© Universiti Tun Hussein Onn Malaysia Publisher's Office

IJIE

http://penerbit.uthm.edu.my/ojs/index.php/ijie
ISSN : 2229-838X e-ISSN : 2600-7916

The International Journal of Integrated Engineering

Statistical Analysis of Accident Patterns and The Causes at A State Road in Perlis

Geetha Doraisamy[1], Farahiyah Abdul Rahman[1*], Afizah Ayob[1,5], Hafnidar A. Rani[2], Mohd Khairul Alhapiz Ibrahim[3], Senja Rum Harnaeni[4]

[1]Faculty of Civil Engineering and Technology,
University Malaysia Perlis, 02600 Arau, Perlis, MALAYSIA

[2]Department of Civil Engineering, Faculty of Engineering,
Universitas Muhammadiyah Aceh, 23123 Aceh, INDONESIA

[3]Driving Simulation and Psychometric Data Unit, Road User Behavioural Change Research Centre,
Malaysian Institute of Road Safety Research, 43000 Kajang, Selangor, MALAYSIA

[4]Department of Civil Engineering, Faculty of Engineering,
Universitas Muhammadiyah Surakarta, 57102 Surakarta, INDONESIA

[5]Centre of Excellent, Water Research and Environmental Sustainability Growth,
University Malaysia Perlis, 02600 Arau, Perlis, MALAYSIA

*Corresponding Author

DOI: https://doi.org/10.30880/ijie.2023.15.02.029
Received 11 January 2023; Accepted 01 May 2023; Available online 13 September 2023

Abstract: According to data from the World Health Organization, approximately 1.3 million road users are at high risk of road traffic accidents every year. This study aims to assess accident patterns and causes on a state road between Kangar and Alor Setar. The evaluation of accident pattern employed include the chi-squared test (CST) and the level of service (LOS) survey. Analysis using Pearson CST reveals that age and vehicle type are significant factors in accidents. Specifically, individuals below 30 years old have a higher likelihood of being involved in accidents (ρ = 0.037), while motorcycles are more prone to accidents (ρ = 0.000). However, gender does not appear to impact accident involvement significantly (ρ = 0.911). The LOS E category indicates unstable traffic flows during Monday and Friday evenings. To evaluate accident causes from the perspective of road users, a questionnaire was used, and its validity and reliability were ensured through a pilot study. Four hypotheses were developed, examining human factors, vehicle factors, environmental factors, and road condition factors as independent variables. The results reveal that a majority of road users (33.3%) travel 1 to 3 times per week, with 23.1% of them being involved in accidents on this road. The validity test using the structural model identifies road factors (t = 6.166, ρ = 0.000), vehicle factors (t = 4.3399, ρ = 0.000), and human factors (t = 2.893, ρ = 0.005) as the most significant contributors to accidents. Hence, it is crucial for authorities to prioritize countermeasures focusing on these factors to reduce accidents on this road.

Keywords: Accident pattern, chi-square, accidents factors, causes of accident, PLS-SEM

1. Introduction

Road or traffic accidents impart economic and social costs towards the victims, the local communities and governments. Thus, the implementation of countermeasures to reduce accident rates is essential and the significant factors

*Corresponding author: farahiyahrahman@unimap.edu.my

that contribute to accidents must be evaluated. The World Health Organization (WHO) defines road accidents as violations or incidents that usually lead to injuries or fatalities that occur on public roads involving at least one vehicle. In 2018, the WHO reported that 50% of deaths are caused by road fatal accidents [1]. The Global Burden of Disease Project in 2004 found that death from road accidents reaches 1.27 million every year, which is equivalent to the number of deaths from a combination of other factors, for instances heart disease and stroke [2]. Substantial increases in the total number of road fatalities have been observed in some developing nations. Motorcycle accidents are the leading cause of death in teenagers and young adults, with approximately 856,000 road deaths occurring annually worldwide, with 74% of them in developing nations [3]. From 1975 to 1988, the fatalities due to road accidents dropped to 27% and 63% in the developed nations of the United States and Canada, respectively, potentially due to the intercession of safety interventions. However, in the same years, the casualties soared in developing nations like China by 243% and Malaysia by 44% [4].

Motor vehicles were introduced in the 19th century and have been in continuous use since [4]. In Malaysia, transportation networks are vital and car demand continues to grow every year. Private vehicles are one of the principal sources of transportation nationwide [5]. The number of registered vehicles was 16,790,732 in 2006, increasing to 29,666,187 in 2018 [6]. The increases in the Malaysian population and the number of vehicles on roads increased the risk of road accidents. Data from the Ministry of Transportation (MOT) Malaysia gives a consistent increase in the number of road traffic accidents. A total of 414,421 cases were recorded in 2010, which increased to 567,516 in 2019 [6]. As a result, MYR 9 billion was used on medical expenses associated with road traffic accidents in 2019 [7]. Road traffic accidents are the leading cause of fatalities and injuries and are a growing public health epidemic [8]. A road accident not only kills individuals but also harms people, property and the environment.

To address the difficulties and long-term complications caused by the increase in road traffic accidents, preventive measures must be implemented. Intelligent measures can be adopted to overcome the consequences of road accidents. Data must be obtained without any major loss of information and made available for future prediction. Policymakers, authorities, researchers and designers are focusing on strict traffic laws and regulations, utilisation of traffic control devices and safety guidance systems in vehicles to decrease accidental risk [4]. To establish an adequate road accident framework, the data from previous accidents are needed for analysis and prognostication. In many developing nations, accident data compilations remain insufficient. Reasons include a lack of training for police and traffic departments, substandard protocols by health officials when handling casualties, substandard analysis techniques and inadequate automation tools [9]. For example, Sri Lanka established a National Road Safety Action Plan 2011–2020 for road safety together with strategies of stakeholders. However, progress has been slow due to insufficient funding and minimal coordination among the parties involved.

