

Design and Implementation of an Instrumented Motorcycle for a Naturalistic Driving Study in Indonesia [†]

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Abstract: Indonesia, a Southeast Asian country with a significant number of motorcycles, faces a high rate of motorcycle accidents, predominantly attributed to rider behavior. Various methods are available to study driver behavior, with the Naturalistic Driving Study (NDS) being one of the most advanced approaches. This study employed a vehicle-based NDS method, utilizing an instrumented motorcycle equipped with sensors and cameras to capture detailed riding activities. These sensors recorded data such as speed, throttle position, brake and horn activation, turn signal usage, and motorcycle tilt. These data provided insights into rider behavior in response to surrounding traffic conditions. The purpose of this research was to transform an electric motorcycle into an instrumented motorcycle and designing experiments to collect relevant data. This innovative approach enabled detailed observation and analysis of motorcyclist behavior in Indonesia, contributing valuable insights for developing strategies to reduce motorcycle accidents.

Keywords: accident; behavior; instrumented motorcycle; naturalistic driving study; traffic condition



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1. Introduction

According to the World Health Organization (WHO), road accidents are a leading cause of death among individuals aged 5–29 years, with the highest fatality rate of approximately 66% occurring in those aged 18–59 years and 19% in those aged 60 years and above [1]. In the Southeast Asia region, two- or three-wheeled vehicles account for 48% of total road fatalities, primarily affecting upper- and lower-middle-income countries, where 79% of these fatalities occur. In Southeast Asia, Indonesia has one of the highest numbers of motorcycles and accident rates. In 2022, Indonesia recorded over 125 million motorcycles in 2022, comprising 85% of its total vehicles [2]. However, the high prevalence of motorcycles is accompanied by an equally high rate of accidents, with motorcycles involved in more than 73% of all vehicle accidents [3]. The economic losses from these accidents are significant, reaching nearly IDR 280 billion in 2022. In that year alone, over 28,000 fatalities, 13,000 serious injuries, and 160,000 minor injuries were reported, totaling over 139,000 accidents [4]. In addition to these recorded data, there are undoubtedly many unrecorded motorcycle crashes in developing countries [5].

Generally, traffic accidents are caused by factors related to humans, vehicles, and the environment. The most significant contributing factor to accidents is human error [6]. Pure

human error accounts for 57% of accident causes and is an additional contributing factor in 90% of cases [7]. Research from Malaysia supports this finding, indicating that driver behavior causes approximately 71–74% of serious motorcycle accidents [7,8]. These human factors can be classified into categories such as unsafe behavior, traffic rule violations, and insufficient regulation [9,10]. Furthermore, inexperienced riders may fail to recognize hazards or respond appropriately to potential dangers [11].

There are various methods to observe driver behavior, including questionnaires, in-depth interviews, accident data analysis, and direct observation. The most commonly used method is questionnaires, such as the Motorcycle Rider Behavior Questionnaire (MRBQ) [12] or questionnaires designed to capture other riding activities. The questionnaire method is easy to use but may lack accuracy, as it relies on the opinions and beliefs of individual riders. Another popular method is conducting in-depth interviews or focus group discussions (FGDs) with drivers who have been involved in accidents [13]. A disadvantage of this method is that the information gathered relies on the memories and perceptions of the interviewed riders. Another frequently used method is analyzing accident data obtained from authorities [14,15]. A disadvantage of this method is that it provides data only at the point of occurrence, often lacking information about the sequence of events leading up to the accident. Given the limitations, more objective research is needed to understand driver behavior, specifically through the use of Naturalistic Driving Studies (NDSs) [13].

The Naturalistic Driving Study (NDS) is a sophisticated traffic safety research method designed to provide insights into drivers' behavior during their daily journeys. It involves recording every detail of the driver, the vehicle, and the surrounding environment using unobtrusive data collection equipment without experimental control [16]. Research using NDSs can identify the sequence of events leading up to an accident [17]. NDS research can be grouped into two categories based on where and how the data are collected [18], namely vehicle-based and site-based. Vehicle-based research involves using instrumented motorcycles, which are motorcycles equipped with various cameras and sensors to capture parameters necessary for assessing rider behavior [19–21]. Site-based research observes driving behavior by placing cameras in specific areas to monitor rider behavior in those locations [22,23]. NDS research was initially conducted on 100 cars at the Virginia Tech Transportation Institute (VTTI) in collaboration with the National Highway Traffic Safety Administration (NHTSA) [24]. NDS research has several objectives, including understanding driver behavior and responses when encountering various situations during trips, evaluating new systems installed on vehicles, and identifying situations that could potentially lead to accidents [18].

