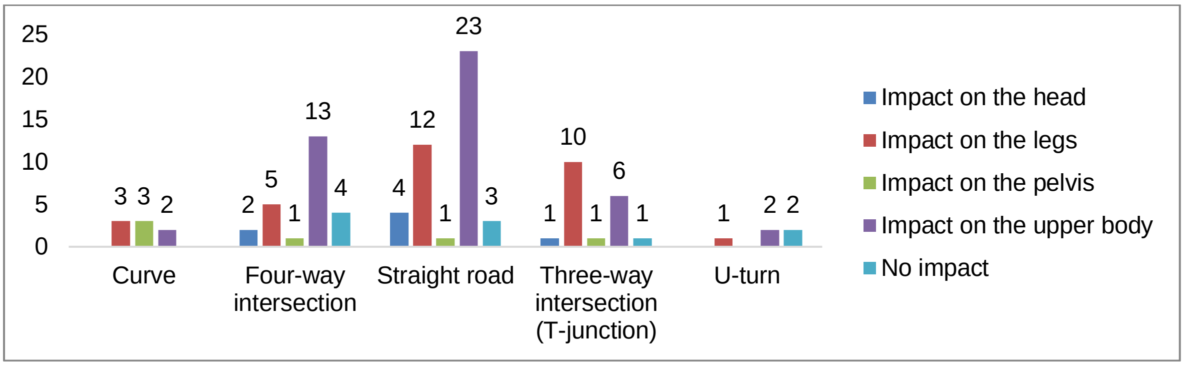

FIGURE 14: Graph of intersections in relation to body impact on rider 1

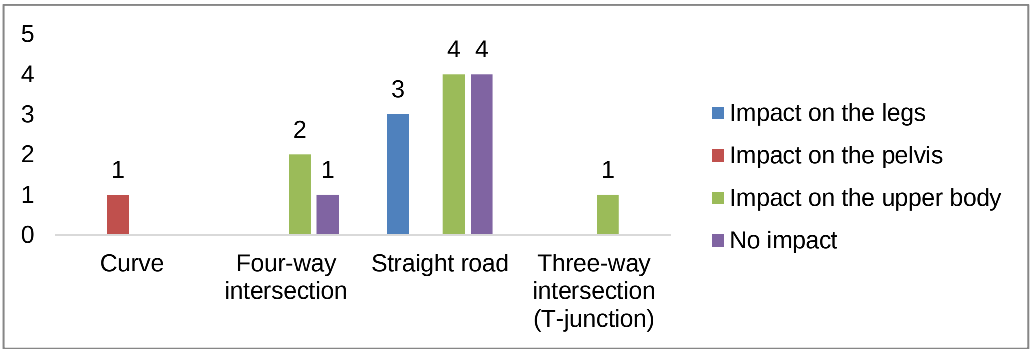

FIGURE 15: Graph of intersections in relation to body impact on rider 3

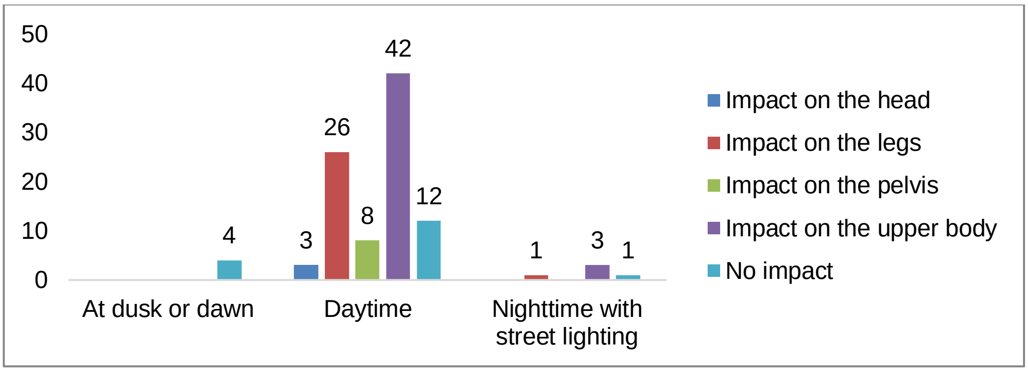

FIGURE 16: Graph of light conditions in relation to body impact on rider 2

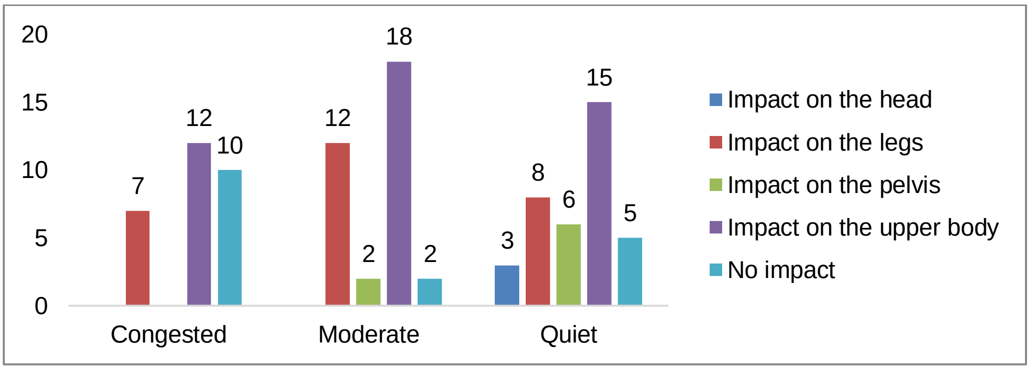

FIGURE 17: Graph of traffic density in relation to body impact on rider 2

3.1.5 Analysis of the Relationship Between Variable X and Vehicle Damage (Y5)

Chi-square test results indicate that several variables are significantly associated with vehicle damage (Y5). Detailed results are presented in Table 15.

TABLE 15: Recapitulation of variables significant to Vehicle Damage (Y5)

No	Variable	Sig. Value	Description
1	Intersection on Vehicle Damage of Rider 3	0.045	Significant
2	Running a Red Light by Rider 1	0.031	Significant

Table 15 shows that two variables are significantly associated with vehicle damage (Y5) and will be further analyzed to assess their influence on accident patterns and risk levels. Visualizations of these relationships are presented in Figures 18 and 19.

Figure 18 shows that high, stable speeds on straight roads increase collision risk, while reduced alertness and limited sight distance further increase the risk of accidents, highlighting the need for careful driving and road management (Syarifudin et al., 2022).

Figure 19 shows that even though most riders obey traffic lights, accidents still occur due to insufficient safe distance, violations by other vehicles, weather or road conditions, and technical issues. The high number of cases reflects rider volume and external factors rather than negligence. Running a red light, however, still significantly increases the risk of damage and injuries at intersections (Truong et al., 2018).

