Transportation Research Interdisciplinary Perspectives 28 (2024) 101273

Contents lists available at ScienceDirect

Transportation Research Interdisciplinary Perspectives

journal homepage: www.sciencedirect.com/journal/transportation-research-interdisciplinary-perspectives

Road traffic facilities, traffic accidents, and poverty: Lesson learned from Indonesia

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A R T I C L E I N F O

Keywords:
Traffic facilities
Traffic accidents
Road user
Poverty
Logit models

A B S T R A C T

The development of road traffic facilities is progressing rapidly in both developed and developing countries. However, the number of deaths caused by road traffic accidents is still increasing and the families of the accident victims are trapped in poverty. This study by taking Indonesia as a case aimed: (1) to investigate the perceptions of road users in viewing road traffic facilities on traffic accidents, means of reducing the fatality of traffic accident victims, types of fatality of road traffic accident victims, and type of transportation mode causing traffic accidents and fatalities of accidents victims, (2) to determine factors affecting the frequency of traffic accidents and the fatality of accident victims, and (3) to examine the correlation between traffic accident victims and poverty. The data source was obtained by distributing questionnaires to 600 sample respondents in ten provinces in Indonesia, categorized as having high death rates in road traffic accident areas. These data were then analyzed using qualitative and quantitative methods. The qualitative results show that most respondents viewed road traffic facilities as useful in reducing the frequency of traffic accidents and the fatality of traffic accident victims. The motorcycle was viewed as the type of transportation with great potential for road traffic accidents. However, the type of fatality in traffic accidents tends to be minor injuries. The quantitative results indicated that factors that significantly affect the chances of never having traffic accidents are the presence of traffic control officers, location, age, and the use of private vehicles. The traffic facilities (excluding ambulances and helmets) are insignificant in reducing traffic accidents. The significant factors affecting the fatality rate were the availability of accident prevention facilities, location, the use of private vehicles, and weather conditions. Traffic accidents were found to correlate with poverty incidence as they incur treatment costs, lost productivity, and the loss of a breadwinner in the family. These findings complement and sharpen previous empirical findings and suggest practical contributions to the government and traffic authorities to improve road traffic facilities and reduce traffic accidents, the fatality of traffic accident victims, and poverty.

1. Introduction

Road traffic accidents are one of the primary causes of global health problems and development (WHO, 2023, 2024a; Ahmed et al., 2023). At present, road traffic accidents are the eighth leading cause of death worldwide and may increase to seventh by 2030 (Ahmed et al., 2023). This present condition of the global traffic death rates has not changed compared to the period between 2010 and 2016 (WHO, 2021, 2023). WHO (2023) recorded that in 2021 several countries with high Gross Domestic Product (GDP) such as Singapore and Japan had death rates of road traffic accidents at about 2.1 and 3.6 per 100 000 population respectively. This contrasts with countries with medium GDPs, which have higher death rates from road traffic accidents than those 'rich' countries. These medium GDP countries include Thailand (32.2), India (15.6), and Indonesia (11.3).

In terms of the number, WHO (2023) reported that in 2021 the

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https://doi.org/10.1016/j.trip.2024.101273
Received 13 July 2024; Received in revised form 25 October 2024; Accepted 1 November 2024

number of deaths caused by road traffic accidents was more than 1.1 million people. Of those deaths, 92 percent occurred in low- and middle-income countries (LMICs). These figures indicated that the Sustainable Development Goals (SDGs) target of 3.6 death rate per 100,000 population has not been met (Cabrera-Arnau et al., 2020). As a result, the governments and transportation planning stakeholders in the countries of the world are seeking alternative methods for improving traffic operations and safety to solve these problems (Almatar, 2024a; Gorea, 2016; Jadaan et al., 2018; WHO and UN Regional Commissions, 2021; WHO, 2024b).

Of many suggestions advanced in the literature, Almatar (2023a) in particular suggests the need to introduce a new public transport system. This public transport system is argued to have significant effects on environmental, social, and economic benefits, such as greenhouse gas (GHG) emissions, reduced traffic accidents, economic opportunities, flexibility, reduced driving time, and more job opportunities. However, barriers associated with public transport utilization include social norms and culture, higher reliance on private vehicles, and low fuel prices.

In addition to public transport systems, Almatar (2023b) suggests a green mobility approach for promoting environmentally friendly and sustainable transportation. Also, he addressed shifting from conventional styles of transport to modernized and smart models and establishing electric vehicle infrastructure (2024a, 2024b). Smart transportation is beneficial as it provides employment opportunities, encourages investments, and improves people's living standards. However, the effective implementation of smart transportation systems cannot be realized if there are lack of resources, no regulatory framework, and no skilled personnel. Other than those, electric vehicle infrastructures improve the use of renewable energy in the transportation industry. Transit-oriented development (TOD) can also be introduced not only to create a sustainable and quality living environment but also to increase automobile mobility, provide more employment opportunities, and reduce travel time (Almatar, 2022).

Apart from the above suggestions, other studies highlight the importance of the improvement of road traffic infrastructures (Kurakina et al., 2020; Ding et al., 2019; Haghani et al., 2022; Yoon et al., 2017; Choi et al., 2016; Runwei and Yachen, 2015; Despriadi et al., 2023; Rais et al., 2023; Zanuardi and Suprayitno, 2018; Effendi and Firdaus, 2016; Supriyanto, 2016). However, Cui (2020) and Zhang and Qiu (2015), for instance, highlighted that the improvement of road traffic facilities is a complex issue. This is partly because many factors need to be considered including the design and installation of traffic facilities (Fengyuan et al., 2008), the management of traffic congestion (Souza et al., 2017; Cao et al., 2017; Huang et al., 2016), the presence of safety features at intersections and black spots (Farida et al., 2021; Yoon et al., 2017), and the behavior of road users (Shinar, 2017; Kochetova, 2022).

Those factors must be properly designed and installed so they can improve driver behavior (Shinar, 2017; Wang et al., 2011; Wilde, 1976), driving safety, improve traffic flow, and reduce travel times (Shams and Zlatkovic, 2020; Kang et al., 2016). If these traffic facilities are ineffective or improperly installed, there is no doubt they can contribute to lead driver misbehavior and increase road traffic accidents (Zhang and Qiu, 2015; Robielos and Lin, 2022; Engwicht, 2012; Reason, 2000; Fengyuan et al., 2008; Chung, 2015; Mannering, 2009; Purnomo et al., 2020; Otu and Ani, 2018; Kinnear et al., 2013; Lewis-Evans et al., 2010; Fuller et al., 2008; Widorini, 2013; Ahdiat, 2023; Tjahjono, 2010).

Like the improvement of road traffic facilities, road infrastructure improvements for road safety and saving lives have also been advanced in the literature. Arguments that support road infrastructure enhance road safety and save lives include Jima and Sipos (2022), Konovalova et al. (2022), Cociu (2020), Kurakina et al. (2020), Shehu et al. (2014), Polus et al. (2005), Batrakova and Gredasova (2016), and Flahaut (2004). Meanwhile, Halona et al. (2023), Noland (2003), and Noland and Oh (2004) argued from their empirical research that it is not always true that increasing lanes and lane widths are associated with increased traffic-related accidents and fatalities. This suggests that the availability and completeness of road infrastructure only guarantee safety if other factors, including road user behavior, are considered.

Since Indonesia is among the ASEAN countries that has a high death rate in road traffic accidents (Ministry of Communication and Information, 2017; Kusnandar, 2022) and this caused economic losses of about 3.1 percent of GDP, higher than 3 percent of GDP (Ahmed et al., 2023), it is urgent to examine whether or not improvement in road traffic facilities enhances road safety and saves lives in Indonesia. The urgency of this study becomes more important as this country plans to have massive improvement of traffic facilities to support road infrastructure development (Kevandra, 2023; Nawir et al. 2023; Haghani et al., 2022).

Therefore, this study has three objectives. First, to investigate the perceptions of road users in viewing traffic facilities on traffic accidents, means of reducing the fatality of traffic accident victims, types of fatality of road traffic accident victims, and type of transportation mode causing traffic accidents and types of fatalities of accident victims. Second, to determine factors affecting the frequency of traffic accidents and the fatality of accident victims. Third, to examine the correlation between traffic accident victims and poverty.