2. Method and Material

2.1. Instrumented Motorcycle

Recording detailed data on the driver, vehicle, and surrounding environment requires sophisticated data collection equipment. NDS research, based on the method of data collection, involves the use of instrumented motorcycles, which are equipped with various cameras and sensors to capture the parameters needed to assess rider behavior. The design captures throttle lever data, horn status, turn signal data, tilt data, brake lever status, and data storage; the data acquisition system (DAS) software is shown in Figure 1, showing a block diagram of the vehicle's DAS. The ESP32 collects data from several sensors, including a speed sensor, tilt sensor, throttle sensor, brake sensor, and turn signal sensor. The ESP32 transmits these data to the Jetson Nano via serial communication, which are processed into a data log file.

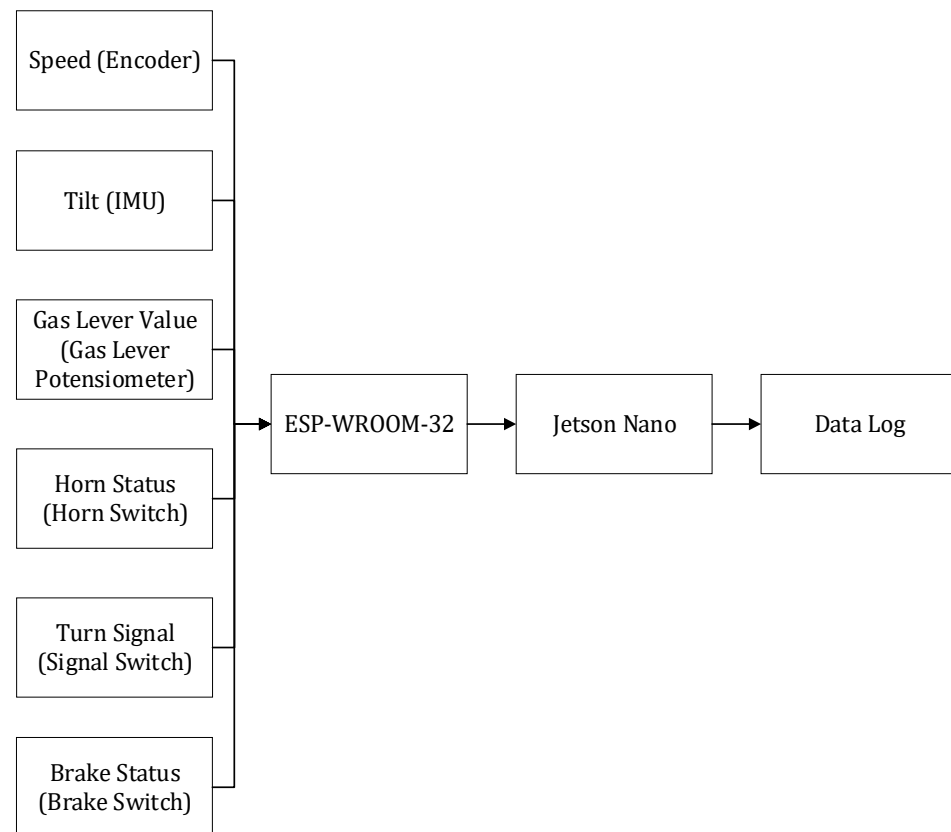


Figure 1. Block diagram of the data acquisition system design.

Data on the speed of two-wheeled vehicles are collected by capturing encoder data and processing them into speed (km/h). The throttle lever value is obtained from the motorcycle's throttle cable. Horn status data are captured from the horn switch on the vehicle, with a voltage divider circuit needed to adjust the voltage for readability. Turn signal data are retrieved from the motorbike's flasher, a flip-flop circuit that makes the turn signal lights blink. When the flasher receives voltage, it sends voltage to the selected turn signal light, causing it to blink. The voltage provided to the flasher is used as turn signal data. Vehicle tilt data are collected using an Inertial Measurement Unit (IMU), specifically the MPU6050, which records tilt in the Y and Z planes, as illustrated in Figure 2.