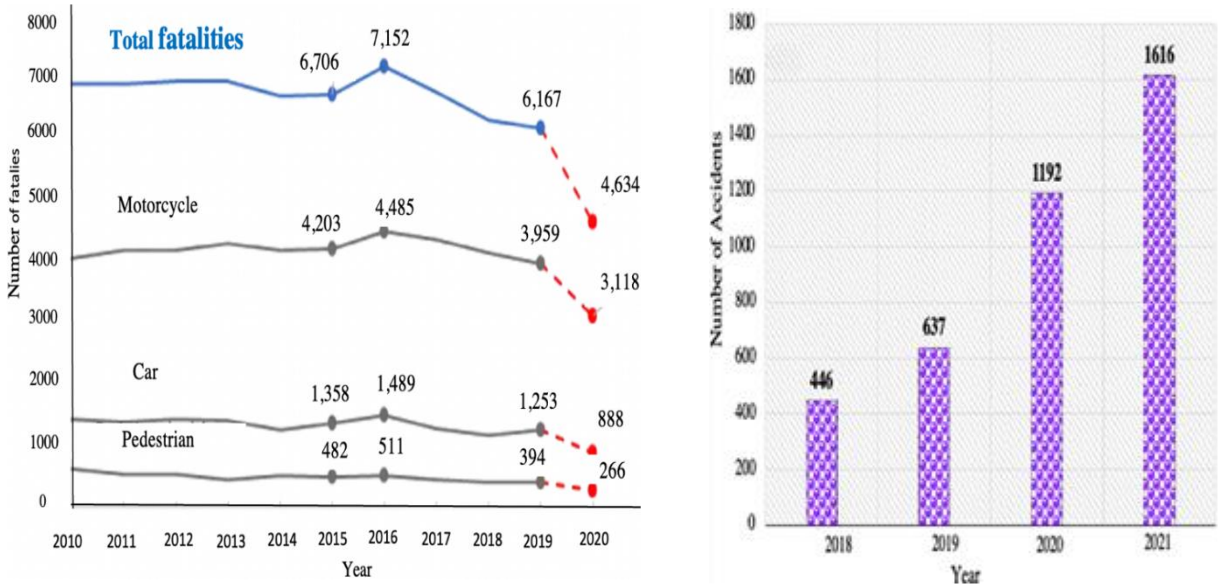
A quantitative study found that over a five-year period (2013–2017), Selangor recorded the highest accident rate of 4,882, whereas Perlis recorded the lowest accident rate (302) [10]. Selangor's high population of 5.46 million and fast development of modernisation have led to excellent infrastructure such as highways. However, Perlis, with its tiny size and less rapid development is having major issues in transforming to urbanisation and an efficient transportation system. According to the Perlis Strategic Plan 2012–2030 [11], this state lacks readily available land with development prospects, high costs for operating businesses, weak economic structure and low private investment. Therefore, this state is not a focus location for employment, and not many roads and highways have been built.

Previous local studies have demonstrated that road accidents are caused by humans, vehicles, road conditions and environmental factors. Some typical causes are careless driving, wrong overtaking, racing and speeding, faulty vehicles, micro-sleeping during driving, unsatisfactory maintained roads, driving under the influence and weather conditions [12]-[15]. Meanwhile, the major critical types of accidents occur on straight-ahead streets and municipal roads in Shah Alam, Selangor [16]. The most typical collision types are straying, digressing and skidding. In Malaysia, an average of 18 persons dies daily in road accidents [6, 10]. Thus, to put together adequate interventions for this issue, the factors associated with road traffic accidents must be recognised. Therefore, this study evaluates the accident patterns and causes of accidents on the state road of Kangar to Alor Setar. This road is classified as an urban region accident-prone route with residential and business areas along the street. This study uses the latest data of road crash accidents in 2021, road level of service (LOS) and Pearson chi-square test (CST) of partial least squares structural equation modelling (PLS–SEM). The findings would assist in reducing the rate of accidents in the state.

2. Literature Review

Sustainable transportation systems are key parts of sustainable cities. One of the main keys that affect transportation system sustainability is traffic safety, as cited in the Sustainable Development Goals via targets 3.6 and 11.2 [7]. The world's first road traffic accident occurred in 1896, after which it was said 'it should never happen again' [17]. However, after more than a century, 1.3 million road users have been killed and more than 50 million have been injured [17]. This issue is not only devastating but could also indirectly strongly influence a country's societal and economic costs if not controlled. Malaysia is also experiencing the same problem. In 2013, the WHO reported that the estimated fatality rate in Malaysia due to traffic accidents is among the highest in the world. Statistics of road traffic accidents from the Royal Malaysian Police in 2010–2020 stated that 2016 had the most fatalities, as shown in Fig. 1(a) [7]. The Department of Statistics Malaysia reported that an average of 6,540 deaths of road users below 30 are because of road accidents in 2020.

These incidents carry financial implications of up to MYR 3.12 million, which is equivalent to an annual loss of approximately MYR 19.7 billion [18]. The Malaysian Institute of Road Safety Research also reported that the motorcycle is one of the main modes of transportation and the top high-risk group on the road [19], [20]. In this case, from the perspective of age group, children and youth below 30 years have shown the highest risk of traffic accident fatality.