This research offers a comparative investigation of road users' perceptions of road traffic facility development and factors in reducing traffic accidents, the fatality rates of traffic accident victims, and the incidence of poverty that have been advanced in the literature. It also contributes evidence to help the government and other traffic authorities gain credible insight in formulating policies and strategies to address issues related to road traffic safety systems not only for Indonesia but also for other countries.

2. Source of data and methods

Concerning the source of data and methods to examine the above three research objectives, we did the following steps. First, we collected secondary data that was published by the World Health Organization (WHO), the Indonesian Central Board of Statistics, the Ministry of Transportation, the Ministry of State-Owned Enterprises, the National Police of the Republic of Indonesia (POLRI), the National Transportation Safety Committee (KNKT), and the life insurance company PT Jasa Raharja. Types of secondary data collected from these institutions included data on traffic accidents, road conditions, the number of vehicles, traffic facilities, and transportation infrastructures. These data were gathered partly as the background analysis of this study.

Second, we organized group discussions together with the analyst staff of the life insurance company PT Jasa Raharja, and the official staff of the Ministry of Transportation to discuss this issue and to determine questions that must be accommodated in two types of questionnaires. The first type of questionnaire related to traffic facilities on traffic accidents, means of reducing the fatality of traffic accident victims, types of fatality of road traffic accident victims, type of transportation mode causing traffic accidents, and types of fatalities of accident victims. The second type of questionnaire was associated with factors affecting the frequency of traffic accidents, the fatality of accident victims, and the correlation between traffic accident victims and poverty. After these two types of questionnaires were completed, we then carried out a pilot survey with 15 road users in Jakarta the Capital City of Indonesia. The purpose of the pilot survey was to seek the views or perceptions of road users on whether or not the questions asked in the two types of questionnaires were important or not. Also, we like to know whether or not the questions addressed in the two types of questionnaires were easy to understand and clear. The inputs and suggestions obtained from the pilot survey were then accommodated and used as the main survey questionnaire.

After the above two steps, the third step was to determine the survey locations and the number of sample respondents. Out of 38 provinces in Indonesia, we determined 10 provinces as the survey locations. These ten provinces were the provinces of East Java, Central Java, West Java, Yogyakarta, Banten, DKI Jakarta, South Sulawesi, Aceh, North Sumatra, and West Sumatra. The main consideration in determining these ten provinces was because these provinces were categorized by the Central Board of Statistics (BPS), The National Police Institution (POLRI), and PT Jasa Raharja Life Insurance Company as high road traffic accident areas in Indonesia.

In terms of the number of sample respondents, we selected 600 road users from ten provinces as the sample respondents. Of these 600 respondents, 300 respondents were road users and the rest of the 300 respondents were those who have experienced victims of traffic accidents. The first 300 road user respondents were asked to fill out the first questionnaire related to their perceptions of the importance of road traffic facilities on traffic accidents, the means of reducing the fatality of traffic accident victims, and the types of fatality of traffic accidents. Also, it highlighted views of road users' perceptions of the kind of transportation that causes traffic accidents and fatalities of accident victims. Meanwhile, the rest of the 300 respondents who have experienced the victim of fatality traffic accidents were asked to fill in the second type of questionnaire associated with factors that affect the frequency of traffic accidents, factors that affect the fatality of traffic accident victims, and the correlation between the number of traffic accidents and poverty.

The method to obtain sample respondents was by employing the non-probability sampling method. The techniques used under this sampling method were convenience sampling and purposive sampling techniques (Campbell et al., 2020; Andrade, 2021) in that the first 300 respondents sampled have to be road users, have life insurance, and know the importance of traffic facilities. The remaining 300 respondents have to be road users, have life insurance, know the importance of traffic facilities, and have experienced a traffic accident individually and/or in the family. Note that, in selecting the 600 sample respondents, we were assisted by the local official branch of PT Jasa Raharja Life Insurance Company and the local government officials of the Transport Department in each survey location.

After determining the survey locations and the number of samples, the fourth step was to distribute the questionnaire to 600 sample respondents. Apart from questions related to the characteristics of respondents, the first 300 road user respondents were asked to give their views or opinions concerning road traffic facilities on traffic accidents, means of reducing fatality of traffic accident victims, types of fatality of traffic accidents, the type of transportation that causes traffic accidents and fatality of accident victims. The number of road facilities questioned was thirteen units (i.e., ambulances, traffic cones, road barricades, land signs, train signs, raincoats, helmets, cone tents, shock tape, emergency unit (ER) information boards, flashlight, scotlight vest, and police tents).

For the rest of the 300 respondents who have experienced victims of traffic accidents individually and/or in the family, we asked questions to examine factors that affect the frequency of traffic accidents, factors that affect the fatality of traffic accident victims, and the correlation between the number of traffic accidents and poverty. To distribute and collect the questionnaires, university students in each survey location were involved. Before the questionnaire was given to them, however, training on materials questioned in the two types of questionnaires was organized for them. This was aimed to minimize any problems associated with questions asked, and language barriers to understanding materials questioned in the two main questionnaires.

The fifth step was to analyze the data obtained from the questionnaires given by the 600 respondents. To examine views or opinions given by the 300 road user respondents concerning thirteen road traffic facilities (ambulances, traffic cones, road barricades, land signs, train signs, raincoats, helmets, cone tents, shock tape, emergency unit (ER) information board, flashlight, scotlight vests, and police tent) on traffic accidents, means of reducing fatality of traffic accident victims, types of fatality of traffic accidents, and the type of transportation that causes traffic accidents and fatality of accident victims, we tabulated their views by calculating the percentages of respondent perceptions for each question. However, these thirteen units of road facilities were grouped into three categories. The first group is categorized as road traffic facilities for accident prevention (i.e., traffic cones, road barricades, land signs, train signs, and shock tape). The second group is categorized as road traffic facilities for fatality reduction (i.e., ambulance and helmets). The third group is categorized as road facilities to support the work of traffic officers in regulating traffic (i.e., raincoats, emergency unit (ER) information boards, flashlights, scotlight vests, cone tents, and police tents).

To analyze the questionnaire given by the 300 respondents who have experienced victims of traffic accidents related to the factors that affect the frequency of traffic accidents, we applied the multinomial logistic regression (Çelik and Oktay, 2014), while the logistic regression model was employed to estimate factors influencing the fatality rate of traffic accident victims (Al-Ghamdi, 2002). We determined and constructed models for the two by considering traffic accidents as multifactorial. All these factors are intertwined and formed the Fishbone Traffic Accident Factors concept (Azimian et al., 2021; Dahlan et al., 2021; Abdel-Aty & Radwan, 2000; Rolison et al., 2018; Sutanto Soehodho, 2017; Islam & Kanitpong, 2008). However, before running these regression analyses, we first carried out reliability and validity tests. These tests were needed to ensure that the questionnaire was consistent and able to produce quality data/information (Heale and Twycross, 2015; Surucu and Maslakci, 2020).

The multinomial logistic regression model to examine factors that affect the frequency of traffic accidents can be mathematically written as follows:

$$frekm = \alpha_0 + \alpha_1 ketsar + \alpha_2 ketfat + \alpha_3 ketofi + \alpha_4 loc + \alpha_5 sexx + \alpha_6 agex + \alpha_7 daycarxx + \varepsilon_1 \quad (1)$$

where:

frekm: dummy frequency of traffic accidents (1 = never, 2 = rare, 3 = medium, 4 = frequent)
ketsar: dummy installation of traffic accident prevention facilities (0 = not installed and 1 = installed)
ketfat: dummy installation of traffic accident fatality reduction facilities (0 = not installed and 1 = installed)
ketofi: dummy installation of supporting facilities for the officer's work in managing traffic (0 = not installed and 1 = installed)
loc: dummy location of road users (0 = outside Java Island and 1 = Java Island)
sexx: dummy gender of road users (1 = male and 2 = female)
agex: age of road user (years)
daycarxx: dummy type of vehicle used daily (1 = private vehicle and 2 = public transportation)
α_0: constant
α_1-α_7: regression coefficient
ε_1: error term

The logistic regression to estimate factors that affect the fatality of traffic accident victims can be written mathematically as follows.

$$fatalxx = \alpha_0 + \alpha_1 ketsar + \alpha_2 ketfat + \alpha_3 ketofi + \alpha_4 loc + \alpha_5 daycarxx + \alpha_6 conweat + \varepsilon_2 \quad (2)$$

where:

Fatalxx: dummy fatality rate of traffic accident victims (0 = non-fatal, 1 = fatal)
ketsar: dummy installation of traffic accident prevention facilities (0 = not installed and 1 = installed)
ketfat: dummy installation of traffic accident fatality reduction facilities (0 = not installed and 1 = installed)
ketofi: dummy installation of supporting facilities for the officer's work in managing traffic (0 = not installed and 1 = installed)
loc: dummy location of road users (0 = outside Java Island and 1 = Java Island)
daycarxx: dummy type of vehicle used daily (1 = private vehicle and 2 = public transportation)
conweat: dummy weather conditions while driving (0 = not rainy season and 1 = rainy season)
α_0: constant
α_1-α_6: regression coefficient
ε_2: error term

Note that, we defined groups of safety facilities or traffic facilities in the two regression models as:

(1) accident prevention and traffic flow measures, such as traffic cones, road barricades, land signs, railway signs, and shock tape,
(2) fatality-reducing measures for traffic casualty, such as ambulance and helmets, and
(3) supporting officers' work includes raincoats, flashlights, scotlight vests, ER information boards, cone tents, and police tents.
(4) The method used to analyze multinomial logistics follows the explanation of Hosmer and Lemeshow (2000). In regression models for response variables that have more than two categories, attention must be given to the measurement scale. The model has the following logistic regression probability function:

$$\pi_1(x) = P(y = 1|\ ) = \frac{\exp g_1(x)}{1 + \exp g_1(x) + \exp g_2(x)} \quad (3)$$

$$\pi_2(x) = P(y = 2|x) = \frac{\exp g_2(x)}{1 + \exp g_1(x) + \exp g_2(x)} \quad (4)$$

$$\pi_3(x) = P(y = 3|x) = \frac{1}{1 + \exp g_1(x) + \exp g_2(x)} \quad (5)$$

Next, cumulative logit models are obtained by comparing their cumulative odds. The probability is less than or equal to the response category to *j* on the p predictor variable expressed in vector form *xi* $P(Y \le j|xi)$, with a greater chance of the response category to j, $P(Y > j|xi)$ (Hosmer and Lemeshow, 2000). In general, the form of multinomial logistics functions becomes as below:

$$g_j(x) = \log\left(\frac{p(Y \le j|x_i)}{p(Y > j|x_i)}\right) = \beta_{j0} + \beta_{j1}X_1 + \beta_{j2}X_2 + \cdots + \beta_{jp}X_p \quad (6)$$

Concurrent testing is used to determine the effect of predictor variables on response variables together. This study used a likelihood test. Partial testing is carried out to determine the effect of predictor variables on response variables partially. This test uses the Wald test. While testing for the goodness of fit of the model by using the following test.

$$\widehat{C} = \sum_{i=1}^{k} \frac{(O_i - n_i\widehat{\pi}_i)^2}{n_i\widehat{\pi}_i(1 - \widehat{\pi}_i)} \quad (7)$$

If $\widehat{C} > X^2_{\alpha,v}$ then rejects H_0 so that the model does not match or there is a difference between the results of observations and the possible results of model predictions. The entire data processing process, including model testing, was carried out with the help of Stata 13 software.

Finally, to measure the correlation between the number of traffic accidents and the poverty of accident victims, Spearman correlation analysis was applied to determine the level of correlation between traffic accident fatalities and total costs needed and income reduction for 1 month after a traffic accident.

$$r_{xy} = \frac{\sum X^2 + \sum Y^2 - \sum d_i^2}{2\sqrt{\sum x^2 \sum Y^2}} \quad (8)$$

3. Results and discussion

3.1. Characteristics of respondents

As mentioned, the study involved 600 respondents collected from ten provinces categorized as high road traffic accidents in Indonesia. Of these 600 respondents, 300 were road users, and the remaining 300 were road users who have been experienced as victims of traffic accidents. While it is true that these 600 sample respondents from ten provinces cannot reflect the entire nation that has 38 provinces with varying road conditions and traffic habits, the determination of these locations was justified by the Central Board of Statistics (BPS), The National Police Institution (POLRI), and PT Jasa Raharja Life Insurance Company as high road traffic accident areas in Indonesia. This suggests that the determination of ten provinces of high road traffic accidents was relevant and justified to investigate the above three objectives of the study. At the same time, the consideration for limiting the number of 600 respondents as we assumed the population of both road users and those who have experienced traffic accident victims were homogenous populations (Asra et al., 2023).

By tabulating method, the characteristics of these 600 respondents under the survey were as follows. By gender category, about 51 percent were male respondents, while the remaining 49 percent were female. By

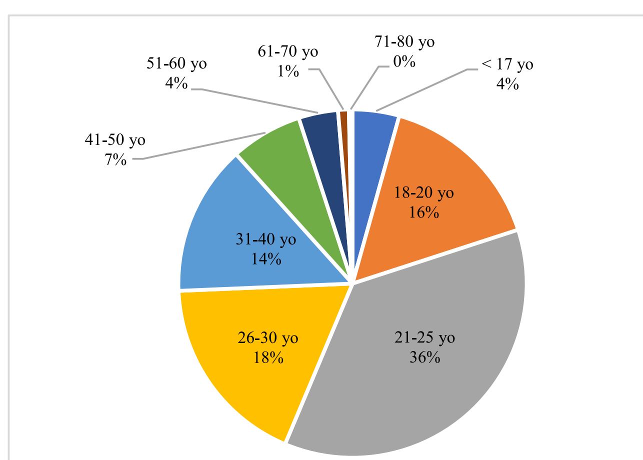

Fig. 1. Proportion of the respondents by age groups. .
Source: calculated from questionnaire data

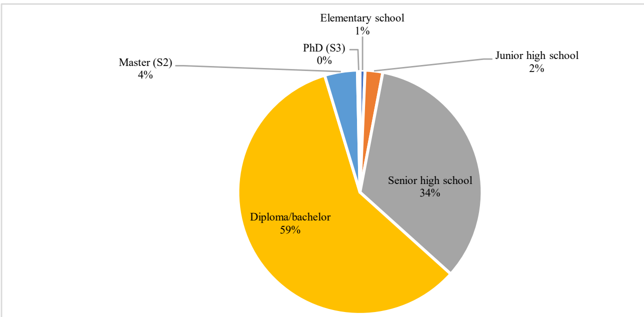

Fig. 2. Respondent proportion based on age and education level. .
Source: calculated from questionnaire data

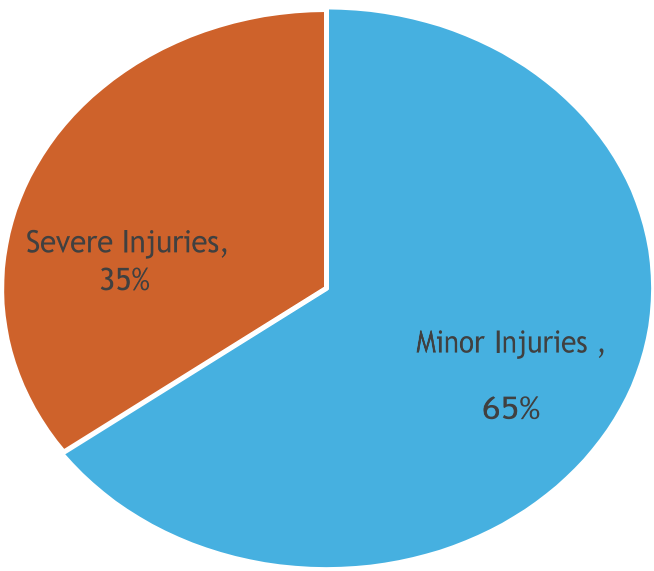

Fig. 3. The percentage of respondents under the survey who have traffic accident fatality. .
Source: calculated from questionnaire data

age characteristics, the largest proportion of respondents was in the age group between 21 and 25 years old (36 %), followed by the age group of 26 to 30 years of age (18 %) and the age groups of 18 to 20 (16 %). The age group less than 17 years old was only 4 percent (Fig. 1).

By educational level, the respondents were dominated by those who have a diploma/bachelor educational background (59 %) and those with a senior high school educational background (34 %) as shown in Fig. 2. Judging from the age and educational level characteristics, the respondents under the survey were qualified to give their perceptions to questions raised in the questionnaire given to them.