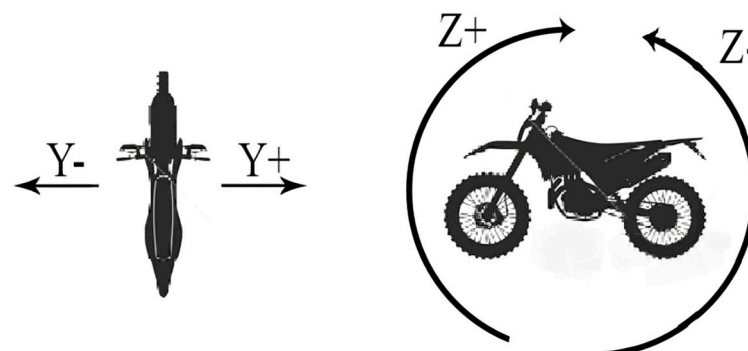


Figure 2. Depiction of the Y and Z planes on the vehicle.

The brake lever status data are captured from the cutoff sensors installed on both brake levers. When the rear brake lever or front brake is pressed, they provide voltage to the cutoff input pin on the vehicle controller. The speed value, Y and Z plane tilt values, throttle lever value, horn status value, turn signal status value, and brake value

are received and processed by the ESP32. These data are then sent to the Jetson Nano via serial communication as an array and converted into log data as a CSV file. The design of the DAS uses two microcontrollers, the ESP32 and Jetson Nano, as shown in Figure 3. The ESP32 processes the acquired data and then sends it to the Jetson Nano, which is saved into a CSV file.

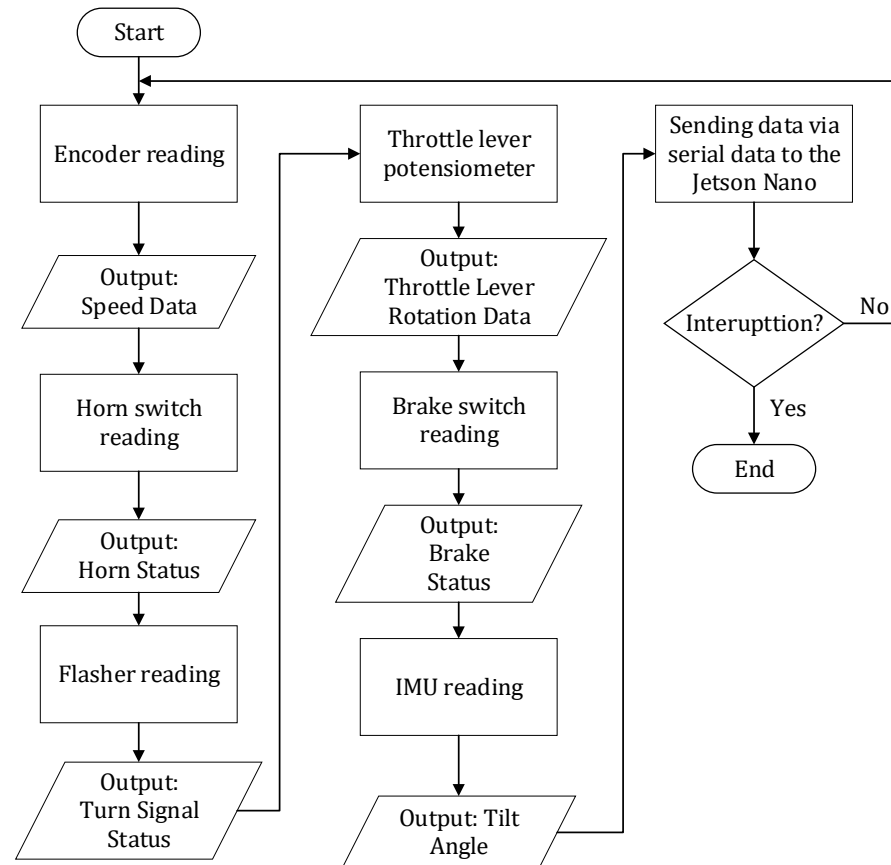


Figure 3. DAS flowchart.