(a) (b)

Fig. 1 - (a) Deaths due to road traffic accidents by vehicle types from 2010-2020 in Malaysia; (b) the number of road traffic accidents in Perlis from 2018 to 2021

Since March 2020 the number of deaths and accidents decreased dramatically due to the implementations of the Movement Control Order by a majority of world governments to fight the COVID-19 pandemic. Hence, the amount of traffic on the road has decreased sharply, indirectly reducing exposure to the risk of road accidents. The number of road fatalities dropped in 32 nations out of 36 nations in April 2020 compared with April 2019. This includes a drop of 50% in 12 nations, 25% to 49% in 14 nations and less than 25% in 6 nations [21]. Similarly, Malaysia has shown a dramatic decline of 18% in total fatalities; 4634 cases were recorded in 2020 (Fig. 1(a)). However, there is a high probability of an increase in these figures since the easing of COVID-19 restrictions and if no intervention measures are implemented. The accident pattern in Malaysia shows the opposite result, with the accident rate in Perlis showing an incremental increase despite the COVID-19 lockdown. The gradually increasing pattern of road accidents in Perlis from 2018 to 2021 is shown in Fig. 1(b) [7]. Consequently, a study on the significant causes of accidents is needed for the target area.

Even though it is denoted as a developing nation, Malaysia does not overlook road safety. The Malaysia Road Safety Plan 2022–2030 upholds the institutional capacity on the elements of enforcement, education and awareness; road infrastructure; vehicle safety operation; public transportation expansion; post-crash management and data management [7]. In this plan, the Safe System (SS) methods are included, such as infrastructural changes, in addition to conventional approaches to reduce the occurrence of deaths in 2019 by 50% by the end of 2030. At hot-spot areas, infrastructural changes could be introduced to replace signalised intersections with roundabouts, horizontal deflections built at pedestrian and cycle crossing ways [6]. A significant number of studies on traffic safety have emphasised that traffic accidents must be based on prevention. Traffic accidents and their contributing aspects vary in perspectives and methodologies, including socio-economic status, engineering technologies and regulations and policies [22]-[24]. Often, the approach to implementing the rules and regulations available to prevent road accidents is ineffective, half-hearted and not completely successful at the desired level.

As elsewhere in the world, road accidents are usually caused by a combination of five factors: driver behaviour, road infrastructure quality, traffic volume, vehicle condition and environment [24]-[27]. By identifying the main causes of road accidents, the problem could be reduced. Some researchers found that parameters such as time, driver manner, weather and vehicle type have a consistent internal link with the incidence and severity of traffic accidents. There is a link between the severity of a single-vehicle collision and the elements that influence it [24]. Therefore, the factors of drunk driving, driver age, poor light conditions, seatbelt use, collision with fixed objects, speeding manner and overturning were discovered to be highly associated with the severity of driver injury. Through a data mining algorithm, it found out that road accidents were influenced by the location and time along the Kano-Wudil highway in Nigeria [28]. Other factors that cause road accidents include erroneous overtaking, loss of control, tyre rupture, low lights, precarious causes and brake failure. Therefore, the analytic hierarchy process and found that road accidents occurred regularly because of the increasing number of road users who drove faster than the speed limit [29].

Prevention of road traffic accidents is the responsibility of various agencies with a multi-disciplinary approach. Although government departments, private bodies and voluntary institutions have launched numerous road safety campaigns, road accidents still occur everywhere during normal days or festival seasons. The absence of monitoring from authorities may lead to road accidents. Authorities such as the police must of places where recurrent accidents have been recognised, and legal action can be imposed against street offenders. Such locations include hilly roads, double lines and traffic light areas. Extended surveillance monitoring will make road users more prudent while on the road, thereby reducing traffic accidents. Non-fatal accidents are unnecessary and avoidable [6]. National speed limits for various road categories are already used to balance mobility and road safety. Thus, advanced planning and interventions are needed in assisting on preventing road users, particularly the users of two-wheelers, with driving road safety awareness campaigns, firm enforcement of traffic laws and behavioural adjustments.

The effects of variables on accident severity in urban and rural locations of truck collisions were investigated by Regev et al. [23]. They found that the level of severity has no significant differences in the effects of seatbelt use and fatigue driving. By contrast, better road accessibility and proper infrastructures contribute to a high probability of injuries causing non-fatalities in urban areas [6]. In rural areas, the conditions of poor roads make vehicle drivers give full focus when driving. Drivers slow down and are extra careful when driving at night and during rainy events. Substandard roads have aspects such as several sharp turns, uneven paving and scattered small shops, which can cause accidents [23]. In addition, the local authorities must have an agile schedule of roadside treatment to eliminate hazards. This treatment includes removing rotten tree trunks, huge hanging twigs and overflowing plants that cover traffic signs and signals.

In fact, traffic volume, driver behaviour, roadway geometry, weather conditions and other environmental characteristics are causes of traffic accidents [25]. Weather factors such as heavy rains could affect drivers typically on wet highways. In this condition, road users do not have sufficient space to brake if the front vehicle brakes instantaneously. Additionally, lack of adherence to driving regulations is the most influential in the category of human factors. This is followed by driver inexperience, sleepiness and tiredness. Notwithstanding, driver attitude should be considered when tackling these problems [3]. Thus, this study considers many aspects of road accident causes before solutions can be proposed to reduce the number of road accidents in Perlis.

3. Methods

The study begins with the identification of the study location and accident data collection from the Kangar Police Department from January to December 2021. Then, the relationship between the severity of accidents with several factors, such as gender of driver, age and type of vehicle, was identified by the CST method in SPSS software. Then, the LOS survey was conducted to evaluate the quality of the traffic service on a particular road. Finally, the causes of accidents in that particular location were determined from the perspective of the road users by using PLS–SEM in SmartPLS software. To analyse the model, a hypothesis was developed by considering several accident factors: human, vehicle, environment and road factors.

3.1 Study Area

Perlis is the smallest state in Malaysia with an area of only 819 km^2, and Kangar is the capital city. Perlis is located on Peninsular Malaysia's northern west coast, bordering the Satun and Songkhla Districts of Thailand and bounded to the south of Kedah state. Perlis had a population of 265,500 people in 2020. The state road of Kangar to Alor Setar, Kedah was chosen as a research location because it has the highest rate of accidents in this state. The specific kilometre marker KM 3, was chosen because it was the closest to the town and one of accident-prone street (Fig. 2).