Concerning traffic accident fatality experienced by respondents, about 65 percent of the total 300 respondents have experienced minor injuries in traffic accidents in the last six months (Fig. 3). This means that these respondents have experienced injuries that do not require hospital treatment. While the rest of the respondents who have experienced severe injuries about 35 percent (i.e., conditions of no hope of recovery, loss of one of the five senses, suffering from a severe disability or paralysis, impaired thinking power for more than four weeks, uterine miscarriage, and injuries requiring hospital treatment for 30 days).

Table 1
The perception of respondents in viewing the installation of traffic facilities in traffic accidents, a means of reducing fatality of traffic accident victims, and types of fatality of traffic accident victims (%).

Descriptions	Traffic facilities (n = 300)	
	Not installed	Installed
Traffic accidents prevention	14.7	85.3
Means of reducing fatality of traffic accident victims	14.3	85.7
Types of fatality of traffic accident victims:		
Minor injuries	10.7	54.3
Severe injuries	3.0	23.3
Death	1.0	7.7

Source: calculated from questionnaire data.

3.2. *The perception of respondents in viewing traffic facilities on traffic accidents, means of reducing fatality of traffic accident victims, and types of fatality of traffic accident victims*

By tabulating data from the first questionnaire, the perceptions of respondents under the survey in viewing road traffic facilities on traffic accidents, means of reducing fatality of traffic accident victims, and types of fatality of traffic accident victims are shown in Table 1. As can be seen in Table 1, about 85.3 percent of the total 300 respondents viewed road traffic facilities as useful for preventing traffic accidents. They also viewed that road traffic facilities can be a means of reducing the fatality of traffic accident victims. However, road traffic facilities were viewed potential to result mostly in minor injuries rather than severe injuries and deaths. These findings suggest that road traffic facilities no doubt play an important role in traffic accident prevention, a means of reducing fatality rates, and fatality of traffic accident victims. These findings support previous studies highlighted, for instance, by WHO (2004); Ahmed et al. (2023).

3.3. *Perceptions of respondents in viewing type of transportation that causes traffic accidents and types of fatalities of accident victim*

Types of transportation that were viewed by the respondents that caused traffic accident was dominated by motorcycles, while bicycle was viewed as the type of transportation that did not cause traffic accidents (Table 2). The fatalities of traffic accident victims of motorcyclists were viewed as causing minor injuries (61.0 %), followed by severe injuries (23.3 %). These findings are not so surprising as the number of motorcycles in Indonesia was dominant in comparison with other types of transportation. Also, it is because motorcyclists tend to disobey the traffic regulations. In most cases, accidents were caused by drivers' mistakes, road characteristics, and vehicle characteristics, or caused by a combination of two or more of these factors. On the other hand, pedestrian and passenger causes were considered minor factors because many do not abide by driving rules and road regulations, and do not follow the instructions necessary for their own safety. These causes of traffic accidents have also been the case in Iraq. As found by Latief et al. (2023) drivers' mistakes, vehicle features, driver impairment, and road features have been the major causes of road traffic accidents. These findings were also confirmed by Singh et al. (2016).

3.4. *Descriptive statistics*

As mentioned previously there are eight variables used in the multinomial logit model of traffic accident frequency (Eq. (1)), namely the frequency of traffic accidents (*frekm*), road traffic facilities for accident prevention (*ketsar*), road traffic facilities for fatality reduction (*ketfat*), road traffic facility to support the work of officers in regulating traffic (*ketofi*), location of road users (*loc*), gender of road users (*sexx*), age of road users (*agex*), and type of vehicle used in daily life (*daycarxx*). The results of the descriptive summary of statistical variables used in the multinomial logit model of traffic accident frequency are shown in Table 3.

As can be seen in Table 3, the variable frequency of traffic accidents (*frekm*) is an ordinal-scale dependent variable, where data numbered 1 shows no traffic accidents, number 2 indicates "rarely" traffic accidents occur (1–2 times), and number 3 indicates "moderate" traffic accidents

Table 2
Perceptions of respondents in viewing type of transportation causing traffic accidents and fatalities of accident victims.

Descriptions	Type of transportation (n = 300)						
	Motorcycle	Car	Bicycle	Train	Public transport	Pick up and Truck	Total (%)
Traffic accidents	91.6	3.0	0	1.3	1.7	2.3	100.0
Fatality of traffic accident victims:							
- Minor injuries	61.0	1.0	0	0.7	1.0	1.3	65.0
- Severe injuries	23.3	1.3	0	0	0.7	1.0	26.3
- Dead	7.3	0.7	0	0.7	0	0	8.7

Source: Calculated from questionnaire data.

Table 3
Descriptive summary of statistical variables used in the multinomial logit model of traffic accident frequency.

Variable	Description	Obs. (n)	Mean	Std. dev.	Min.	Max.
frekm	Frequency of traffic accidents	300	2.623	0.831	1	4
ketsar	Road traffic facilities for accident prevention (i.e., traffic cones, road barricades, land signs, train signs, and shock tape).	300	0.853	0.354	0	1
ketfat	Road traffic facilities for fatality reduction (i.e., ambulance and helmets).	300	0.857	0.351	0	1
ketofi	Road facilities to support the work of officers in regulating traffic (i.e., raincoats, emergency unit information boards, flashlights, scotlight vest, cone tents, and police tents).	300	0.690	0.463	0	1
loc	Location of road users, either in Java Island or outside Java Island	300	0.600	0.491	0	1
sexx	Gender of road user	300	0.510	0.501	0	1
agex	Age of road users	300	0.893	0.309	0	1
daycarxx	Types of vehicles used daily	300	0.927	0.261	0	1

Source: calculated from questionnaire data.

Table 4
Descriptive summary of statistical variables used in the logit model of the fatality of traffic accident.

Variable	Description	Obs.	Mean	Std. dev.	Min.	Max.
fatalxx	The fatality of traffic accident	300	0.650	0.478	0	1
ketsar	Road traffic facilities for accident Prevention (i.e., traffic cones, road barricades, land signs, train signs, and shock tape).	300	0.853	0.354	0	1
ketfat	Road traffic facilities for fatality reduction (i.e., ambulance and helmets)	300	0.857	0.351	0	1
ketofi	Road traffic facilities to support the work of officers in regulating traffic (i.e., raincoats, emergency unit information boards, flashlights, scotlight vest, cone tents, and police tents).	300	0.690	0.463	0	1
loc	Location of road users, either in Java Island or outside Java Island	300	0.600	0.491	0	1
daycarxx	Types of vehicles used daily	300	0.927	0.261	0	1
conweat	Weather conditions while driving	300	0.943	0.232	0	1

Source: calculated from questionnaire data.

occur (3 times). Number 4 indicates "frequent" traffic accidents (>3 times) during the last 6-month period. The variation in data from the frequency of traffic accidents (*frekm*) was found low because the standard deviation value (Std. dev.) is below the average (mean).

Data from independent variables include data on the road traffic facility of traffic accident prevention (*ketsar*), road facilities to reduce the fatality of traffic accident victims (*ketfat*), road traffic facilities to support the work of officers in regulating traffic (*ketofi*), location of road users (*loc*), gender of road users (*sexx*), age of road users (*agex*), and the type of vehicle used in daily life (*daycarxx*). Data related to road traffic facilities (*ketsar*, *ketfat*, *ketofi*) is numbered 0 if not installed and 1 if the facility is installed. Road user location data (*loc*) is on a nominal scale, where zero indicates the location of respondents outside Java and number 1 is in Java.

Meanwhile, road user sex data (*sexx*) is a nominal scale where the number 0 indicates female respondents and number 1 represents male respondents. Road user age data (*agex*) is included in the simplified internal data category to number 0 for respondents under 17 years old and number 1 for people over 17 years old. Finally, the type of vehicle used in daily life (*daycarxx*) is provided by nominal scale data, indicating that if the number 0 is a private vehicle (2 and 4 wheels) and the number 1 indicates public transportation. All independent variable data was found to have a standard deviation that is smaller than the average value so that the variation of the data is low.

Further, there are seven variables in the logit model of traffic accident fatality rates (Eq. (2)). These variables are the fatality rate of traffic accident victims (*fatalxx*), road traffic facilities for accident prevention (*ketsar*), road traffic facilities for fatality reduction (*ketfat*), road traffic facilities for supporting the work of officers in regulating traffic (*ketofi*), the location of road users (*loc*), the type of vehicle used in daily life (*daycarxx)*, and weather conditions while driving (*conweat*). The results of the descriptive summary of statistical variables used in the traffic accident fatality rate logit model are shown in Table 4.