The DAS utilizes the first core of the ESP32 to continuously take readings from the encoder, horn switch, flasher status, throttle lever potentiometer, brake switch, and IMU. The data from each reading process are then processed as follows: the output of the encoder reading is the speed of the two-wheeled vehicle (km/h); the output of the horn switch is the horn status (0 = off, 1 = on); the output of the flasher status is the turn signal status (0 = off, 1 = on); the output of the throttle lever potentiometer is the rotation of the throttle lever (0–100%); the output of the brake switch is the brake status (0 = off, 1 = on); and the output of the IMU is the angle of inclination in the Y and Z planes (degrees). These data are then sent to the Jetson Nano via serial communication. The Jetson Nano creates a CSV file upon activation, which is used to store the data provided by the ESP32. Each time the Jetson Nano receives input from the ESP32, it decodes the input data (converting from UTF-8 to ASCII), splits the data based on a specific delimiter, and appends the processed data to the CSV file. The flowchart depicting the CSV file creation process is presented in Figure 4.

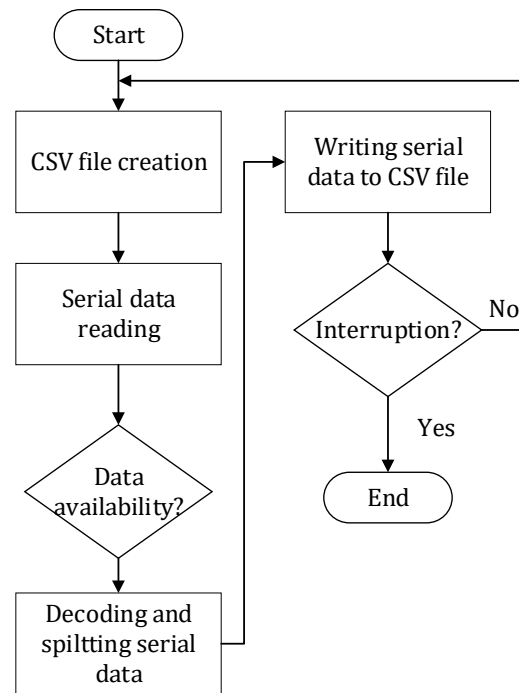


Figure 4. CSV file creation flowchart.

The final result of the data acquisition system (DAS) is a data log file containing various data, such as turn signal status, horn condition, throttle condition, brake condition, speed, and slope. This data log file with a CSV extension is stored on the Jetson Nano. The speed value obtained from the encoder matches the speed value indicated on the two-wheeled vehicle's speedometer. The throttle lever value accurately reflects the throttle position, as shown by the corresponding increase in speed value when the throttle lever value increases. The design of the tested components and motor is shown in Figure 5.

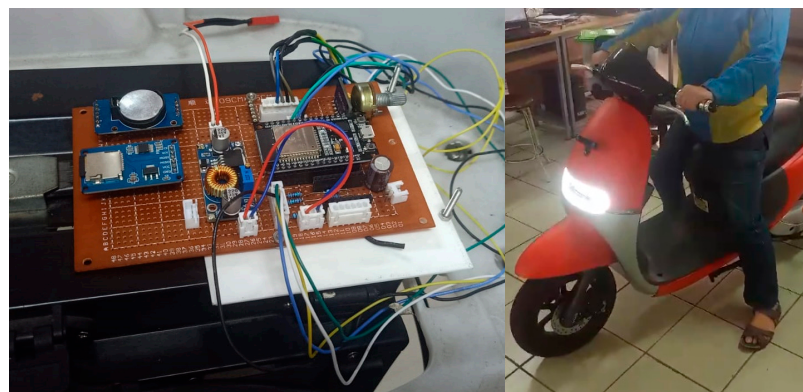


Figure 5. Instrumented motorcycle.

Calibration is performed to ensure the sensor and camera accurately measure position, velocity, and inclination. This involves taking multiple measurement points (e.g., minimum, maximum, and intermediate values) across the working range of the sensor. These readings are then compared to those from a reference measuring instrument. By comparing the sensor and camera readings with the reference values, a correction factor is calculated to determine the precision and accuracy of the sensors and cameras used.

2.2. Experimental Design

The instrumented motorcycle will be used alternately by participants for a period of at least one week. Participants will be asked to use the instrumented motorcycle until they become accustomed to it in their daily activities. The data collected will be transferred to an external hard drive each day. Participants are expected to be diverse in terms of sociodemographic and personality factors.