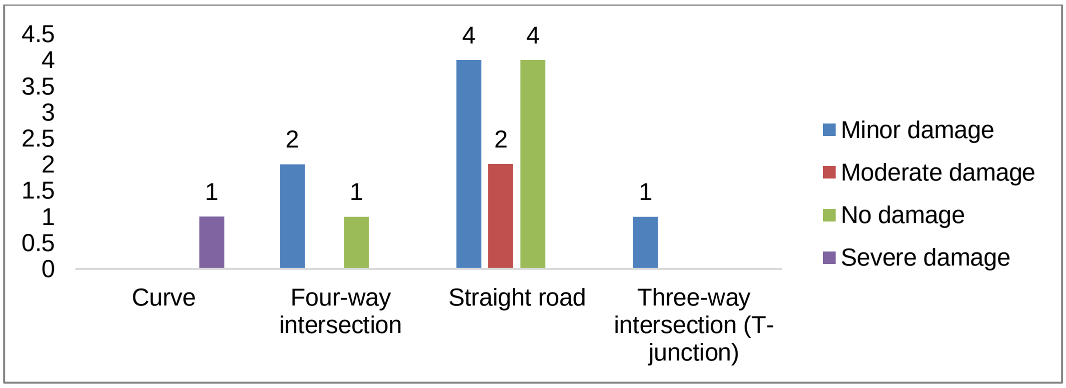

FIGURE 18: Graph of intersection versus vehicle damage of rider 3

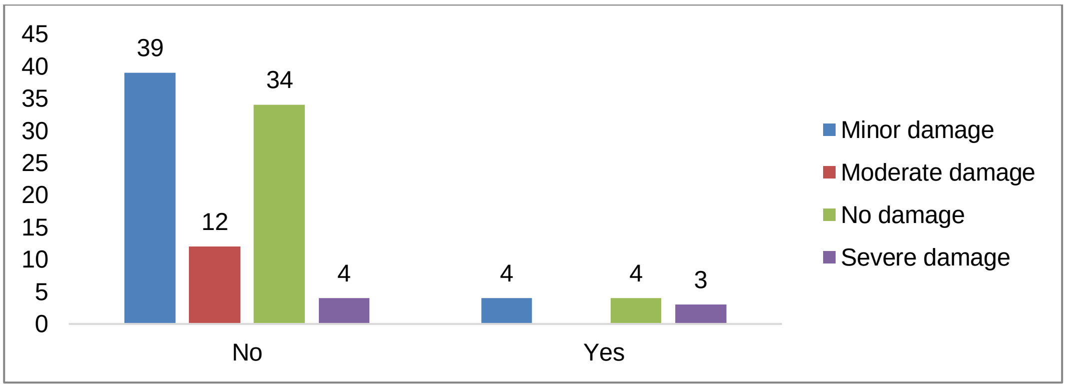

FIGURE 19: Graph of running a red light versus vehicle damage of rider 1

3.2 Analysis of the Relationship Between Independent Variables (X) and Dependent Variables (Y) in Questionnaire Responses

3.2.1 Analysis of the Relationship Between Variable X and Injury Severity (Y1)

Chi-square test results indicate that several variables are significantly associated with injury severity (Y1). Detailed results are presented in Table 16.

TABLE 16: Recapitulation of variables significant to Injury Severity (Y1)

No	Variable	Sig. Value	Description
1	Not Checking Mirrors When Changing Lanes/Turning	0.018	Significant
2	Passenger Helmet Usage	0.043	Significant

Table 16 shows that two variables are significantly associated with injury severity (Y1) and will be further analyzed to assess their influence on accident patterns and risk levels. Visualizations of these relationships are presented in Figures 20 and 21.

Figure 20 shows that riders who check mirrors usually experience minor or no injuries, while accidents still occur due to external factors. This highlights the importance of mirror use, alertness, and safe distances, as neglect increases the risk of side and rear collisions (Schreurs et al., 2023).

Figure 21 shows that helmets significantly reduce injury severity for passengers, lowering head injury risk and preventing serious injuries. Unhelmeted passengers face higher risks. Helmets can reduce injuries by 72% and fatalities by 39% (Bosawer et al., 2021; WHO, 2023), underscoring their critical safety role.