As shown in Table 4, the variable fatality of traffic accident victims (*fatalxx*) is an ordinal-scale dependent variable, where data numbered 0 shows a low fatality rate of traffic accident victims (minor injuries) and number 1 indicates a high fatality rate of traffic accident victims (severe injuries and deaths). The variation in traffic fatality data is low because the standard deviation is below the average.

Data from independent variables used in the logit model include data on road traffic facilities for accident prevention (*ketsar*), road traffic facilities for accident victim fatality reduction (*ketfat*), road traffic facilities for supporting officer work in regulating traffic (*ketofi*), location

Table 5
Results of the validity test.

Description		*frekm*	*ketsar*	*ketfat*	*ketofi*	Total
frekm	Pearson Correlation	1.000	0.274	0.538*	0.487	0.873**
	Sig. (2-tailed)		0.322	0.039	0.066	0.000
	N	15	15	15	15	15
ketsar	Pearson Correlation	0.274	1.000	0.075	0.564*	0.615*
	Sig. (2-tailed)	0.322		0.789	0.029	0.015
	N	15	15	15	15	15
ketfat	Pearson Correlation	0.538*	0.075	1.000	0.134	0.588*
	Sig. (2-tailed)	0.039	0.789		0.635	0.021
	N	15	15	15	15	15
ketofi	Pearson Correlation	0.487	0.564*	0.134	1.000	0.753**
	Sig. (2-tailed)	0.066	0.029	0.635		0.001
	N	15	15	15	15	15
Total	Pearson Correlation	0.873**	0.615*	0.588*	0.753**	1.000
	Sig. (2-tailed)	0.000	0.015	0.021	0.001	
	N	15	15	15	15	15

Note: *: Correlation is significant at the 0.05 level (2-tailed),
**: Correlation is significant at the 0.01 level (2-tailed).
frekm is the frequency of traffic accidents,
ketsar is the availability of road traffic facilities for accident prevention,
ketfat is the availability of road traffic facilities for accident reduction,
ketofi is the availability of road traffic facilities to support officers in regulating traffic.
Source: calculated from the questionnaire.

Table 6
Results of the reliability test.

Cronbach's alpha = 0.669			Number of items 4	
Variable	Scale means if the item deleted	Scale variance if item deleted	Corrected item-total correlation	Cronbach's alpha if the item deleted
Frekm	2.0000	1.000	0.600	0.529
ketsar	4.1333	1.981	0.392	0.642
ketfat	4.0667	2.067	0.384	0.650
ketofi	4.4000	1.686	0.554	0.542

Note: *frekm* is the frequency of traffic accidents,
ketsar is the availability of road traffic facilities in accident prevention,
ketfat is the availability of road traffic facilities for traffic accident reduction,
ketofi is the road traffic facility to support facilities for officers to regulate traffic.
Source: calculated from questionnaire data.

of road users (*loc*), types of vehicles used in daily life (*daycarxx*), and weather conditions while driving (*conweat*). Data on road traffic facilities (*ketsar*, *ketfat*, *ketofi*) is numbered 0 if not installed and 1 if these facilities are installed. Road user location data (*loc*) is on a nominal scale, where zero indicates the location of respondents outside Java and number 1 is in Java. The type of vehicle used in daily life (*daycarxx*) is nominal scale data with the provision that if the number 0 indicates the vehicle used is a private vehicle (2 and 4 wheels) and the number 1 indicates public transportation. Finally, weather condition data when driving is a dummy variability, where the number 0 indicates that the rainy season does not affect traffic accidents, and the number 1 indicates if the rainy season affects traffic accidents. All independent variable data was found to have a standard deviation that is smaller than the average value, so the variation of the data is low.

3.5. Tests of validity and reliability

The results of the validity and reliability test are shown in Tables 5 and 6. As can be seen in Table 5, the validity test results show that the level of significance items for variable *frekm* (0.00), variable *ketsar* (0.015), variable *ketfat* (0.021), and variable *ketofi* (0.01) < α (0.05). These suggest that the measuring instruments used in this study are valid.

The results of reliability test calculations using the method Cronbach's Alpha (α) can be seen in Table 6. It is shown in Table 6, Cronbach's Alpha calculated (r-count) was 0.669 with four items. Based on this, the result of Cronbach's Alpha for four questions was 0.688. Meanwhile, the r table for Cronbach's Alpha at 5 percent is 0.113. Therefore, it can be concluded that r Cronbach's Alpha (α) calculated is greater than r Cronbach's Alpha table at 5 percent, which is 0.669 > 0.113, so the data is reliable and consistent (Table 6).

3.6. Factors affecting the frequency of traffic accidents

The results of the multinomial logistic regression analysis are exhibited in Table 7. As can be seen in this Table, the *probability* value of the model (Chi-square) is 0.002, less than the significant level of 5 percent. This indicates that all variables used in the model are considered feasible and simultaneously affect the frequency of traffic accidents. However, the results of the multinomial logistic regression shown in Table 7 need to be divided into three traffic accident frequency categories: never, rare (infrequently), and often (frequent).

Concerning the chances of never having a traffic accident, the results of the analysis showed that the road traffic facilities to support the work of traffic control officers (*ketofi*), location (*loc*), age (*agex*), and type of vehicle used daily (*daycarxx*) have a significant effect on the chances of never having a traffic accident (*frekm)*. The variable road traffic facilities for supporting the work of the officer (*ketofi*) have a negative influence with an odds ratio value of 0.330. This can be interpreted that the road of traffic facilities for supporting the work of the officer-*ketofi* (in the form of raincoats, flashlights, scotlight vests, ER information boards, cone tents, and police tents) reduces the probability of traffic accidents by 0.33 times or 33 percent compared to the uninstalled or unavailability of these facilities. These suggest that the existence of supporting facilities for these traffic officers (traffic police) can improve their performance in the field and change the behavior of road users to be more orderly when driving. Ultimately, this behavior change will impact the absence of traffic accidents at that location (Pembuain et al., 2018). However, Beenstock et al. (2001) found that only large-scale enforcement of traffic officers has any measurable effect on road accidents while small-scale enforcement has no apparent effect and the enforcement effect is slightly larger in the long run than it is in the short run. Also, the effect of enforcement tends to dissipate rapidly after the dosage of enforcement is reduced but enforcement has no effect on fatal road accidents.

Location (*loc*) has also been shown to have a negative and significant effect on the chances of not having a traffic accident (*frekm*), with a value of odds ratio of 0.153. This indicates that locations in Java Island have a lower probability of no traffic accidents in the last six months by 0.153 times or 15.3 percent than locations outside Java. This is not surprising as the volume of vehicles on Java Island is much greater than that outside Java Island. That is why the possibility of traffic accidents on Java island is greater than on outside Java islands. The Indonesian Central Board of Statistics (2022) recorded that the proportion of motor vehicle ownership in 2022 amounted to 59.88 percent concentrated in Java Island. These findings supported previous studies conducted by Sutanto Soehodho (2017) who found that high-traffic accidents correlated with traffic flow on Java Island. Other studies that supported this correlation include Ma et al. (2020) for the case in China and Retallack and Ostendorf (2020) for the case in Australia.

Further, Age (*agex*) motorists also significantly affected the non-occurrence of traffic accidents. The estimated odd ratio showed that increasing the age of road users by one year will reduce the probability of having a traffic accident by 0.243 times or 24.3 percent. This indicates as driver age increases traffic accidents tend to decrease. This is because

Table 7
Results of estimated multinomial logit model of traffic accident frequency.