Participants will complete an informed consent form, agreeing to the recording of their travel activities using the instrumented motorcycle. They will also fill out a profile form detailing their sociodemographic data. Additionally, participants will complete a questionnaire related to personality traits. Each participant will maintain a logbook documenting daily riding activities, including the origin and destination of trips, the type of route taken whether usual or not, whether they were riding alone or carrying passengers or goods, and any unusual events encountered during the trip [25].

The video and sensor data recordings will then be analyzed to identify driving activities that result in risky situations. These identified incidents will be reviewed with the rider to confirm the actual events and understand the rider's reasons for their decisions [19–21]. Additionally, the detected risky situations will be reviewed with other experienced riders and safety riding experts to assess the risk level of the actions taken. The stages of the experimental design can be seen in Figure 6.

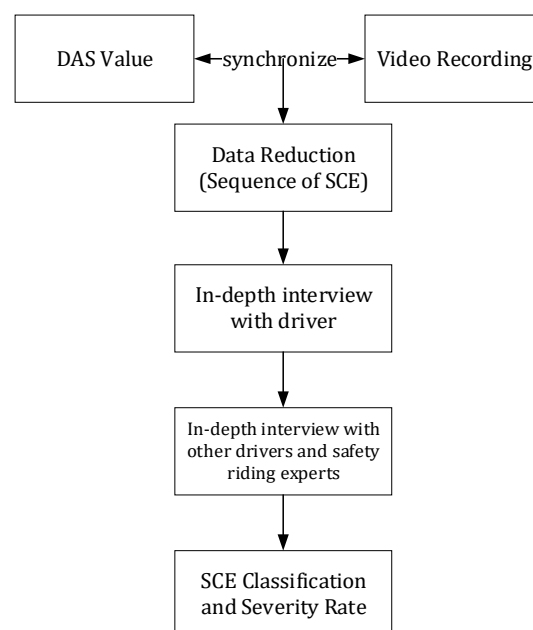


Figure 6. Experimental design.

3. Result and Discussion

3.1. Naturalistic Driving Study (NDS)

NDSs have been conducted in various countries, including the United States [26], France [25], Italia [27], Vietnam [28], and Malaysia [29]. These studies primarily aim to observe driver behavior across different vehicle types, such as cars, trucks, and motorcycles. Insights from NDSs can assist authorities in enhancing traffic regulations, facilities, and infrastructure, ultimately contributing to accident reduction.

NDSs were initially applied to passenger cars and trucks [24]. Driver behavior in critical driving situations is recorded using cameras and sensors placed in various locations within the vehicle. These recordings can identify anomalies in driving behavior, capturing near-miss incidents and even actual crashes [30]. These data provide valuable insights into

the sequence of events, aiding in identifying the causes of near crashes and collisions. NDS research is often supplemented with interviews [19] and questionnaires [28] to enhance data quality and enrich analysis.

3.2. Data Acquisition System (DAS) Results

The results include CSV data files and graphs of the speed values (positive value = move forward; negative value = move backward), throttle lever values, brake value (0 = off; 1 = on), horn (0 = off; 1 = on), turn signal (0 = off; 1 = on), and the Y and Z planes (see Table 1). Speed data, horn status, turn signal status, brake status, and throttle lever value are obtained by tapping into various devices on the electric motor. Tilt data acquisition is carried out using an IMU (sensor addition). An example of the data can be seen in Table 1.

Table 1. DAS value.

Speed (km/hours)	Throttle Lever (Degree)	Brake *	Horn *	Signal *	Y (Degree)	Z (Degree)
−1	0	0	1	0	8.07	1.53
0	33	0	0	0	52.3	11.04
2	33	0	0	0	0.02	1.52
4	33	1	0	1	0.11	0.34
5	11	1	1	0	11.19	15.69
5	11	0	0	1	52.3	11.04
5	11	0	1	0	0.21	−2.41
4	0	0	0	1	1.84	−7.73
−2	0	0	0	1	0.17	−2.14
−2	0	0	0	1	−0.28	−1.62
−3	0	0	0	0	−0.77	−1.96
−3	0	0	0	0	52.3	11.04
−3	0	0	0	0	52.3	11.04

Note: * = on (1); off (0).

Data from the front-mounted camera is captured simultaneously using the sensor data. The camera footage and sensor data will be synchronized to provide a comprehensive overview of road conditions and the detection of variables recorded by the sensors. The quantitative data obtained from the sensors can complement the qualitative observations from the camera footage, making the subjective judgments more grounded and accountable.