3.2 Crash Data Collection

The crash data for 2021 were obtained from the Kangar Police Department. The data collected include the names of the victims, accident times, accident dates, types of vehicle involved and weather conditions during the accident. The data were used to evaluate the accident pattern, with crash severity being the dependent variable in the model. The independent variables are the types of vehicle, gender of driver and age of driver. The Pearson CST was used to assess the correlation of both independent and dependent variables using SPSS. CST is a statistical test for categorical data. It is very computationally efficient and scalable to big data, and it is valid and universally consistent [30] The basic formula is shown in Eq. (1) and Eq. (2), where x^2 is chi-square, f_o is the frequency in observation and f_e is the expected frequency.

$$x^2 = \sum \frac{\left(f_0 - f_e \right)^2}{f_e} \tag{1}$$

$$f_e = \frac{\left(\text{Row sum} \times \text{Column sum}\right)}{\text{Grand total}} \tag{2}$$

Fig. 2 - Study location

3.3 Level of Service

LOS is directly related to the volume of vehicles on the road. Traffic volume can have a significant relationship to the occurrence of traffic accidents but not necessarily in a way that would at first seem logical. Although accidents may be expected to increase due to a larger number of vehicles on the road, they may also decrease due to a reduction in speed [31]. LOS describes the operating conditions of traffic and how they are perceived by motorists. Conditions such as speed, travel time and freedom to manoeuvre are considered, with road segments being grouped into one of six levels ranging from A (best) to F (worst) based on these conditions [32].

To obtain the road LOS, the peak hour traffic volume was collected by the traffic survey method for both morning and evening peaks. Data were taken from 7.30 am to 8.30 am and 5.00 pm to 6.00 pm on Monday, Wednesday and Friday. At any location, a complex relationship exists between the accident rate and traffic volume. Thus, a strong understanding of this relationship is necessary to improve traffic management and reduce accident frequency [14]. The traffic volume data of peak hours is converted into passenger car units per hour (PCU/hr), which then the LOS is defined. For calculation of the LOS, the volume/capacity ratio was determined using the design capacity volume of the road, which depends on the number of lanes based on the Highway Capacity Manual [20].

3.4 Questionnaire Survey

To obtain the perspective of road users, a questionnaire survey research tool was used. Random sampling was used to determine the respondents so that road users have an equal chance of being selected as respondents. Before distribution, the questionnaire underwent a pilot study to evaluate the effectiveness of its questions. The pilot was conducted to ensure validity and reliability [33]. The pre-test of the measures was conducted by 30 students and lecturers from UniMAP. After being reviewed, some items were adjusted and included in the questionnaire according to the feedback received.

The questionnaire is divided into four sections from Sections A to D. Section A is the driving characteristic of the respondent, including driving experience, vehicle used, summons and common trip purposes. Section B focuses on the respondent's familiarity with the studied road, difficulties while travelling on the road and experience of accidents while using the road. Section C aims to obtain the respondent's opinions about the causes of accidents. Section D evaluates the opinion about the type of accident severity likely to occur on the road related to its condition. A total of 65 respondents gave their feedback on the questionnaire. The questionnaire was developed based on four hypotheses that are related to the main causes of accidents: human, vehicle, environment and road factors.

3.4.1 Hypothesis Development

Through literature review, the hypothesis (*H*) is determined to evaluate the relationship between the variables. The influence of four variables of human factor, vehicle factor, environment factor, and road factors on traffic accidents are empirically analyzed to determine whether the hypothesis developed is supported in relation to traffic accidents. There are four hypotheses has been developed to access the relationship between the variable which are:

- H_1: Human factor has a significant relationship with traffic accidents.
- H_2: Vehicle factor has a significant relationship with traffic accidents.
- H_3: Environment factor has a significant relationship with traffic accidents.
- H_4: Road factor has a significant relationship with traffic accidents.

