

Analysis of Human, Environmental, and Vehicle Factors Affecting Traffic Accident Severity in Jurisdiction of Metro Jaya Police

Original Article

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Abstract

The jurisdiction of the Jakarta Metropolitan Police (Polda Metro Jaya) is one of the areas experiencing traffic accident problems. Traffic accidents in the Jakarta Metropolitan Police jurisdiction can involve two-wheeled vehicles, four-wheeled vehicles, trucks, and even pedestrians. Accidents can be assessed based on the severity of the accident, usually classified as mild, moderate, and severe. Accident severity in this study focuses on human, environmental, and vehicle factors. This study aims to determine the most important sub-factors that increase the severity of traffic accidents in the Jakarta Metropolitan Police jurisdiction. The theories used in this study are transportation theory and human error theory. This study uses accident data in the form of the Integrated Road Safety Management System (IRSMS) from the Police, which is tested using Structural Equation Modeling (SEM), and validated using questionnaire data collected through a Google Form survey analyzed using partial least squares (PLS). The results of the IRSMS data analysis indicate that attention and drowsiness are strong predictors of increased severity. The results of the survey analysis indicate that drowsiness and vehicle age are significant predictors of severity. The validation results of the Integrated Road Safety Management System (IRSMS) data analysis and questionnaire provide a comprehensive picture of the complexity of the causes of the severity of accidents that can be experienced.

Keywords: Accident Severity Rate, Driving Behavior, Traffic.

1. Introduction

Traffic is an important part of community life and is governed by various regulations to ensure order, smooth flow and safety on the roads (Oktopianto et al., 2021). Road traffic in Indonesia is governed by Law No. 22 of 2009 on Road Traffic and Transport, which covers safety, traffic management, and the rights and obligations of road users (Faida et al., 2023). This regulation aims to create a safe, comfortable and efficient transport system. Transport is a vital element of modern society, particularly in major cities such as Jakarta. As a centre of government and the economy, transport options range from private vehicles (two- and four-wheeled) to public transport (TransJakarta, MRT, LRT and KRL). Although there are many public transport alternatives, many people still choose to use private vehicles because public transport is not yet fully integrated. This situation has negative consequences, as the growth in vehicle users is not matched by improvements in road infrastructure. One of the consequences of the increase in vehicles is, of course, a direct correlation with the risk of road accidents (Puspoprojjo & Laila, 2021).

A road traffic accident can be defined as an incident occurring on the road involving a motor vehicle that may result in injury, death or material damage (Putra et al., 2022). According to Law No. 22 of 2009 on Road Traffic and Transport, a road traffic accident is an



unexpected and unintentional incident involving a vehicle, with or without other road users, resulting in loss of life or property damage. According to the Kamus Besar Bahasa Indonesia (KBBI), the word '*kecelakaan*' (accident) derives from the root word '*celaka*', which means to experience difficulty or misfortune (Irani et al., 2022). In road traffic, accidents occur because road users fail to anticipate the conditions around them. In addition to human factors, accidents can also be influenced by environmental factors such as road conditions and the weather. Unless there is an element of intent in a road incident, in which case the event is not classified as a road traffic accident (Mubalus, 2023).

Globally, road traffic accidents cause approximately 1.19 million deaths and around 50 million injuries each year. The financial losses borne by countries as a result of accidents are estimated to amount to 3% of national income or gross domestic product (GDP). Essentially, road traffic accidents regard human factors as the primary cause due to vulnerability to error. A comprehensive understanding of the factors driving risky driving behaviour is essential for the design of interventions and even traffic policy. As understanding of driving behaviour is heavily dependent on demographic characteristics—such as men being at greater risk of dying in accidents than women, and the majority of accident-related deaths occurring in low- and middle-income countries (Somoray et al., 2024). In line with efforts to promote road safety, studies into driving behaviour should be conducted amongst the general public.

As the capital of Indonesia, the jurisdiction of the Metro Jaya Regional Police is one of the areas facing significant issues with road traffic accidents (Simanullang et al., 2024). Road traffic accidents in Jakarta are a serious issue affecting public safety and well-being. The traffic accident data compiled over the last five years covers the period from 2019 to 2024.