3.3. Expected Result

Based on the DAS results and video recordings, driving activities can be identified more accurately. Observations using the NDS method do not always capture actual accidents, so an alternative approach is often employed to identify safety-critical events (SCEs) [31]. SCEs are essentially situations that are considered risky and are encountered by motorists during their driving activities [30]. These situations can potentially lead to accidents if an appropriate response is not made. Risky situations are identified under several conditions, such as non-compliance with traffic regulations (e.g., running red lights, making dangerous maneuvers, and driving over the speed limit), based on the subjective judgment of the observer, or when anomalies are detected in the data obtained (e.g., sudden braking) [32]. The identified safety-critical events (SCEs) are observed not only from the driver's perspective but also include SCEs caused by other road users and those identified from prevailing traffic conditions. These SCEs will be analyzed and classified, focusing on those with the highest frequency and severity using a risk management matrix. The goal of this classification process is to rank activities based on their potential for harm. This ranking will enable the design of mitigation strategies to reduce unsafe driving activities. The classification and ranking will be validated by consulting relevant parties, such as driving safety trainers and traffic police.

Research to understand the driving characteristics of motorcyclists in Indonesia using the Naturalistic Driving Study (NDS) technique has not been conducted before, making this study a valuable contribution to the field. The behavior of riders, other road users, and traffic conditions can be comprehensively and clearly recorded. However, one limitation of this study is that participants may exhibit unnatural behavior since they are not using their own motorcycles but rather the instrumented motorcycles provided by the researchers. This issue is mitigated by having participants use the instrumented motorcycles for at least one week, allowing them to acclimate. Another challenge is managing the large volume of data that will be collected, which must be identified and analyzed.

4. Conclusions

Indonesia, as a country with a high number of motorcycles, continues to experience a high accident rate. Motorcyclists are particularly vulnerable compared to other vehicles. Several factors contribute to road accidents, including human, vehicle, and environmental factors. Among these, human behavior plays a significant role in traffic accidents. Human behavior can be studied in various ways, both subjectively and objectively, with one of the most advanced methods being the Naturalistic Driving Study (NDS). Research using NDSs requires sophisticated equipment, including an instrumented motorcycle. This motorcycle is equipped with cameras and sensors that provide information on the traffic situations encountered by the rider and the maneuvers performed by the rider. This instrumented motorcycle is equipped with several sensors to detect speed, throttle rotation, activation of lights, brakes, and turn signals, as well as motorcycle tilt. The data from these sensors are collected using an ESP-Wroom-32 and transmitted to a Jetson Nano to produce data logs, with the final output being a CSV file. In addition to sensors, a forward-facing camera records the traveling situation. The camera footage helps detect safety-critical events (SCEs) that may arise from not only the driver but also other road users and traffic conditions. The detection of SCEs is based on the subjective judgment of the observer, supported by the sensor data readings. These results will be validated with other riders and safety riding experts to assess the risk level of the identified SCEs.

For example, a practical application is to analyze rider behavior at intersections. Instrumented motorcycles can record behaviors such as speed, signal timing, braking patterns, and motorcycle tilt. Based on these observations, authorities can design and implement improved signage systems. Once installed, rider behavior can be re-evaluated using instrumented motorcycles to assess the signage's effectiveness.

This article proposes a design of an instrumented motorcycle and a methodology for conducting research using NDSs. The expected outcome of this research is an understanding of the characterization of SCEs, which can then be classified and ranked. The highest-ranked SCEs can be addressed by designing mitigation strategies to reduce the potential for accidents.