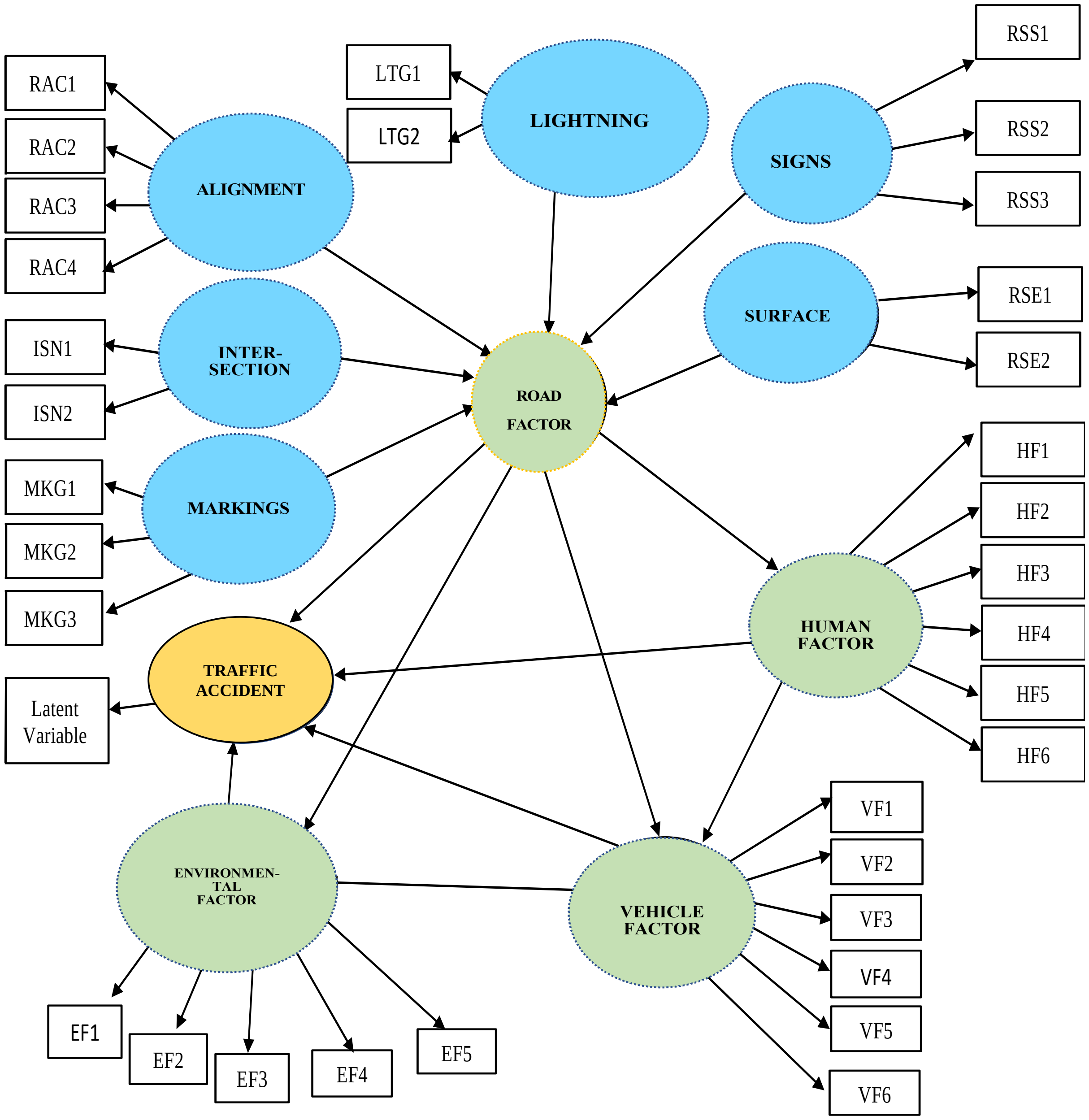


Fig. 3 - Schematic diagram of PLS-SEM for four contributing factors in relation to traffic accidents

3.4.2 Data Analysis

The collected data among the road users of Kangar to Alor Setar were then analysed by using PLS–SEM. The descriptive data obtained provide clear demographic information about the respondents who participated in this survey. The model was developed based on the hypotheses of four contributing groups to traffic accidents: the human, vehicle, environment and road factors. The PLS–SEM model comprises 33 effect factors divided into four groups: human (HF), vehicle (VF), environment (EF) and road factors. The road factor has been divided into road marking (MKG), intersection (ISN), alignment (RAC), lighting (LTG), road signs (RSS), and road surface (RSE). Each of that acts as an independent variable and is linked to a single group of traffic accidents as a dependent variable (Fig. 3).

4. Results and Discussion

4.1 Overview of Accidents at State Road of Kangar to Alor Setar

As regards the overview pattern of accident trends in 2021, male drivers of all ages are more likely to be involved in road accidents than women drivers. Men accounted for 61 accidents (70.9%), whereas women accounted for 25 accidents (29.1%), as shown in Fig. 4(a). The age groups that contributed the most to accidents are those under 30 and between 31–40 years old at 42.3% and 31.8%, respectively (Fig. 4(b)). Male drivers are more vulnerable to traffic accidents, consistent with previous findings which stated that the aggressive nature of male drivers makes them more likely to contribute to fatal and non-fatal collisions than women [5], [16], [24]. The hormonal influence in men results in higher risk-taking and a tendency to drive excessively and overconfidently [6]. Another factor is that men drive more frequently and for longer distances, exposing them to road safety risks. Fig. 4(c) shows that the motorcycle vehicle type is the most often categorised as causing minor injuries and severe injuries (22.3%). Car is one of the vehicles with the highest number of accident victims but with no injuries (Fig. 4(c)). These findings agree with those of previous studies, which stated that, in many developing nations, two-wheeled vehicles such as motorcycles dominated road use, leading to motorcyclists being at the highest risk of encountering traffic accidents [3], [6].