In 2019, there were 8,877 recorded accidents, resulting in 559 fatalities, 1,565 serious injuries, and 8,433 minor injuries. The number of accidents fell in 2020 to 8,052 cases, likely influenced by mobility restrictions due to the COVID-19 pandemic. However, this figure rose gradually in subsequent years. In 2022, the number of accidents increased significantly to 10,494 cases, with 707 fatalities. This trend continued into 2023, when the number of accidents surged dramatically to 13,051 cases, making it the year with the highest accident figures in the last five years. The number of fatalities also rose to 753, with 2,648 seriously injured and 12,666 slightly injured.

However, in 2024, the number of accidents decreased to 11,442 cases, with 619 fatalities, 1,633 seriously injured, and 11,832 slightly injured. This decline can be attributed to various road safety improvement initiatives undertaken by the government and the police. In terms of material losses, the total value of losses resulting from road traffic accidents also fluctuated. In 2019, losses amounted to Rp18.33 billion, decreasing in 2020 and 2021 before rising again in 2022 to Rp19.44 billion. The year 2024 saw a slight decrease in losses to Rp16.34 billion.

Each accident results in varying levels of severity based on the injuries sustained, ranging up to fatalities, and is typically categorised as minor, moderate, or severe/critical. There are various factors and specific conditions considered to exacerbate the severity of road traffic accidents. Generally, high-severity accidents occur when a four-wheeled vehicle strikes a pedestrian, or when the accident causes a vehicle to roll over. In terms of age, the severity of accidents tends to be experienced by drivers aged 50 and over (Masoumi et al., 2016). Other researchers point out that the severity of accidents is on the rise due to poor street lighting and disparities in vehicle size, such as collisions between buses and motorcycles (Skhvediani et al., 2023).

Within the jurisdiction of the Jakarta Metropolitan Police, driver behaviour is a frequently discussed issue when it comes to road traffic accidents. The number of two-wheeled vehicles continues to rise in line with the high demand for fast and efficient transport

(Handayani, 2023). Motorcycles are the vehicle of choice for many people, given their ability to bypass traffic jams and their ease of access to densely populated areas. However, this convenience is offset by the high rate of accidents involving motorcyclists. Motorcycles are often the cause of accidents, with the victims mostly being the riders or passengers themselves. These accidents are closely linked to the way individuals ride their motorcycles at high speeds and fail to respect the rights of other road users (Mauludi et al., 2021).

Another factor contributing to motorcycle accidents is the behaviour of riders, who tend to break the rules of the road. Many motorcyclists fail to observe speed limits, disregard traffic signs, or do not wear safety equipment such as helmets. Furthermore, another equally significant behaviour is the habit of motorcyclists to ride in unauthorised lanes, such as cutting across bus lanes, riding on pavements, or even riding against the flow of traffic. These practices endanger not only the riders themselves but also other road users. It is not uncommon for accidents to occur due to a lack of coordination between motorcyclists' behaviour and the existing traffic flow, particularly during rush hour (Deanty et al., 2022).

In addition to two-wheeled vehicles, four-wheeled vehicle users also play a role that is no less significant in the incidence of road traffic accidents within the jurisdiction of the Metro Jaya Regional Police. Although four-wheeled vehicles physically offer better protection for drivers and passengers than two-wheeled vehicles, accidents involving four-wheeled vehicles remain a major problem. The number of four-wheeled vehicles in Jakarta is increasing, and as the number of vehicles rises, the challenges on the roads become increasingly complex (Sahara & Syuhada, 2023).

Car drivers often feel safer and more protected than motorcyclists. This frequently leads car drivers to feel more at liberty when driving, meaning they often break traffic rules or drive at high speeds. One common example of such driving behaviour is car drivers who become impatient in traffic jams, leading them to try to cut across lanes or even run red lights. Furthermore, factors such as fatigue and the influence of alcohol are frequently observed among car drivers, which further exacerbates road safety conditions (Wahid et al., 2022).

Drivers of four-wheeled vehicles must also be more cautious when interacting with other road users, particularly motorcyclists and pedestrians. One of the causes of accidents involving four-wheeled vehicles is drivers' lack of awareness of smaller vehicles, such as motorcyclists who are often caught in traffic jams and overtake larger vehicles on the left or right. Congested and narrow road conditions also prompt drivers of four-wheeled vehicles to drive recklessly, for example by making sudden manoeuvres that can disrupt traffic flow and cause accidents. Therefore, an analysis of the behaviour of drivers of four-wheeled vehicles and how their actions affect road safety within the jurisdiction of the Metro Jaya Regional Police is required.