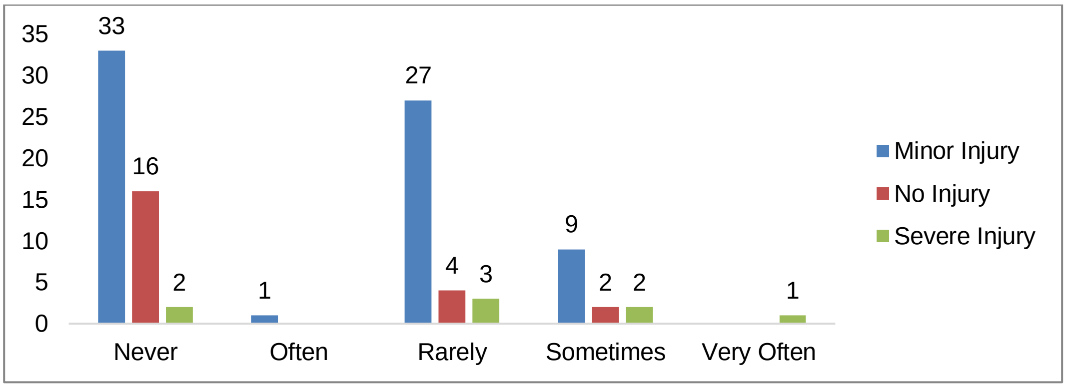

FIGURE 20: Graph of not checking mirrors when changing lanes/turning against injury severity

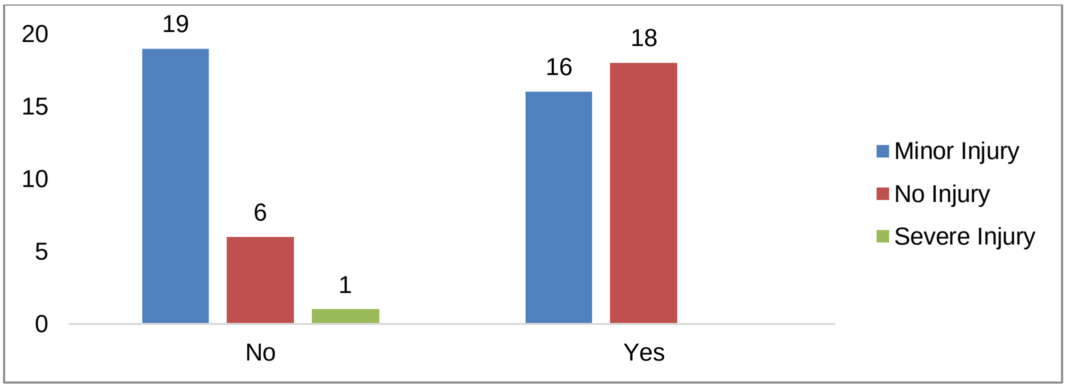

FIGURE 21: Graph of passenger helmet usage against injury severity

3.2.2 Analysis of the Relationship Between Variable X and the First Impact on the Body (Y2)

Chi-square test results indicate that several variables are significantly associated with the first impact on the body (Y2). Detailed results are presented in Table 17.

TABLE 17: Recapitulation of variables significant to the First Impact on the Body (Y2)

No	Variable	Sig. Value	Description
1	Age	0.005	Significant
2	Passenger Helmet Usage	0.005	Significant
3	Driving Above Speed Limit	0.004	Significant
4	Vehicle Mechanical Issues	0.001	Significant

Table 17 shows that four variables are significantly associated with the first impact on the body (Y2) and will be further analyzed to assess their influence on accident patterns and risk levels. Visualizations of these relationships are presented in Figures 22-25.

Figure 22 shows that riders aged 21–30 experience the most body impacts, especially on the legs, followed by the upper body and head. Riders aged 17–20 have lower frequencies, and those aged 31–50 are rare. The high risk among 21–30-year-olds is linked to frequent riding and bolder behaviour, highlighting the need for safety education and protective gear for productive-age riders to reduce injury severity.

Figure 23 indicates that passengers with helmets are more likely to prevent impacts, whereas those without helmets face increased risks of head and leg injuries. Helmets effectively protect the head and reduce the risk of serious upper-body injuries, highlighting their importance for riders and passengers. Additional protection, such as protective clothing and safe riding behaviour, is also necessary.

Figure 24 shows that helmets significantly reduce head and upper-body injuries for passengers, while unhelmeted riders face higher risks. Protective clothing and safe riding are also important. Helmets can lower head injuries by 72% and fatalities by 39% (Bosawer et al., 2021; WHO, 2023), emphasizing their critical role in safety.

Figure 25 shows that vehicle damage or mechanical failure increases the risk of impact, especially to the legs and upper body, while head and pelvis impacts are rarer. This highlights the importance of regular maintenance. Laloma et al. (2023) note that brakes, tires, and lighting significantly affect accident risk, and Arfidguampe emphasizes that neglecting pre-ride inspections increases the risk of mechanical accidents as riders prioritize speed and skill over vehicle condition.