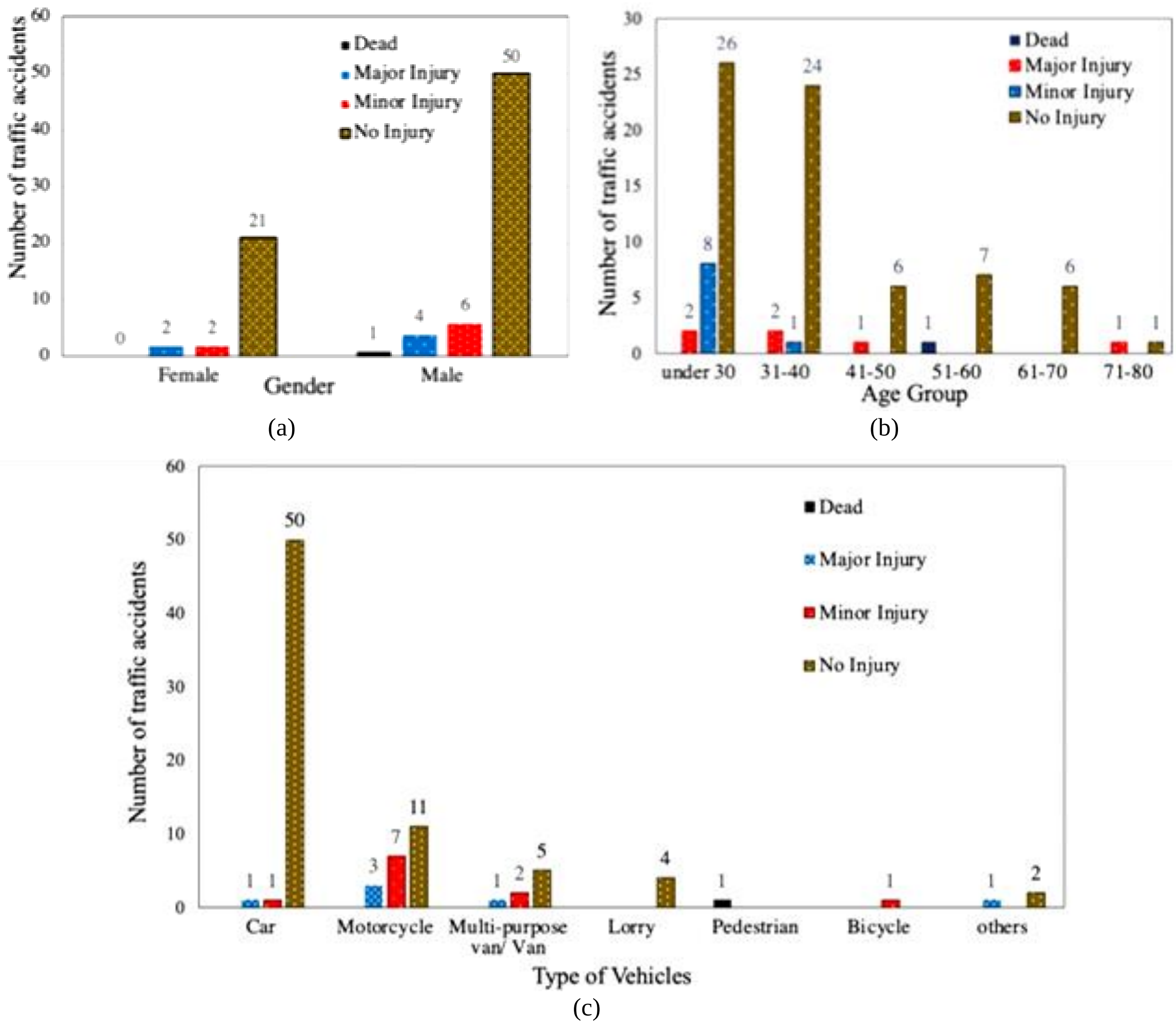


Fig. 4 - The number of traffic accidents in 2021 by; (a) gender; (b) age group; (c) type of vehicles

4.2 Pearson Chi-Square Test

Table 1 shows the observed CST values for age, gender of drivers and type of vehicles towards the severity of the crash. Drivers under 30 are more often to have minor injuries in an accident as opposed to fatal injuries. The significance of the probability value (ρ-value) for the severity towards the age of driver and type of vehicle are 0.037 and 0.0, respectively. The result shows that these values are less than the required significance level (α) of less than 0.05. This might be because youthful drivers have better health, physical body condition and perception responsiveness to circumstances than senior drivers [19]. The observed ρ-value for the gender of driver is 0.911 (greater than α = 0.05). Hence, there is no significant relationship between gender and the severity of the accident on the road.

Table 1 - The CST values for age and gender of drivers and type of vehicles

Value	Age	Gender	Type of vehicles
Pearson CST	26.130	0.536	141.190
Significance (2-sided)	0.037	0.911	0

4.3 Level of Service

Table 2 illustrates the LOS of Kangar to Alor Setar road for mornings and evenings on Monday, Wednesday and Friday. On mornings of Monday and Wednesday, the LOS was satisfactory (level B), indicating that speed increases as volume decreases. However, on evenings (Wednesday) and mornings (Friday) the LOS is C, with free-flowing traffic, low volumes, rapid speeds and low traffic density. By contrast, traffic flow is unpredictable on Monday and Friday evenings (LOS E), represented by approaching unstable flow, high volumes and extended delays at intersections, as well as the exceedingly slow urban street traffic. The higher vehicle-to-capacity ratio might cause more accidents with injuries and fatalities due to more conflict of traffic [26]. These findings agree with those of Shaadan et al. (2021), who observed that the most critical time in which accidents occurred is during busy hours in Shah Alam, Selangor [16]. These busy times were in the morning (8.00 to 10.00 am), evening (4.00 to 6.00 pm) and night hours (6.00 pm until 8.00 pm). Therefore, the results show that the high number of accidents on this road might be due to its high volume of traffic and low serviceability.

Table 2 - The LOS result of Kangar to Alor Setar road

Time	Peak Hour Volume in PCU/hr (V)	Number of lanes	Design Service Volume (C)	V/C	LOS
Monday morning	2451.70	2	4000	0.61	B
Monday evening	3640.95	2	4000	0.91	E
Wednesday morning	2741.95	2	4000	0.69	B
Wednesday evening	2867.75	2	4000	0.72	C
Friday morning	2938.60	2	4000	0.73	C
Friday evening	3814.35	2	4000	0.95	E

4.4 Descriptive Analysis of Questionnaire Survey

Among the respondents are 53.8% women and 46.2% men (Fig. 5). The highest proportion of respondents is in the 21–40 age group (66.2%), positively affecting the study because this age group is the most involved in road accidents (Fig. 5(a) and Fig. 5(b)). The age group least represented was those over 60 (7.7%). In terms of education level, the group most represented is the degree holders (46%) and the majority of respondents work in the private sector (43%), as shown in Fig. 5(c) and Fig. 5(d), respectively. The majority of respondents (61.5%) used a car as their primary mode of transportation, followed by motorcycles (29.2%), van/multi-purpose vehicles (6.2%) and heavy vehicles (3.1%), as shown in Table 3. Cars are the preferable chosen mode in this area because of low traffic flow particularly on Monday and Wednesday mornings (Table 2), allowing the driver to avoid serious traffic accidents.

Most of the respondents have 0–10 years of driving experience (63.0%). The majority of respondents (84.6%) have travelled on this road, with most of them (33.3%) driving on it 1 to 3 times per week, with the purposes of work and school trips (Table 4). Some of them (23.1%) had experience with traffic accidents. These results are consistent with a previous study, which mentioned that in developing nations, the police are obliged to occupy more time controlling traffic, with less time available for traffic law enforcement [34]. Given that the majority of the respondents used cars or multi-purpose vans, they experienced no injury (76.9%).