One study in Indonesia classifies accidents through a three-factor mechanism: driver, vehicle, and environmental factors. These three factors give rise to constructs that explain the dynamics of accidents. The driver factor, for example, comprises constructs such as inattention, drowsiness, intoxication, lack of skill, and non-compliance. Environmental factors include winding roads and rainy conditions. Vehicle factors range from faulty brakes to burst tyres. However, the researchers found that the predictor with the strongest effect on accidents is driving in a disorderly manner (Marsaid et al., 2013). The researchers used a three-factor model, as was done by Marsaid et al. (2013), which focuses on factors relating to the human element (drivers), the surrounding environment (including road conditions) and the vehicles themselves.

This research is urgently needed given the high incidence of road traffic accidents within the jurisdiction of the Metro Jaya Regional Police. Unsafe driving behaviours, such as disobeying traffic signs, speeding, and disregarding the safety of oneself and others, are

frequently exhibited by drivers and constitute the primary factors in accidents. Within the jurisdiction of the Metro Jaya Regional Police, where traffic density is high, awareness of road safety remains relatively low. This study aims to identify constructs within the scope of human, environmental, and vehicle factors that influence the severity of road traffic accidents. The results of this study are expected to provide an understanding of the factors causing the increasing severity of accidents and to assist in efforts to reduce accidents in Jakarta, thereby creating a safer and more orderly driving environment for all road users.

Based on this background, the objective of this study is to determine the factors frequently identified as causes of road traffic accidents within the jurisdiction of the Metro Jaya Regional Police, to analyse the extent of their influence on the severity of road traffic accidents, and to validate these findings through a survey distributed to individuals who have experienced road traffic accidents. The entire research process provides a comprehensive overview of the factors influencing the severity of traffic accidents within the jurisdiction of the Metro Jaya Regional Police.

2. Literature Review

2.1. Driving Behaviour

Driving behaviour reflects an individual's attitudes and habits whilst driving, which are influenced by psychological, social and environmental factors (Herani & Jauhari, 2017). A responsible driver will obey the traffic rules, stay focused, and consider their own safety as well as that of other road users. Conversely, aggressive driving behaviour such as running red lights, driving at high speeds, or using a mobile phone whilst driving can increase the risk of accidents. Factors such as stress, emotions, and driving experience also influence how a person drives. Thus, education and awareness of the importance of road safety must be continuously improved in order to reduce the risk of accidents on the roads (Ludyaningrum, 2016).

In addition to individual factors, driving behaviour is also influenced by road conditions and transport policies. Good infrastructure, such as smooth roads, clear traffic signs and an integrated transport system, can help foster a more orderly driving culture. The government and the authorities play a vital role in enforcing regulations and imposing penalties on traffic offenders to create a deterrent effect. Further, road safety campaigns, such as promoting the use of seatbelts and helmets for motorcyclists, also need to be stepped up (Kusumastutie, 2018).

2.2. Road Traffic Accident

Road traffic accidents are a serious problem in Indonesia, with far-reaching social, economic and legal consequences. According to Law No. 22 of 2009 on Road Traffic and Transport, a road traffic accident is an unexpected and unintentional event on the road involving a vehicle, with or without other road users, resulting in human casualties and/or property damage (Dewi et al., 2022).

According to the WHO (2004), road traffic accidents cause around 1.2 million deaths each year worldwide, including in Indonesia. In addition to causing loss of life, accidents also have economic impacts in the form of medical costs, loss of productivity, and damage to infrastructure and vehicles. Therefore, an understanding of the concept of road traffic accidents is essential to prevent and reduce accident rates.

2.3. Transport Systems Theory

Transportation Systems Theory explains how the movement of people and goods takes place within a system comprising various interrelated elements. According to Tamin (2000), The macro transport system is divided into four main components: the transport demand

system, the transport supply system (infrastructure), the traffic flow system, and the institutional framework. These four elements work synergistically to ensure that transport operates efficiently and meets the needs of the community. For example, increased economic activity and urbanisation will boost transport demand, thereby necessitating the development of adequate road networks, terminals, and modes of transport. On the other hand, the institutional framework plays a role in regulating policies that support transport efficiency, such as urban spatial planning integrated with public transport systems to reduce congestion and improve accessibility.