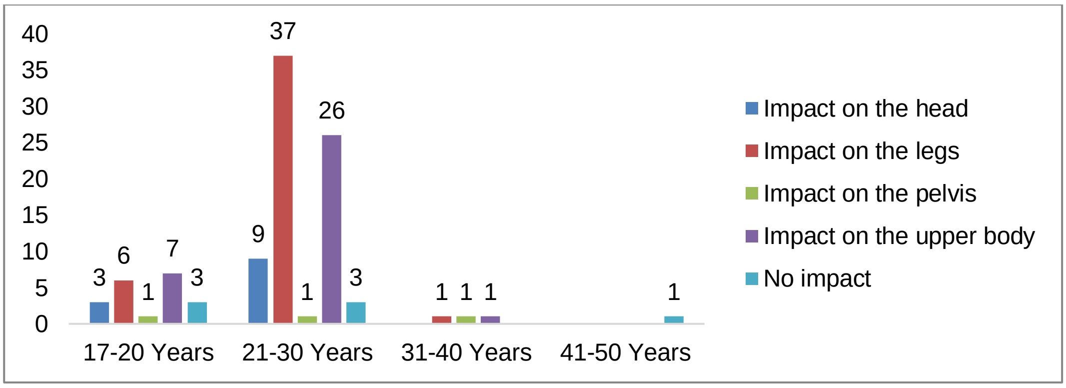

FIGURE 22: Graph of age versus first impact on rider's body

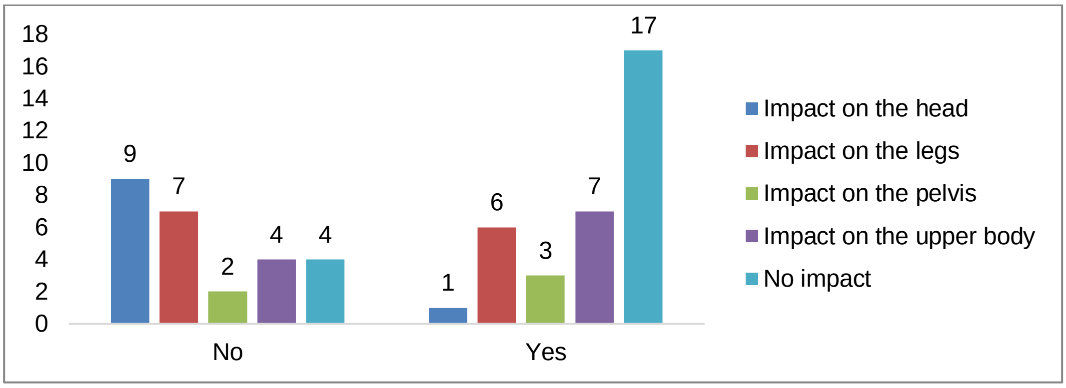

FIGURE 23: Graph of helmet use versus first impact on passenger's body

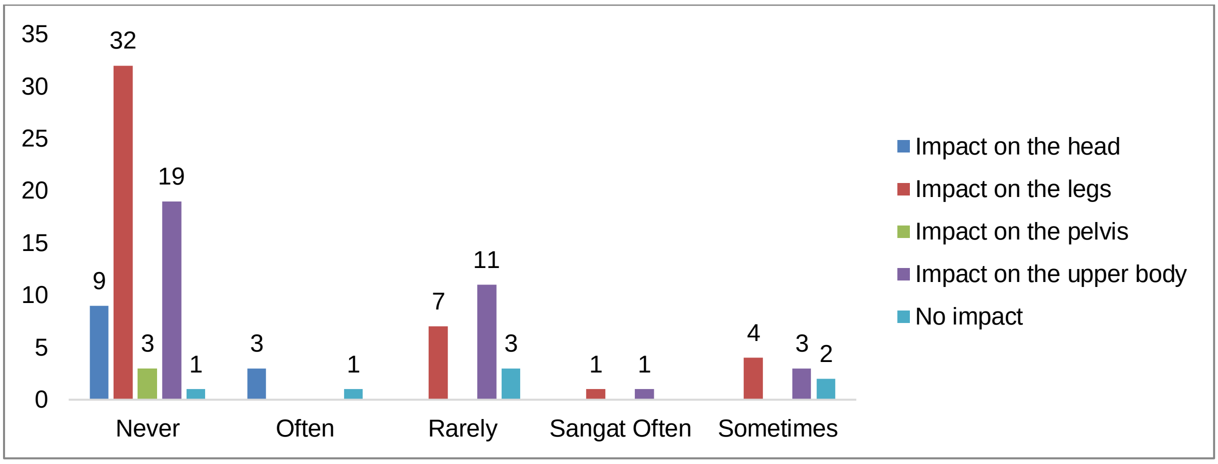

FIGURE 24: Graph of driving above speed limit versus first impact on rider's body

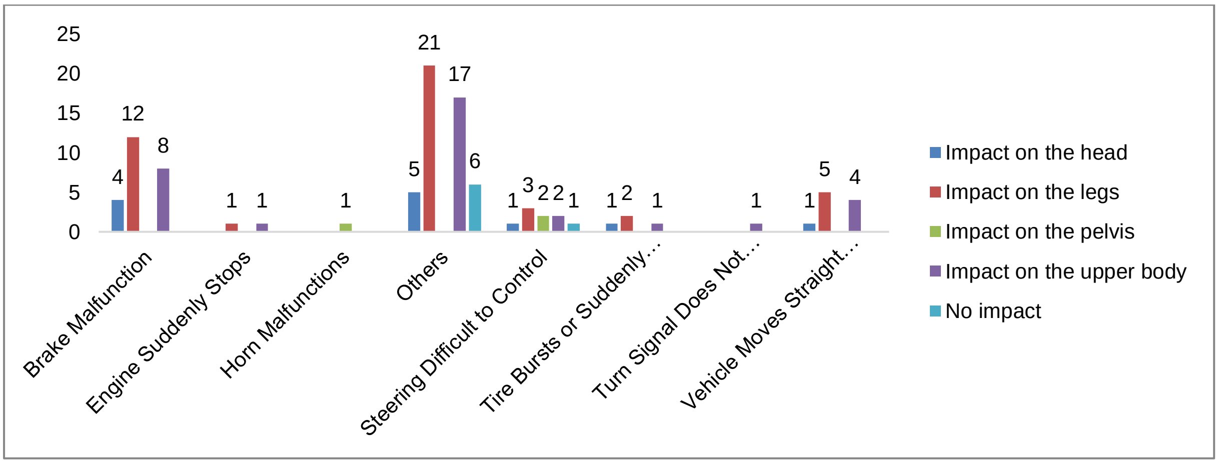

FIGURE 25: Graph of vehicle mechanical issues versus the first impact on the rider's body

Significance tests on the video and questionnaire data show that motorcycle accidents result from a combination of rider behaviour, road, vehicle, and environmental factors. Prevention can thus focus on two approaches: implementing active motorcycle safety technologies and improving environmental conditions and rider behaviour.

Based on accident patterns and key contributing factors, prevention strategies emphasize both active and passive safety technologies. Active safety features include the Anti-lock Braking System (ABS) and Traction Control System (TCS) to prevent wheel slip (Sharma & Mishra, 2025; Rasri et al., 2024), Forward Collision Warning (FCW) for early alerts (Banerjee & Jeihani, 2023), and Lane Departure Warning/Lane Keeping Assist (LDW/LKA) to reduce lane violations (Singh et al., 2025). Other recommended systems include Adaptive Cruise Control (ACC), Intelligent Speed Assistance (ISA), Traffic Sign Recognition, Driver Monitoring, Blind Spot Monitoring, Automatic Headlamps, Traffic Jam Assist (TJA), Intersection Assist/Cross Traffic Alert, and Automatic Turn Signal/Smart Indicator, which together help maintain speed, distance, visibility, and rider awareness across varied road and traffic conditions (Lapardhaja et al., 2024; Özkan et al., 2025; El Khadri et al., 2023). Passive measures include wearable airbags and helmets with inner sun visors to reduce injury severity during unavoidable collisions.