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References

1. WHO. *Global Status Report on Road Safety 2023*; World Health Organization: Geneva, Switzerland, 2023.
2. Badan Pusat Statistik. *Statistik Transportasi Darat 2022*; Badan Pusat Statistik/ BPS-Statistics Indonesia: Jakarta, Indonesia, 2023. Available online: <https://www.bps.go.id/id/publication/2023/11/27/5a5e4c75e4a25d44b1846446/statistik-transportasi-darat-2022.html> (accessed on 5 September 2023).
3. Korlantas. *Polisi Lalu Lintas Dalam Angka Tahun 2021; 2022*. Available online: https://web.k3i-korlantas.id/pustaka/informasi_setiap_saar (accessed on 5 September 2023).
4. Solagberu, B.A.; Ofoegbu, C.K.P.; Nasir, A.A.; Ogundipe, O.K.; Adekanye, A.O.; Abdur-Rahman, L.O. Motorcycle Injuries in a Developing Country and the Vulnerability of Riders, Passengers, and Pedestrians. *Inj. Prev.* **2006**, *12*, 266–268. [CrossRef]
5. Smiley, A.; Rudin-Brown, C. (Missy). Human Factors in Transportation. In *International Encyclopedia of Transportation*; Vickerman, R., Ed.; Elsevier: Oxford, UK, 2021; pp. 331–345, ISBN 978-0-08-102672-4.
6. Green, M.; Senders, J. Human Error in Road Accidents. Available online: <https://www.visualexpert.com/Resources/roadaccidents.html> (accessed on 8 September 2023).
7. Abdul Manan, M.M. Motorcycles Entering from Access Points and Merging with Traffic on Primary Roads in Malaysia: Behavioral and Road Environment Influence on the Occurrence of Traffic Conflicts. *Accid. Anal. Prev.* **2014**, *70*, 301–313. [CrossRef] [PubMed]
8. Abdul Manan, M.M.; Várhelyi, A. Exploration of Motorcyclists' Behavior at Access Points of a Malaysian Primary Road—A Qualitative Observation Study. *Saf. Sci.* **2015**, *74*, 172–183. [CrossRef]
9. Sultan, Z.; Ngadiman, I.; Kadir, F.; Roslan, N.; Moeinaddini, M. Factor Analysis of Motorcycle Crashes in Malaysia. *Plan. Malays. J.* **2016**, *4*, 135–146. [CrossRef]
10. Zhang, Y.; Jing, L.; Sun, C.; Fang, J.; Feng, Y. Human Factors Related to Major Road Traffic Accidents in China. *Traffic Inj. Prev.* **2019**, *20*, 796–800. [CrossRef] [PubMed]
11. Hosking, S.G.; Liu, C.C.; Bayly, M. The Visual Search Patterns and Hazard Responses of Experienced and Inexperienced Motorcycle Riders. *Accid. Anal. Prev.* **2010**, *42*, 196–202. [CrossRef] [PubMed]
12. Elliott, M.A.; Baughan, C.J.; Sexton, B.F. Errors and Violations in Relation to Motorcyclists' Crash Risk. *Accid. Anal. Prev.* **2007**, *39*, 491–499. [CrossRef]
13. Huth, V.; Füssl, E.; Risser, R. Motorcycle Riders' Perceptions, Attitudes and Strategies: Findings from a Focus Group Study. *Transp. Res. Part F Traffic Psychol. Behav.* **2014**, *25*, 74–85. [CrossRef]
14. de Craen, S.; Doumen, M.J.A.; van Norden, Y. A Different Perspective on Conspicuity Related Motorcycle Crashes. *Accid. Anal. Prev.* **2014**, *63*, 133–137. [CrossRef]
15. Karpinski, E.; Bayles, E.; Daigle, L.; Mantine, D. Comparison of Motor-Vehicle Involved e-Scooter Fatalities with Other Traffic Fatalities. *J. Saf. Res.* **2023**, *84*, 61–73. [CrossRef]
16. van Schagen, I.; Welsh, R.; Backer-Grondahl, A.; Hoedemaeker, M.; Lotan, T.; Morris, A.; Sagberg, F.; Winkelbauer, M. *Towards a Large Scale European Naturalistic Driving Study: Final Report of PROLOGUE: Deliverable D4.2*; Loughborough University: Leidschendam, The Netherlands, 2011.
17. Dozza, M.; González, N.P. Recognising Safety Critical Events: Can Automatic Video Processing Improve Naturalistic Data Analyses? *Accid. Anal. Prev.* **2013**, *60*, 298–304. [CrossRef] [PubMed]
18. Winkelbauer, M.; Donabauer, M.; Pommer, A.; Jansen, R. Naturalistic Data on Time Headway behind Motorcycles and Other Vehicles. *Saf. Sci.* **2019**, *119*, 162–173. [CrossRef]
19. Aupetit, S.; Riff, J.; Buttelli, O.; Espié, S. Naturalistic Study of Rider's Behaviour in Initial Training in France: Evidence of Limitations in the Educational Content. *Accid. Anal. Prev.* **2013**, *58*, 206–217. [CrossRef]
20. Aupetit, S.; Espié, S.; Bouaziz, S. Naturalistic Study of Riders' Behaviour in Lane-Splitting Situations. *Cogn. Technol. Work* **2015**, *17*, 301–313. [CrossRef]
21. Aupetit, S.; Gallier, V.; Riff, J.; Espié, S.; Delgehier, F. Naturalistic Study of the Risky Situations Faced by Novice Riders. *Ergonomics* **2016**, *59*, 1109–1120. [CrossRef] [PubMed]
22. Ramlan, R.; Irawan, M.Z.; Munawar, A. Behavioral Factors of Motorcyclists in Right-Turn Movements at Unsignalized Intersections: An Insight from Yogyakarta, Indonesia. *IATSS Res.* **2021**, *45*, 116–122. [CrossRef]