2.4. Human Error Theory

Human Error Theory explains that human errors in various situations, including road traffic, can be caused by cognitive, psychological and environmental factors. According to this theory, errors occur due to human limitations in processing information, making decisions and acting appropriately in certain situations. Reason (1990) classifies human errors in accidents into three main categories: slips and lapses (errors resulting from memory or attention lapses), mistakes (errors in decision-making or planning), and violations (deliberate breaches of rules)

2.5. The Dynamics of Road Traffic Accidents

There are various types of road traffic accidents, the most common being head-on collisions, side-impact collisions and rear-end collisions. When categorised by time of day, accidents most frequently occur during rush hour, when people are travelling to and from work, namely in the morning and evening (Santosa et al., 2017). When considering the severity of accidents, researchers consider head-on collisions to be the most severe, as they generate the greatest impact energy, which can result in serious injury or even death (Pradipta et al., 2020). The severity can be determined by examining the evasion manoeuvre in the pre-impact phase. Severity increases when the rider has no opportunity to evade, due to limited space and time, as well as high speed (Yastremska-kravchenko et al., 2022).

3. Methods

3.1. Research Design

This study utilised traffic accident data from the Integrated Road Safety Management System (IRSMS) as the primary source for identifying accident patterns and rates, which were subsequently validated using primary data in the form of questionnaires on driving behaviour to ensure consistency between the system data and road users' perceptions. The approach used is a descriptive method, which aims to describe phenomena systematically and factually without manipulating variables (Nazir, 2014). This method also focuses on analysing existing facts without seeking causal relationships, thereby enabling the identification of trends and patterns within a population (Sugiyono, 2018). In addition, descriptive research is used to describe current conditions, particularly in the study of society and human behaviour (Whitney, 1960).

Through this approach, the study provides a comprehensive understanding of the factors that influence the severity of road traffic accidents, as well as the most critical factors in exacerbating such severity; these findings were subsequently validated through a survey, ensuring that the results are presented systematically and provide a comprehensive explanation of the phenomenon.

3.2. Data Source

The primary data used consists of survey data collected via Google Forms, comprising questions or a questionnaire relating to the research variables. This research survey was distributed to motorcyclists within the jurisdiction of the Metro Jaya Regional Police, with responses collected from a total of 100 individuals. The sample size of 100 was determined by Ghazali (2016), is the minimum requirement for the use of PLS analysis tools. In this study, secondary data was obtained from the Integrated Road Safety Management System (IRSMS) developed by the police. This data was analysed to understand patterns of driver behaviour—such as spontaneous actions, drowsiness or lack of focus—that contribute to road traffic accidents. Specifically, from the entire police IRSMS database, data was filtered to focus on the IRSMS records specifically relating to accidents within the jurisdiction of the Metro Jaya Regional Police Headquarters between 2022 and 2025. The results are expected to provide a factual overview of the relationship between driving behaviour and human error factors in accidents within the jurisdiction of the Metro Jaya Regional Police Headquarters.

3.3. Data Collection Techniques

In this study, data were collected using two main methods: field research, library research and online research. The data collection techniques employed were as follows:

1) Integrated Road Safety Management System (IRSMS)

The Integrated Road Safety Management System (IRSMS) is an official document containing written records of the results of interviews with witnesses, victims or suspects conducted by investigators during the investigation and inquiry into a criminal offence (Karnavian, 2018). The IRSMS contains detailed information regarding the chronology of events, environmental conditions, and details of the vehicles and objects involved in the accident. In this study, the IRSMS was used as the primary data source. The IRSMS was analysed to uncover patterns of driving behaviour that caused accidents, such as rule violations, drowsiness, or lack of concentration. Through the analysis of the IRSMS, this study sought to identify factors influencing the severity of accidents.

2) Survey

A survey is a data collection technique used to obtain empirical data in order to examine the relationships between variables in a study. According to Sugiyono (2018) is a technique commonly used in quantitative research. Survey techniques can collect data relating to events that have already occurred in the past, particularly regarding individuals' beliefs, opinions, characteristics and behaviour. The nature of the data collected through surveys is not particularly in-depth, so the results obtained can generally be generalised to the population (Sugiyono, 2018).