The second approach combines safety education, driving discipline campaigns, and law enforcement to complement active safety technologies in reducing accident risks. This aligns with the ASEAN NCAP Roadmap: 2026–2027, which emphasizes active safety systems and collision warnings, and the 2028–2030 roadmap, which focuses on safety culture and driver behaviour. The study underscores the importance of motorcycle safety technologies and supports ASEAN policies for safer, more sustainable road transport, prioritizing the protection of vulnerable road users.

4. CONCLUSION

This study shows that motorcycle accidents in Indonesia are largely driven by human factors, especially risky behaviors such as failing to use turn signals, speeding, and ignoring road markings, alongside vehicle, road, and environmental conditions. Enhancing safety requires a balanced strategy combining active safety technologies, rider education, behavioral discipline campaigns, and stricter law enforcement. The results align with the ASEAN NCAP Roadmap 2026–2030, highlighting the importance of both technology and behaviour in reducing risks. Future research should expand the dataset to include more diverse contexts and apply longitudinal analysis to assess the long-term impact of these measures.

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REFERENCES

Adib, K., Mazouzi, M., & Elyoussoufi, S. (2024). Investigation of annual trucks fatal accidents in El Hajeb province of Morocco using TRIZ-Ishikawa diagram. Heliyon, 10(4), e26295.

Arefin, M. S., Mahin, M. I. S., & Mily, F. A. (2025). Real-time rapid accident detection for optimizing road safety in Bangladesh. Heliyon, 11(4), e42432.

Banerjee, S., & Jeihani, M. (2023). Forward Collision Warning Systems - Validating driving simulator results with field data. In Transportation Safety and Emerging Technologies: Selected Papers from the International Conference on Transportation and Development 2023 (pp. 286–298). American Society of Civil Engineers (ASCE).

Bosawer, S. S., Rahmadian, R., & Rofinda, Z. D. (2021). Hubungan penggunaan helm dengan derajat cedera kepala akibat kecelakaan lalu lintas pada pengendara sepeda motor di RSUP Dr. M. Djamil Padang tahun 2016-2017. Jurnal Ilmu Kesehatan Indonesia, 1(3), 352–357.

El Khadri, S., Matloub, N., Moreau, X., Neto, A. B., Chevrié, M., Guillemard, F., & Gonçalves, W. (2023). Traveling wave ultrasonic piezoelectric motor modelling for the control design of an Automatic Headlight Levelling System. IFAC-PapersOnLine, 56(2), 6326–6331.

Fauzan, B. L., Agustin, T., & Mahmudah, A. M. H. (2024). Prediksi klasifikasi kecelakaan lalu lintas di Kota Surakarta dengan menggunakan Metode Regresi Logistik Multinomial. Sustainable Civil Building Management and Engineering Journal, 1(4), 9.

Hermawan, I., Mulya Firdausy, C., Rizqy Rambe, K., Zuhdi, F., Erwidodo, Dewi Nugraheni, R., Malisan, J., Isnasari, Y., Marpaung, E., & Milawati Asshagab, S. (2024). Road traffic facilities, traffic accidents, and poverty: Lessons learned from Indonesia. Transportation Research Interdisciplinary Perspectives, 28, 101273.

Laloma, A., Lefrandt, L. I. R., & Rompis, S. Y. R. (2023). Pengaruh usia dan tingkat pendapatan terhadap potensi kecelakaan lalu lintas dengan menggunakan Structural Equation Modeling (SEM). Jurnal Teknik, 21(1), 102–111.