Frequency of traffic accidents (Dependent variable: *frekm*)	Independent Variable	Coefficient	z	P > Z	Odds ratio
Never	*ketsar*	−0.917	−1.220	0.222	0.400
	ketfat	−0.740	−0.880	0.380	0.477
	ketofi	−1.109	−1.480	0.138*	0.330
	loc	−1.876	−2.440	0.015***	0.153
	sexx	−0.478	−0.710	0.477	0.620
	agex	−1.414	−1.480	0.138*	0.243
	daycarxx	−2.737	−2.060	0.040***	0.065
	_cons	4.737	2.520	0.012***	114.044
Rare (infrequently)	*ketsar*	0.206	0.480	0.635	1.229
	ketfat	−0.595	−1.270	0.206	0.551
	ketofi	0.043	0.130	0.896	1.044
	loc	0.049	0.160	0.870	1.050
	sexx	−0.389	−1.360	0.172*	0.678
	agex	−0.081	−0.190	0.853	0.922
	daycarxx	−2.255	−2.150	0.031***	0.105
	_cons	3.221	2.590	0.010***	25.054
Often (frequently)	*ketsar*	0.086	0.160	0.872	1.090
	ketfat	−0.807	−1.470	0.141*	0.446
	ketofi	0.131	0.310	0.756	1.140
	loc	−0.839	−2.320	0.020	0.432
	sexx	0.103	0.290	0.775	1.109
	agex	0.623	0.890	0.371	1.864
	daycarxx	−1.488	−1.260	0.208	0.226
	_cons	1.366	0.910	0.361	3.921
Number of observations: 300 LR $Chi^2(21) = 45{,}230$; Prob. $> Chi^2 = 0.002$*** $R^2 = 0.065$					

Source: calculated from questionnaire data.
Note: Significance level α = 1 percent, ***Significance level α = 5 percent, **Significance level α = 10 percent, and *Significance level α = 20 percent. The basis of the outcome is the moderate frequency of traffic accidents.

the increase in driver age improves the proficiency of drivers to avoid events that could potentially cause traffic accidents. Also, increasing age affects the maturity attitude of drivers. This change in behaviour with increasing age is expected to minimize the incidence of traffic accidents (Mc Carthy & Kim, 2024; Dahlan et al., 2021; Rumate et al., 2023; Puspita et al., 2020; Putri, 2014; Laberge-Nadeau et al., 1992; Al-Balbissi, 2003).

Similarly, the type of vehicle used daily (*daycarxx*) significantly affected the chances of never having a traffic accident. The use of private vehicles was considered to have a chance of never having a traffic accident up to 6.5 percent lower than public transportation. This condition can occur because someone who uses a private vehicle can control the vehicle's movement to obey the signs, while passengers of public transportation cannot control the vehicle's movement and/or the public transportation driver who violates traffic signs (Angin and Ali, 2021; Dahlan et al., 2021; Rumate et al., 2023).

However, the availability of road traffic facilities in accident prevention (*ketsar*), road traffic facilities for fatality reduction (*ketfat*), and gender of road user (sexx) had an insignificant effect on the chances of never having traffic accidents. These findings seem to be against the large number of previous empirical studies including Pembuain et al. (2018), Mc Carty and Kim (2024), Laberge-Nadeau et al. (1992), Al-Ghamdi (2002) to name just four studies. The explanations for these different findings are because factors that affect traffic accidents are complex (Cui, 2020; Zhang and Qiu, 2015). These factors include the design and installation of traffic facilities (Fengyuan et al., 2008), the management of traffic congestion (Souza et al., 2017; Cao et al., 2017; Huang et al., 2016), the presence of safety features at intersections and black spots (Farida et al., 2021; Yoon et al., 2017), and the behavior of road users (Shinar, 2017; Kochetova, 2022; Wang et al., 2011; Wilde, 1976; Robielos and Lin, 2022; Engwicht, 2012; Reason, 2000; Chung, 2015; Mannering, 2009; Purnomo et al., 2020; Otu and Ani, 2018; Kinnear et al., 2013; Lewis-Evans et al., 2010; Fuller et al., 2008; Widorini, 2013; Ahdiat, 2023; Tjahjono, 2010). In the case of Indonesia, these different results may be attributed to socio-economic, cultural, and environmental factors. In other words, factors that affect traffic accidents cannot be simplified as they can vary from one country to another.

In the context of the rare (infrequently) traffic accidents category, gender (*sexx*) and the type of vehicle used daily (*daycarxx*) significantly affected traffic accidents in the last six months. The coefficient of the sex variable (*sexx*) was negative with a value odds ratio of 0.678. This can be interpreted that male drivers have a lower chance of 0.678 times or 67.8 percent to rarely experience traffic accidents than female drivers. This happens because male motorists' concern for safety and traffic signs is lower, increasing the chances of traffic accidents. These findings align with the research (Al-Balbissi, 2003; Chen and Jou, 2019; Retallack and Ostendorf. 2020), which confirms that women have a lower risk of traffic accidents than men. Karacasu and Er (2011) also explained that men are involved in more traffic accidents than women and are caused by violations of priority passing through intersections and failure to control vehicle speed when there are obstacles ahead of the road. However, accident differences are significant only in normal driving conditions (Al-Balbissi, 2003).

Further, the use of private vehicles has a chance of rarely experiencing traffic accidents up to 10.5 percent lower than public transportation. Like the never-category traffic accidents discussed above, these infrequently traffic accidents of the use of private cars can occur because someone who uses a private vehicle can control the vehicle's movement to obey the signs, while passengers of public transportation cannot control the vehicle's movement and/or the public transportation driver who violates traffic signs (Angin and Ali, 2021; Dahlan et al., 2021; Rumate et al., 2023).

Concerning the frequent (often) traffic accidents category, only the installation of means of reducing the fatality of traffic accident victims (*ketfat*) shows a significant effect on frequent traffic accidents. The statistics indicated the availability of means to reduce the fatality of traffic accident victims has a probability or the possibility of frequent traffic accidents up to 0.446 times or 44.6 percent compared to the unavailability of these facilities. This suggests that the availability of ambulances and helmets as means of reducing the fatality of traffic accidents influenced the reduction of traffic accidents. This may happen because the availability of ambulances and helmets shows concern for driving safety so that road users' behavior is more careful. As Suparmanta (2019) found that ambulances and helmets increase road users' awareness of possible dangers while driving or riding, better obey traffic rules, and reduce the frequency of traffic accidents.

The explanation why the road traffic facilities in the form of road traffic quality, traffic cones, road barricades, land signs, train signs, and shock tape (excluding ambulances and helmets) do not considerably lower the number of traffic accidents by road users in Indonesia is due to human factors as the leading cause (Angin and Ali, 2021; Dahlan et al., 2021; Rumate et al., 2023). These findings were confirmed by the Indonesian Ministry of Transportation (2023) in that it was found that traffic accidents are mostly caused by the behavior of drivers who do not control the vehicle (31 percent), do not maintain a safe distance (24 percent), and are careless when turning (20 percent). Therefore, to reduce the frequency of traffic accidents in Indonesia, the government, the life insurance company, and other stakeholders need to place ambulances in high-road traffic accident areas, encourage the use of helmets, and actively assist in providing public education about driving safety, and more efforts to promote public awareness of road and traffic safety to improve the human factors including the behavior of drivers.

3.7. Factors that affect the fatality of traffic accident victims

The estimated results of factors that affect the fatality of traffic accidents by applying the logistic regression model are shown in Table 8. As can be seen in Table 8, the fatality rate of traffic accidents was significantly influenced by the availability of road traffic facilities for accident prevention (*ketsar*), location (*loc*), the type of vehicle used daily (*daycarxx*), and weather conditions while driving (*conweat*).

The estimated value of the availability of road facilities for accident prevention (*ketsar*) was 0.575. This indicates that the availability of road facilities for accident prevention was 57.5 percent to a lower chance of causing the fatality of traffic accidents (*fatalxx*) than if there is no availability of these facilities. This suggests that the availability of road traffic facilities (i.e., traffic cones, road barricades, land signs, train signs, and shock tape) is effective in reducing the fatality of traffic accidents. This finding reconfirmed the research conducted by Pratama and Koesyanto (2020) and Ferko et al. (2019) who found that the availability of road traffic facilities correlated negatively with the fatality of traffic accidents. Also, it was found that the fatality of traffic accident victims was also influenced by the location (*loc*). Java Island is the location that has a greater chance of causing 1.43 times more fatal casualties than outside Java. This is mainly because Java Island is not only the highest-populated location (Sutanto Soehodho, 2017) but also has the highest intensity of the number of vehicles in the country (Ministry of Transportation, 2023).

Table 8
Results of estimated logit model of fatality of traffic accident victims (*fatalxx*).

Independent variable	Coefficient	z	P > Z	Odds ratio
ketsar	−0.553	−1.410	0.157*	0.575
ketfat	−0.371	−0.950	0.340	0.690
ketofi	0.342	1.170	0.241	1.407
loc	0.358	1.430	0.153*	1.430
daycarx	−0.740	−1.630	0.102*	0.477
conweat	0.897	1.750	0.080**	2.452
_Cons	0.187	0.290	0.771	1.205

Number of observations: 300
LR $Chi^2(21) = 10{,}680$; Prob. > $Chi^2 = 0.099$
$R^2 = 0.028$

Source: calculated from questionnaire data.
Note: Significance level α = 1 percent, ***Significance level α = 5 percent, ***Significance level α = 10 percent, and *Significance level α = 20 percent.