3.4. Data Analysis Techniques

Analysis of Integrated Road Safety Management System (IRSMS) data to explore patterns, themes and key information regarding the severity of accidents. Tens of thousands of IRSMS data records were progressively reduced based on the completeness of the information. Incident data with minimal information were excluded from the analysis. Once the volume of IRSMS data had been reduced, presented in thematic form, and the validity of each piece of information verified, the researchers transformed the IRSMS data into numerical values. Consequently, all the IRSMS data used possessed values that could be statistically tested. Subsequently, the numerical data were analysed using Structural Equation Modelling (SEM), as this method is capable of testing causal relationships between complex latent constructs simultaneously (Hair et al., 2018). The PLS-SEM analysis was conducted using the SmartPLS version 4 software.

Before conducting structural testing to examine the relationships between constructs, namely between human, environmental and vehicle factors, and accident severity, reliability and validity must be established. Reliability, according to Sugiyono (2018), is the extent to which a measurement instrument or research survey can produce consistent results when used repeatedly on subjects with the same characteristics. Reliability is generally measured using Cronbach's Alpha to determine the reliability of a measurement instrument (Sugiyono, 2018). The Cronbach's alpha value commonly recommended for a measurement is ($\alpha=0.7$), but according to Taber (2018) a relatively low alpha value may still be useful, depending on the context of use and the construct being measured. A Cronbach's alpha value ($\alpha = 0.45-0.60$) is still acceptable given the small number of items (Taber, 2018).

In the subsequent method, the researchers utilised a survey as a source of secondary data to validate the findings of the IRSMS. The survey was designed in accordance with the traffic context in Indonesia, using human, environmental, and vehicle factors as the primary references. From these three factors, nine sub-factors were devised to form the constructs in this study. The survey data were analysed using partial least squares (PLS), a multivariate analysis method capable of modelling relationships between constructs to predict values across constructs (Hair et al., 2018). Before conducting the PLS analysis, the reliability of each construct must be demonstrated by an alpha value of at least $\alpha=0.45$, given the limited number of items included in this study (Taber, 2018). Each item must also have factor loadings greater than or equal to 0.500 to be considered valid; if the value is lower than this, the item is eliminated. Once all constructs have been deemed reliable and valid, a PLS analysis is conducted to examine the effect of each predictor construct on the severity level. In addition, the amount of variance explained by the research model is assessed, as interpreted through the R-squared value (Hair et al., 2018).

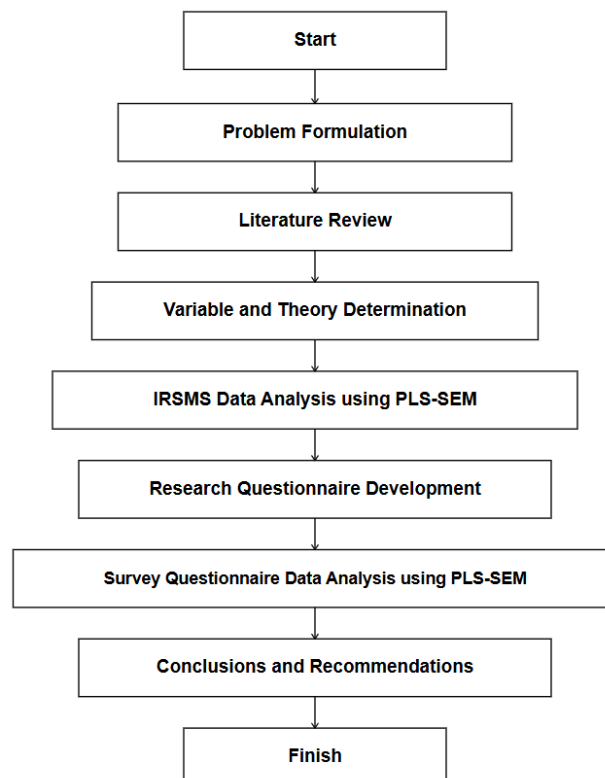


Figure 1. Research Flowchart

4. Results and Discussion

4.1. Research Results

4.1.1. IRSMS Analysis

A. Overview of Research Respondents

The researchers described the parties involved in the accidents, the type of collision, gender, age and length of driving experience.