23. Conrad, P.; Bradshaw, Y.S.; Lamsudin, R.; Kasniyah, N.; Costello, C. Helmets, Injuries and Cultural Definitions: Motorcycle Injury in Urban Indonesia. *Accid. Anal. Prev.* **1996**, *28*, 193–200. [[CrossRef](#)]
24. Dingus, T.; Klauer, S.; Lewis, V.; Petersen, A.; Lee, S.; Sudweeks, J.; Perez, M.; Hankey, J.; Ramsey, D.; Gupta, S.; et al. *The 100-Car Naturalistic Driving Study: Phase II—Results of the 100-Car Field Experiment*; National Highway Traffic Safety Administration: Virginia, United States, 2006.
25. Aupetit, S.; Riff, J.; Gallier, V.; Espié, S. Conceptual and Methodological Tools for Analyzing Situations of Vulnerability on the Road: Examples from a Motorcycle Riding Study. In Proceedings of the 30th European Conference on Cognitive Ergonomics, Edinburgh, UK, 28 August 2012; ACM: Edinburgh, UK, 2012; pp. 29–36.
26. Hanowski, R.J.; Soccolich, S.A.; Hammond, R.L.; Glenn, L.; Ibrahim, M.K.A.B.; Rashid, A.A.B.A.B. *Motorcycle–Heavy Vehicle Crashes: USA Data and Implications for Other Parts of the World*; Hong Kong Society for Transportation Studies Limited: Hong Kong, China, 2019; pp. 65–72.
27. Bella, F.; Gulisano, F. A Hazard-Based Model of the Motorcyclists’ Overtaking Duration. *Accid. Anal. Prev.* **2020**, *141*, 105522. [[CrossRef](#)]
28. Yoshida, N.; Koyanagi, T. Empirical Analysis of Hazard Perception and Driving Behaviors among High School and College Students on Motorcycles in Phnom Penh, Cambodia. *IATSS Res.* **2018**, *42*, 171–179. [[CrossRef](#)]
29. Ibrahim, M.K.A.; Yusoff, M.F.M. Use of Instrumented Motorcycle to Measure the Effectiveness of Malaysian Rider Training: A Pilot Study. In Proceedings of the 6th International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design: Driving Assessment, 2011; University of Iowa: Olympic Valley-Lake Tahoe, CA, USA, 2011; pp. 489–495.
30. Soccolich, S.A.; Blanco, M.; Hanowski, R.J.; Olson, R.L.; Morgan, J.F.; Guo, F.; Wu, S.-C. An Analysis of Driving and Working Hour on Commercial Motor Vehicle Driver Safety Using Naturalistic Data Collection. *Accid. Anal. Prev.* **2013**, *58*, 249–258. [[CrossRef](#)]
31. Cai, M.; Yazdi, M.A.A.; Mehdizadeh, A.; Hu, Q.; Vinel, A.; Davis, K.; Xian, H.; Megahed, F.M.; Rigdon, S.E. The Association between Crashes and Safety-Critical Events: Synthesized Evidence from Crash Reports and Naturalistic Driving Data among Commercial Truck Drivers. *Transp. Res. Part C Emerg. Technol.* **2021**, *126*, 103016. [[CrossRef](#)]
32. Bagdadi, O. Assessing Safety Critical Braking Events in Naturalistic Driving Studies. *Transp. Res. Part F Traffic Psychol. Behav.* **2013**, *16*, 117–126. [[CrossRef](#)]

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