In addition to the availability of road facilities for accident prevention (*ketsar*) and location (*loc*), the vehicles used daily (*daycarxx*) and weather conditions *(conweat*) were found to affect the fatality of traffic accident victims. The use of private vehicles is considered to have a lower chance of up to 0.477 times or 47.7 percent experiencing fatal traffic accidents compared to public transportation. However, this finding does not necessarily imply that public transportation is the only cause of fatality of traffic accidents. As argued by Sutanto Soehodho (2017), traffic accidents are the result of three different factor types, namely, human factors, vehicle factors, and external factors (including road conditions). Of these three factors, human factors have the strongest influence. The use of public transportation is even argued to reduce the number of traffic accidents if accompanied by the government's role that prioritizes improving public transportation (Chen and Jou, 2019). Not only that, the public transport system has been considered significant to contribute environmental, social, and economic benefits, such as greenhouse gas (GHG) emissions, reduced traffic accidents, economic opportunities, flexibility, reduced driving time, and more job opportunities. However, there are indeed barriers associated with public transport utilization including social norms and culture, higher reliance on private vehicles, and low fuel prices (Almatar, 2023a).

With weather conditions, the result indicates driving in the rainy season had a greater chance of causing fatal traffic accidents 2.45 more than driving not in the rainy season. The reason for this is partly because the rainy season causes the road to become more slippery, and visibility is disturbed, so motorists have difficulties controlling the vehicle as braking systems become imprecise (Pratama and Koesyanto, 2020). Previous studies that support the significant effect of weather conditions on the fatality of traffic accident victims include Gorzelanczyk and Tylicki (2023) and Hyodo and Hasegawa (2021). As addressed by Gorzelanczyk and Tylicki (2023) extreme climate and weather conditions will increase the potential for fatal traffic accidents. Foggy weather conditions and the presence of smoke are also considered to be one of the leading causes of traffic accidents. Therefore, road users can prevent accidents while driving in rainy or bad weather by ensuring that the vehicle is in good condition, choosing a safe mode of transportation (Sutanto Soehodho, 2017), pay attention to early warnings related to weather conditions from relevant agencies, and increase monitoring of compliance with speed limits and distance between vehicles (Ministry of Transportation, 2023). Additionally, the government needs to provide standardized road infrastructure, enforcement of traffic rules such as evaluation of vehicle conditions and speed limits, and education on safe driving practices (Almatar, 2024c).

However, the results of the estimated multinomial logit model that showed road traffic facilities for accident prevention (*ketsar*), and road traffic facilities for fatalities reduction (*ketfat*) insignificantly affected the frequency of traffic reduction as exhibited in Table 7 were not supported by the results of qualitative analysis shown in Table 9. As shown in Table 9, the percentages of respondents' perceptions under the survey agreed that three variables of *ketsar, ketfat and ketofi* reduced the frequency of traffic accidents. The percentages of these three variables were 93.3 percent, 76.7 percent, and 81.3 percent respectively. These different findings of the estimated results derived from the statistical (quantitative) analysis with the results of the qualitative analysis on the three variables (i.e., *ketsar*, *ketfat* and *ketofi*) were due to the use of two methodological differences (Asra et al., 2023).

Similarly, the qualitative results showed that the road traffic facilities for accident prevention *(ketsar)*, road traffic facilities for reducing

Table 9
Road user perceptions related to road traffic facilities towards reducing the frequency of traffic accidents and traffic accident fatality (percentage).

Perception	Traffic accident prevention facilities (*ketsar*)	Means of reducing fatality of traffic accident victims (*ketfat*)	Supporting facilities for the work of officers managing traffic (*ketofi*)	Traffic accident prevention facilities (*ketsar*)	Means of reducing fatality of traffic accident victims (*ketfat*)	Supporting facilities for the work of officers managing traffic (*ketofi*)
	Reducing the frequency of traffic accidents (*frekm*)			Reducing the fatality rate of traffic accident victims (*fatalxx*)		
Disagree	6.67	23.33	18.67	13.00	10.33	19.33
Agree	93.33	76.67	81.33	87.00	89.67	80.67

Source: calculated from questionnaire data.

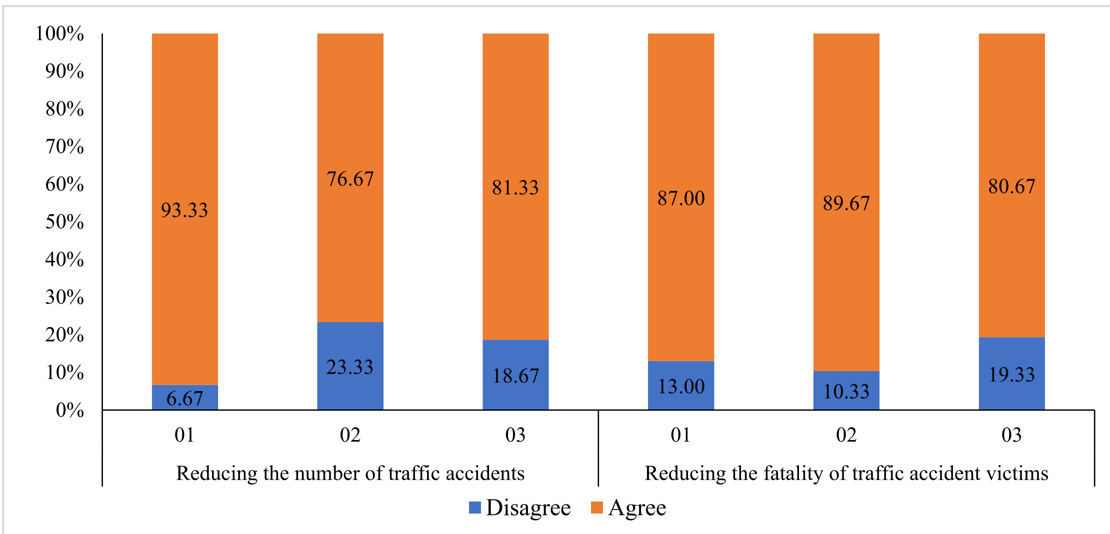

Fig. 4. Road user perceptions related to the installation of traffic facilities for reducing accidents and fatality (Percentage). .
Source: calculated from questionnaire data. Note: 01: installation of traffic facilities for accident prevention. 02: installation of traffic facilities for reducing the fatality. 03: installation of traffic facilities to support the work of officers in regulating traffic

fatality of traffic accident victims (*ketfat*), and road traffic facilities for supporting the work of officers in regulating traffic (*ketofi*) were agreed to reduce the fatality rate of traffic accidents. As can be seen in Table 9 and Fig. 4, the percentages of these three factors were about 87.0 percent, 89.7 percent, and 80.7 percent respectively. However, from the statistical logit analysis (Table 8) it was shown that of these three variables, only the availability of road traffic facilities for accident prevention (*ketsar*) significantly reduced the fatality of traffic accident victims. Again, these different findings were due to methodological differences between the quantitative (statistical model-based) analysis and qualitative (perception-based) analysis used in the study. Thus, caveats apply to understand the above different findings.

Table 10
Correlation between the respondents who experienced the last traffic accident and their monthly income.

Information			**Last accident**	**Revenue per month**
Spearman's rho	**Last accident**	Correlation coefficient	1.000	−0.061
		Sig. (2-tailed)	0.000	0.294
		N	300	300
	Revenue per month	Correlation coefficient	−0.061	1.000
		Sig. (2-tailed)	0.294	0.000
		N	300	300

Source: calculated from questionnaire data.

Table 11
The correlation between the respondents who experienced the last traffic accident and their income decreased.

Information			**Last accident**	**Reduced revenue**
Spearman's rho	**Last accident**	Correlation coefficient	1.000	−0.327***
		Sig. (2-tailed)	0.000	0.000
		N	300	300
	Reduced revenue	Correlation coefficient	−0.327***	1.000
		Sig. (2-tailed)	0.000	0.000
		N	300	300

Source: calculated from questionnaire data.
Note: The significance level α = 5 percent.