Table 1. Overview of Research Respondents

Parties Involved in the Accident	N	%
Victim of the Accident (the person hit)	68	67,33%
Perpetrator of the Accident (the person who caused the crash)	33	32,67%
Type of Crash	N	%
Front-to-rear crash	42	41,58%
Front-to-front crash	35	34,65%
Side-to-side crash	17	16,83%
Other	7	6,93%
Gender	N	%
Male	65	64,36%
Female	36	35,64%
Age	N	%
≤ 25 years old	56	55,45%
26–35 years old	39	38,61%
36–45 years old	6	5,94%
Driving experience	N	%
≤ 5 years	39	38,61%
6–10 years	40	39,60%
11–15 years	15	14,85%
> 16 years	7	6,93%

Table 1 shows that the majority of the data in this study was obtained from victims affected by road accidents. The researchers then present a table detailing the distribution of the types of accidents experienced. Based on the type of collision, accidents were predominantly characterised by impacts involving the front of the vehicle, whether against the front or rear of another vehicle. The researchers then describe the demographics of the drivers, starting with the gender of the respondents.

The gender composition indicates a predominance of men involved in accidents. The distribution of the respondents' ages is described below. The distribution of respondents in the data shows a predominance of drivers in early adulthood. Finally, the researchers discuss driving experience, specifically the duration or length of an individual's driving experience. From the driving experience table, it can be seen that the majority of respondents fall within the low to medium range of driving experience. Thus, having presented all the descriptive data on the study's respondents, the following section explains the results of the statistical analysis.

B. Descriptive Statistics

There are 10 constructs, nine of which are factors predicted to influence the severity of road traffic accidents. These nine factors were measured using scales developed by the researchers, with each factor comprising five items. During the data testing process, 11 of the 45 statements were eliminated. The elimination of statement items was carried out because the items were invalid, as indicated by low factor loadings (< 0.500). The statements that were removed were item codes M1.5, M2.5, M3.4, L1.5, L2.4, L3.1 and L3.5, K1.1 and K1.5, K2.4,

and K2.5. After eliminating the invalid statements, the following is a presentation of the descriptive results for all constructs used:

Table 2. Descriptive statistics for the construct

	N	Mean	SD	Factor Loadings	Alpha	Skewness	Kurtosis
Severity	1	1,743	0,766	1,000	1,000	0,481	-1,156
Rules	4	1,421	0,518	0,658 – 0,789	0,706	1,496	1,701
Drowsiness	4	1,569	0,580	0,609 – 0,859	0,684	0,718	-0,449
Caution	4	1,547	0,536	0,525 – 0,740	0,596	0,886	-0,011
Weather	4	1,693	0,636	0,650 – 0,844	0,766	0,417	-1,033
Geometry	4	1,728	0,581	0,502 – 0,824	0,645	0,321	-0,951
Lighting	3	1,591	0,608	0,632 – 0,933	0,674	0,901	0,061
Engine	3	2,013	0,650	0,537 – 0,883	0,637	-0,113	-1,070
Type	4	1,723	0,565	0,558 – 0,753	0,634	0,446	-0,776
Age	4	1,530	0,597	0,587 – 0,829	0,728	0,910	-0,366

Table 2 shows that almost all variables have values below the mean. As previously noted, the researcher used a 3-point response scale, with a value of 2 serving as the mean reference point. For example, the mean severity score ($\bar{x}=1.743$) indicates that, in this dataset, the accidents experienced tend to be concentrated among individuals who suffered minor to moderate injuries.

The ‘Alpha’ column displays the reliability values for each construct, which refer to Cronbach’s alpha. In the table above, almost all constructs have an adequate level of reliability, with the exception of the ‘attention’ construct ($\alpha=0.549$), which requires careful interpretation. Furthermore, in the skewness and kurtosis columns, no values exceeding +2 or -2 are observed, indicating a normal data distribution. Overall, these descriptive findings indicate that the data quality is adequate for subsequent structural equation modelling analysis.

4.1.2. Table of Inter-Construct Correlations

The following table presents the results of the correlation analysis between the constructs of each sub-factor representing the human, vehicle and environmental factors, as well as accident severity.