Lapardhaja, S., Gong, Y., Murshed, M. T., & Kan, X. (David). (2024). Commercial Adaptive Cruise Control (ACC) and capacity drop at freeway bottlenecks. International Journal of Transportation Science and Technology.

Nugroho, H. W. (2021). Ergonomi makro sebagai suatu pendekatan untuk pencegahan kecelakaan travel Pekanbaru-Padang di jalan raya.

Özkan, Ö., Rowe, R., Norman, P., Day, M., & Poulter, D. (2025). Increasing drivers' intentions to use Intelligent speed Assistance: A randomised controlled trial of a theory of planned behaviour-based intervention. Transportation Research Part F: Traffic Psychology and Behaviour, 111, 238–249.

Panumasvivat, J., Kitro, A., Samakarn, Y., Pairojtanachai, K., Sirikul, W., Promkutkao, T., & Sapbamrer, R. (2024). Unveiling the road to safety: Understanding the factors influencing motorcycle accidents among riders in rural Chiang Mai, Thailand. Heliyon, 10(3), e25698.

Rasri, N., Satiennam, T., Satiennam, W., Sukkho, P., Jaensirisak, S., Kronprasert, N., & Champahom, T. (2024). Factors influencing wrong way driving behavior of motorcycle riders in Thailand. Transportation Research Interdisciplinary Perspectives, 25, 101122.

Salsabila, C. A., Yulianto, F., & Siswa, T. A. Y. (2025). Implementasi Metode Naive Bayes Untuk Klasifikasi Kecelakaan Lalu Lintas Di Kota Samarinda. Jurnal Informatika dan Teknik Elektro Terapan, 13(1).

Saputra, H. D., Navyano, I. B., Rezka, M. Z., & Istiyanto, B. (2025). U-Turn analysis on accident risk levels on Kaligangsa Road, Tegal City: Evaluasi risiko kecelakaan pada u-turn: Studi kasus jalan raya Kaligangsa, Kota Tegal. Publikasi Riset Orientasi Teknik Sipil (Proteksi), 7(1), 53-58.

Sârbescu, P., & Maricuţoiu, L. (2019). Are you a "bad driver" all the time? Insights from a weekly diary study on personality and dangerous driving behavior. Journal of Research in Personality, 80, 30–37.

Schreurs, K. V., Ross, V., & Brijs, K. (2023). Investigating the relationship between self-reported (near) crashes, fined traffic offences, and risky riding behaviours among Flemish motorcyclists using the motorcycle rider behaviour questionnaire. Transportation Research Part F: Traffic Psychology and Behaviour, 98, 337-353.

Sharma, G., & Mishra, S. (2025). Alert modalities in connected and smart work zones to enhance workers' safety from traffic accidents using virtual reality (VR) experiments. Transportation Research Part C: Emerging Technologies, 174(March), 105085.

Singh, A., Charly, A., & Pawar, D. S. (2025). Impact of lane departure warning systems in critical driving conditions among young drivers. Transportation Research Part F: Traffic Psychology and Behaviour, 115(January).

Sukmayasa, I. made, Ahmad, R., Fitasari, Y., Ariani, N., & Hidayat, D. W. (2022). Dampak pemasangan marka khusus dalam kemampuan menjaga jarak kendaraan saat bergerak pada ruas jalan dengan kecepatan tinggi. Jurnal Teknologi Transportasi Dan Logistik, 3(1), 63–72.

WHO (2023). Global status report on road safety 2023. Geneva, Switzerland: World Health Organization.

Yulyanti, D., Rudiansyah, R., & Fadjriyanto, F. (2022). Analisis faktor penyebab kecelakaan lalu lintas pada pengendara sepeda motor di Kabupaten Indramayu. Jurnal Kesehatan Indra Husada, 10(1), 79-89.

Zheng, Z., Wang, Z., Liu, S., & Ma, W. (2024). Exploring the spatial effects on the level of congestion caused by traffic accidents in urban road networks: A case study of Beijing. Travel Behaviour and Society, 100728.