As regards the respondents' travel experience, many of them (73.8%) faced difficulties concerning roundabouts (36.9%) and vehicles that travel to shops located too close to the street (15.3%). The mini roundabouts could create congestion when built inappropriately in relation to other access roads towards Kangar downtown because the majority of respondents commute for work and school purposes (Table 3). At busy intersections, road users cannot easily enter the junctions due to the lack of compromise amongst drivers. Motorcyclists, however, due to their smaller size, usually enter the junctions easily. However, they are at higher risk because other drivers might not notice and not have sufficient time to avoid collisions. Additionally, appropriate actions should be taken by local authorities in providing solutions and road treatment regarding scattered shops once a road accident has occurred on this street to decrease the rate of casualties and injuries. These findings are consistent with the report of the Perlis Strategic Development Plan 2012–2030, which mentions that bad road design has resulted in poor traffic flow and congestion during weekends and school holidays [11].

The major issues in transportation in this state are an unsatisfactory public transport system, the road system needing upgrading, the absence of a direct connection from Kangar to the North–South expressway and improper sustainable township planning.

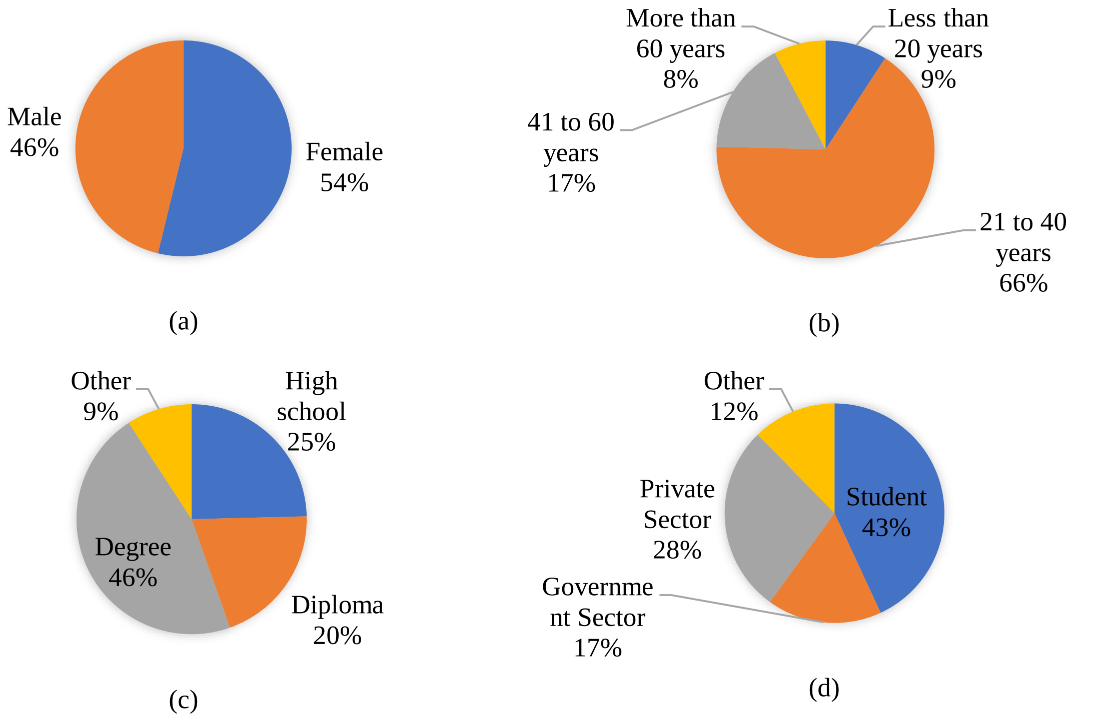


Fig. 5 - Demographic data of the respondents; (a) gender; (b) age; (c) highest education level; (d) type of occupation

Table 3 - Respondents' driving experience

Question	Category	No of Sample (N = 65)	Percentage (%)
How long have you been driving?	0 -10 years	41	63.0
	11-20 years	15	23.1
	21-30 years	4	6.2
	Over 30 years	5	7.7
What type of vehicles do you usually use?	Car	40	61.5
	Motorcycle	19	29.2
	Multi-purpose vehicle/Van	4	6.2
	Heavy Vehicle	2	3.1
How old is the vehicle that you are driving?	0-5 years	30	46.2
	6-10 years	16	24.6
	11-15 years	11	16.9
	Over 15 years	8	12.3
Have you received any summons during the past five years?	Yes	32	49.2
	No	33	50.8
What is your most common trip purpose?	Work	29	44.6
	Grocery Shopping	5	7.7
	Hospital	3	4.6
	College	28	43.1

Table 4 - Respondents' perspective on research location

Question	Category	No of Sample (N = 65)	Percentage (%)
Experiencing in using KM1-KM6 Kangar to Alor Setar state road	Yes	55	84.6
	No	10	15.4
Frequency of pass through KM1-KM6 Kangar to Alor Setar road	Everyday	18	27.7
	1 to 3 times per week	22	33.8
	3 to 6 times per week	15	23.1
	Never	10	15.4
Experience involving in road accident	Yes	15	23.1
	No	50	76.9
Severity of injuries	Severe injury	0	0
	Minor Injury	7	10.8
	Vehicle damage	8	12.3
	No injury	50	76.9
Face difficulties during driving on this road compared to other roadways	Yes	48	73.8
	No	17	26.2
Location that difficult to drive	Roundabouts	24	36.9
	Traffic Light	7	10.8
	Unsignalized intersection	7	10.8
	Street road which near to shops	10	15.3
	No difficulties	17	26.2

4.5 Statistical Analysis of the Causes of Accident

The obtained data from the questionnaire were analysed via PLS-SEM and tested with the measurement model, formative hierarchical component model, and structural models. The designed relationship of the models of four set of variables which is factors of human, vehicle, environment, and road to the risk of traffic accidents are shown in following sections.