Table 3. Correlation matrix between constructs

	1	2	3	4	5	6	7	8	9
1. Severity	1	-	-	-	-	-	-	-	-
2. Regulations	0,436	1	-	-	-	-	-	-	-
3. Drowsiness	0,524	0,693	1	-	-	-	-	-	-
4. Attention	0,454	0,575	0,882	1	-	-	-	-	-
5. Weather	0,266	0,498	0,543	0,575	1	-	-	-	-
6. Geometry	0,437	0,638	0,777	0,686	0,790	1	-	-	-
7. Lighting	0,353	0,516	0,635	0,599	0,763	0,821	1	-	-
8. Engine	0,323	0,519	0,361	0,237	0,214	0,331	0,376	1	-
9. Type	0,525	0,457	0,476	0,674	0,756	0,791	0,760	0,656	1
10. Age	0,442	0,289	0,297	0,269	0,173	0,212	0,426	0,129	0,240

The correlation matrix as in table 3 shows that all variables have a positive correlation, indicating a direct relationship between the accident factors. As for severity, it shows an association with all sub-factors. The effect of each sub-factor on severity is explained in the following section.

4.1.3. Path Analysis Results

This section presents the results of the partial least squares (PLS) analysis, including the effect coefficients between paths and the significance levels obtained for each path.

Table 4. Results of the partial least squares (PLS) analysis

Relationship	Coefficients (β)	SD	P-value	Sig.
Regulations -> Severity	0,090	0,103	0,381	Not significant
Drowsiness -> Severity	0,220	0,111	0,047	Significant
Attention -> Severity	0,114	0,106	0,279	Not significant
Weather -> Severity	-0,097	0,114	0,397	Not significant
Geometry -> Severity	0,046	0,114	0,688	Not significant
Lighting -> Severity	-0,041	0,132	0,758	Not significant
Engine -> Severity	0,079	0,101	0,432	Not significant
Type -> Severity	0,228	0,117	0,051	Not significant
Age -> Severity	0,279	0,106	0,008	Significant

The results of the structural equation modelling as in table 4 indicate that the severity of accidents is influenced by only two of the nine identified factors. Of all the predicted pathways, only the human factors of drowsiness ($\beta=0.220$, $p=0.047$) and vehicle age ($\beta=0.279$, $p=0.008$) had a significant effect on accident severity. Other factors, such as human factors (attention and rule violations) and environmental factors (weather, road geometry, and lighting), were not found to increase accident severity.

Overall, the nine formulated factors had an R^2 of 0.400 in predicting severity. This indicates that 40.0% of the variation in the severity of road traffic accidents can be explained by all the predictor variables used. The remaining 60.0% is explained by other variables not used in this study. Figure 2 illustrates the outcomes of the PLS analysis, highlighting the key findings from the research survey.