3.8. *Correlation between traffic accident victims and poverty*

By applying the Spearman correlation test, the study indicated that the relationship between the respondents who experienced the last traffic accident and their monthly income was insignificant. This is reflected in the results of the Spearman Rank correlation test which showed the significance level is more than 0.05 (0.294 > 0.05) as exhibited in Table 10. This suggests that traffic accidents correlate with poverty.

However, the relationship between respondents who experienced the last traffic accident and their income reduction for one month after the traffic accident had a significant relationship. This was indicated by the value of the Spearman Rank correlation test that was smaller than 0.05

Table 12
Correlation between traffic accident fatality rate and total cost required.

			Fatality rate of traffic accident victims	Total cost required
Spearman's rho	**Fatality rate of traffic accident victims**	Correlation coefficient	1.000	0.643***
		Sig. (2-tailed)	0.000	0.000
		N	300	300
	Total cost required	Correlation coefficient	0.643***	1.000
		Sig. (2-tailed)	0.000	0.000
		N	300	300

Source: calculated from questionnaire data.
Note: The significance level α = 5 percent.

Table 13
Correlation between traffic accident fatality rate and income reduction for 1 month after traffic accidents.

			Fatality rate of traffic accident victims	Reduced revenue
Spearman's rho	**Fatality rate of traffic accident victims**	Correlation Coefficient	1.000	0.468***
		Sig. (2-tailed)	0.000	0.000
		N	300	300
	Reduced revenue	Correlation Coefficient	0.468***	1.000
		Sig. (2-tailed)	0.000	0.000
		N	300	300

Source: calculated from questionnaire data.
Note: The significance level α = 5 percent.

(i.e., 0.000 < 0.05) and had a correlation value of −0.327 (Table 11). This result can be interpreted that the longer the traffic accident occurs, the decrease in income of the traffic victims for one month after the traffic accident is small or minor. However, if the traffic accident occurred not long ago (less than a month), the income that decreases for one month after the traffic accident becomes significant. This finding supported the report issued by the Ministry of Transportation (2004), which stated that traffic accidents incur treatment costs, lost productivity, and the loss of a breadwinner in the family. This condition further leads to a decrease in income and contributes to poverty.

In terms of the correlation analysis between the traffic accident fatality rate and the total cost required, the result showed a significant relationship as the Spearman correlation test is less than 0.05 (0.000 < 0.05) and has a correlation value of 0.643 (Table 12).

In line with the above finding, the correlation between the traffic accident fatality rate and income reduction for one month after traffic accidents also indicates a significant relationship as the correlation of the Rank Spearman test is less than 0.05 (i.e., 0.000 < 0.05) and has a correlation value of 0.468 (Table 13). These results indicate that the higher the fatality rate of traffic accidents, the greater the total cost required, especially in early traffic accidents (Laloma et al., 2023). This finding supported the study conducted by Emamgholipour et al. (2021) in that they stated the cost of treatment after a traffic accident becomes more significant. This condition particularly occurs if the victim of the traffic accident has injuries to the head and neck, as well as for victims who require hospitalization for more than three days and elderly patients. Additionally, Yasmeen (2019) and Alghnam et al. (2021) showed that the victims of traffic accidents that require the greatest maintenance costs are pedestrians and motorcyclists, who today are often associated with people with lower middle income because of the type of vehicle they use.

Other studies that supported the findings of this study have been highlighted by the Asian Development Bank (ADB, 2005), Islam et al. (2020), Khare et al. (2023), and Truong (2020) to name just four studies. The ADB (2005), for instance, indicated that the death of the main income earner, the cost of medical treatment, and the loss of a job and/or income resulting from a road crash often have important adverse economic and social consequences on a household. Also, Islam et al (2020) in their study in Bangladesh confirmed that the main income earners involved in traffic accidents causing serious injury have a significant economic effect on family income. In the case of India, road crash fatalities, which rank highest globally, pose a significant burden on its demographic advantage and have a substantial effect on poverty levels (Khare et al., 2023). Victims of road traffic accidents in India encounter physical, mental, and economic hardships, often relying on family support for rehabilitation. These accidents primarily affect both men and women, with the majority involving two-wheeled vehicles (Chellamuthu et al., 2023). Therefore, the findings of this study reconfirmed and complemented those of comparable studies conducted in other developing nations regarding the relationship between traffic accidents and poverty and indicated there are no particular elements specific to Indonesia that affect this relationship.

In sum: the results of this study showed that based on the qualitative analysis, it was indicated that the majority of respondents viewed the road traffic facilities as useful means to prevent road traffic accidents, a means of reducing fatality in road traffic accidents, and only cause minor injuries. The motorcycle was viewed as the type of transportation that has great potential to have road traffic accidents if there are road traffic facilities installed. However, the type of fatality in traffic accidents tends to be minor injuries. Further, the results of statistical analysis showed specifically that factors that have a significant effect on the chances of never having traffic accidents were the presence of traffic control officers, location, age, and the use of private vehicles. While road traffic facilities (excluding ambulances and helmets) are insignificant in reducing traffic accidents. Additionally, the significant factors affecting the fatality rate of traffic accident victims were the availability of accident prevention facilities, location, the use of private vehicles, and weather conditions. Finally, traffic accidents correlated with poverty incidence as they incur treatment costs, lost productivity, and the loss of a breadwinner in the family.

4. Conclusions, policy implications, and future research

This study had three objectives. First, to investigate the perceptions of road users in viewing traffic facilities on traffic accidents, means of reducing the fatality of traffic accident victims, types of fatality of road traffic accident victims, and type of transportation mode causing traffic accidents and types of fatalities of accident victims. Second, to determine factors affecting the frequency of traffic accidents and the fatality of accident victims. Third, to examine the correlation between traffic accident victims and poverty.

The results of the qualitative analysis showed that the majority of respondents viewed the road traffic facilities as useful means to prevent road traffic accidents and a means of reducing fatality in road traffic accidents. However, the results of statistical analysis differed from the qualitative results due to the different methods used in this study. The statistical results of the multinomial and the logit regressions showed specifically that factors that have a significant effect on the chances of never having traffic accidents were the presence of traffic control officers, location, age, and the use of private vehicles. While road traffic facilities (excluding ambulances and helmets) are insignificant in reducing traffic accidents. Further, the significant factors affecting the fatality rate of traffic accident victims were the availability of accident prevention facilities, location, the use of private vehicles, and weather conditions. Additionally, traffic accidents correlate with poverty incidence as they incur treatment costs, lost productivity, and the loss of a breadwinner in the family.

The policy implications of this study at least are as follows. First, the development of road traffic facilities by the governments or other related authorities should be based on data and evidence. So, the development of road traffic facilities to reduce traffic accidents, the fatality of traffic accident victims, and poverty is achieved optimally. Second, the government and other transportation stakeholders need to improve public education on safe driving practices and introduce technologies directed at solving human, vehicle, and external factors (including road conditions). Third, the government and traffic accident insurance companies need to continue programs that aim to help the poor families of the death of traffic accident victims who are trapped in poverty. Finally, further future research can be expanded by integrating overlooked factors like road traffic infrastructure quality, public awareness, and others affecting road traffic accidents and the fatality of traffic accidents. Additionally, the scope of this study which limits the survey locations to ten provinces with 600 respondents can be added to generalize the study findings for Indonesia. Thus, much remains to be done.

CRediT authorship contribution statement

Iwan Hermawan: Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Carunia Mulya Firdausy:** Writing – review & editing, Writing – original draft, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Khoiru Rizqy Rambe:** Writing – original draft, Software, Methodology, Investigation. **Fadhlan Zuhdi:** Writing – original draft, Software, Methodology, Investigation, Data curation. **Erwidodo:** Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Reninta Dewi Nugraheni:** Methodology, Investigation, Formal analysis, Data curation. **Johny Malisan:** Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Yovita Isnasari:** Writing – original draft, Software, Methodology, Investigation, Data curation. **Edward Marpaung:** Writing – original draft, Methodology, Investigation, Data curation. **Sri Milawati Asshagab:** Writing – original draft, Resources, Methodology, Investigation, Data curation.

Declaration of competing interest

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

Acknowledgment

The authors would like to thank and highly appreciate the Editor and blind reviewers of this journal for improving this paper in better shape. Also, thanks to Christoph Ehrler Ph.D and Tania Puspita M. Sc who professionally improved the language. The authors express their gratitude to PT. Jasa Raharja (Persero) and National Research and Innovation Agency Republic of Indonesia for their kind support in publishing this work. Any errors are ours.

Data availability

Data will be made available on request.

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