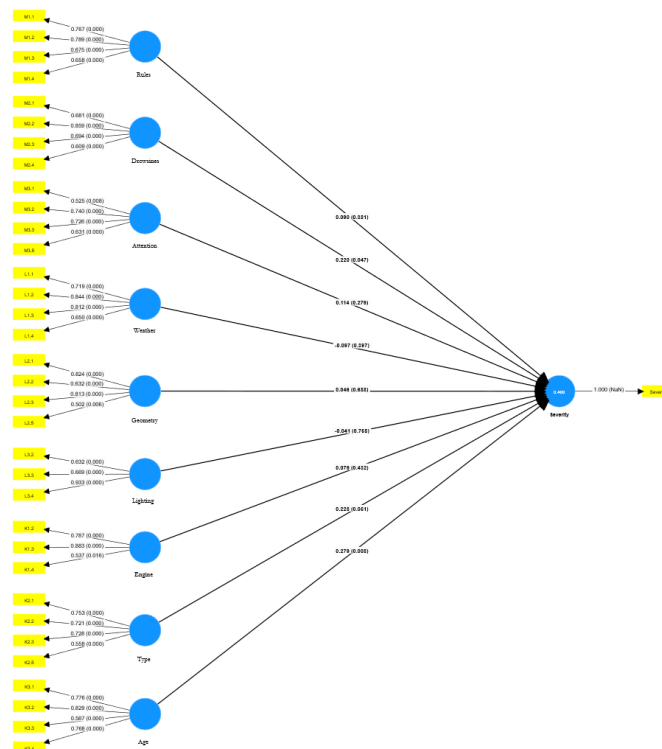


Figure 2. Results of the PLS analysis of the research survey

4.2. Discussion

The research findings indicate differences in the factors identified as predicting the severity of road traffic accidents. In the IRSMS-based analysis of 188 data points, human factors, including attention and drowsiness, exhibited the strongest effect in predicting severity. Meanwhile, the findings of a subsequent survey indicated that vehicle age and drowsiness were the strongest predictors of severity. From these two findings using different approaches, drowsiness emerged as a factor proven to be significant in both the IRSMS data and the survey. Drowsy behaviour is classified as a human factor, which is relevant in increasing severity when an individual is involved in a road traffic accident.

This research is consistent with Moradi et al. (2018), that the risk of accidents increases by an estimated 29% to 34% when drivers are drowsy. Driving whilst drowsy can impair cognitive function, leading to reduced attention, alertness and concentration. Drowsiness also reduces psychomotor skills, resulting in slower reaction times (Moradi et al., 2018). In Australia, accidents caused by drowsiness account for around 20% of all accidents. Measures to prevent accidents caused by drowsiness are still being implemented on a case-by-case basis and have not yet been formalised into policy, as there are no verifiable indicators for drowsiness. However, sleeping for only ≤ 4 -5 hours in the 24 hours prior to driving is considered to double the risk of being involved in an accident (Sprajcer et al., 2023).

In addition to the drowsiness sub-factor, which was found to be significant in both research approaches, the attention factor and the vehicle age factor were also found to influence severity. In line with Sundfør et al. (2019), that attention-related factors were also found to be linked to the severity of accidents. These attention-related factors include distracted driving, failure to check blind spots, delayed detection of other road users, and simply glancing at something without paying close attention to it (Sundfør et al., 2019). Meanwhile, the age of a vehicle can also exacerbate the severity of an accident, due to technological limitations, whether these systems are beginning to fail or are simply absent altogether. As vehicles age, their level of protection decreases (Santolino et al., 2022). A longitudinal study conducted between 2010 and 2022 found that the proportion of high-severity cases decreased in accidents involving relatively new vehicles. In the study, vehicles aged three years or less were found to have made a significant contribution to ensuring passenger safety (Adanu et al., 2025).

This study acknowledges several limitations that mean any generalisation to other populations should be made with caution. Firstly, the researchers used a sample of motorists in an urban area, which influences not only the driving behaviour of the local population but also their lifestyle. Secondly, the researchers did not separate the data analysis by type of involvement in accidents, distinguishing between those responsible for accidents and accident victims.

5. Conclusion

This study examines nine indicators of traffic accident causes, grouped into three main factors (human, environmental and vehicle) based on 188 accident records from the IRSMS for the period 2022-2025. Human factors include rule violations, drowsiness, and lack of attention; environmental factors include adverse weather, poor lighting, and road geometry; whilst vehicle factors consist of engine size, vehicle type, and vehicle age. The results of the SEM-PLS analysis indicate that, of all these indicators, drowsiness and lack of attention significantly increase the severity of accidents. These findings were reinforced through a mixed-methods approach involving questionnaire validation among 101 respondents in the

Jakarta Metropolitan Police Region, which again demonstrated that drowsiness and ageing vehicles have a significant influence. Overall, drowsy driving behaviour is the most consistent and dominant factor; therefore, it is important to ensure adequate sleep duration to reduce the risk of high-severity accidents.

This study confirms that driver drowsiness significantly increases accident severity due to reduced or lost responsiveness, resulting in collisions occurring without braking attempts and generating greater impact energy. These findings are consistent with data from the IRSMS and surveys; however, they still need to be tested in other regions and further explored using additional indicators, such as the duration of the previous night's sleep, to determine drowsiness thresholds more comprehensively. Further research is also recommended to develop comparative analyses based on respondent characteristics to understand differences in the relationships between variables. In practical terms, these results underscore the importance of road safety policy interventions, such as education on the importance of adequate sleep before driving and raising public awareness, particularly within the jurisdiction of the Metro Jaya Police, that driving whilst drowsy poses a serious risk that can exacerbate accidents.

6. References

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