4.5.1 Measurement Model

Table 5 presents the value of composite reliability (CR) at a range between 0.892 to 0.954 and Cronbach's alpha (CA) value at a range between 0.824 to 0.931. In this case, internal consistency and reliability are obtained because both criteria of CR and CA values are greater than the minimal required level of 0.70 [35].

Table 5 - Reliability and validity of constructs

Construct	CA	CR	AVE
HF	0.931	0.946	0.745
VF	0.891	0.917	0.649
EF	0.870	0.906	0.660
RSS	0.898	0.937	0.831
LTG	0.763	0.892	0.805
RSE	0.8678	0.938	0.883
RAC	0.874	0.914	0.727
ISN	0.824	0.919	0.850
MKG	0.928	0.954	0.874

Next, the convergent validity values via the analysis of the average variance extracted (AVE) are higher than the threshold of 0.6, and all the outer loading values for the study indicators were greater than standard values of 0.6 [24], as shown in Fig. 6. To assess the discriminant validity, the Fornell and Larcker criterion was used (Table 6). This criterion was used to compare the square root of the AVE to the correlations of latent constructs. In this case, it is valid because the square root of the AVE of each latent construct along the diagonals is greater than its correlation value, in correlation with other latent constructs, indicating that the mode met discriminant validity criteria [36].

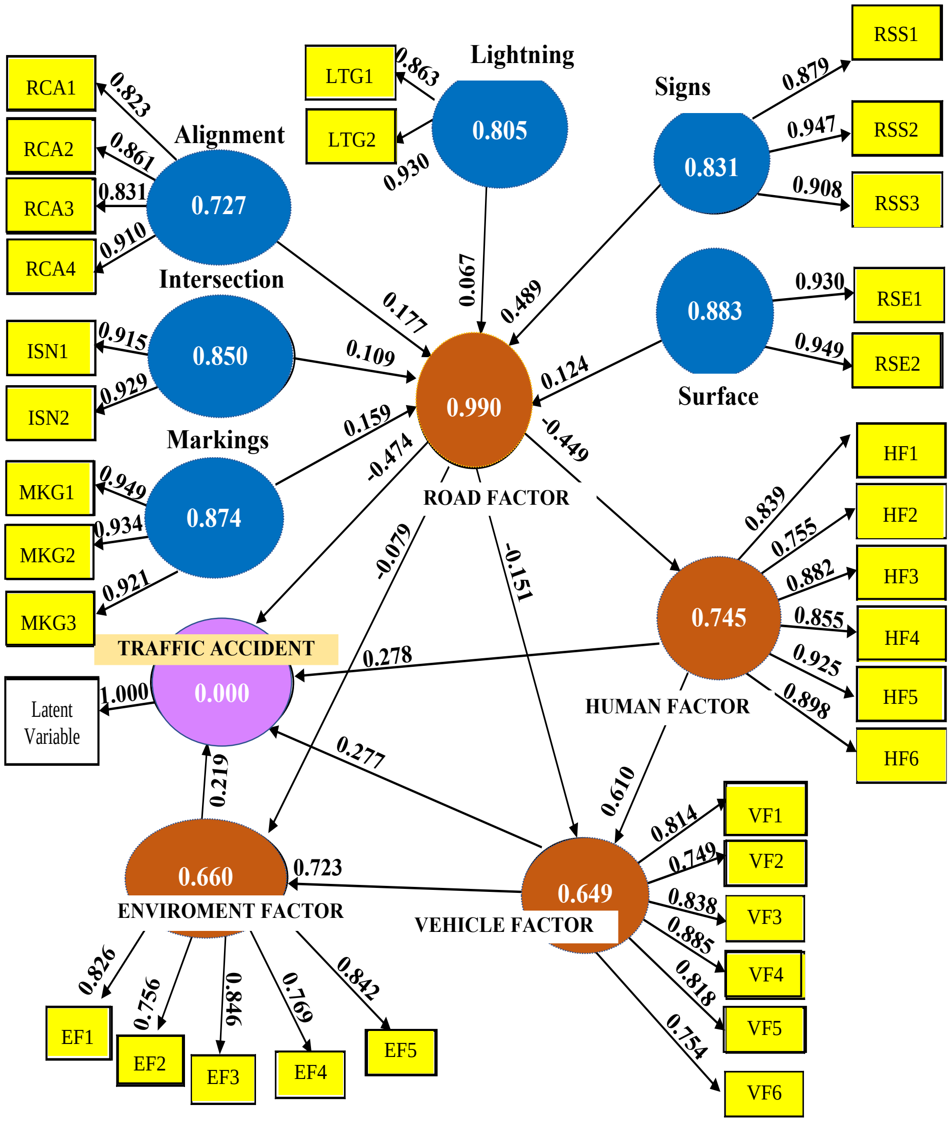


Fig. 6 - Measurement model for four factors of human, vehicle, environment, and road associated to traffic accidents

Table 6 - Fornell - Lacker criterion

Construct	EF	HF	VF	RAC	ISN	LTG	MKG	RSS	RSE
EF	0.812								
HF	0.518	0.863							
VF	0.756	0.677	0.805						
RAC	-0.199	-0.091	-0.222	0.853					
ISN	0.034	-0.211	-0.162	0.726	0.922				
LTG	-0.142	-0.244	-0.167	0.663	0.585	0.897			
MKG	-0.075	-0.238	-0.183	0.533	0.778	0.493	0.935		
RSS	-0.369	-0.404	-0.308	0.673	0.615	0.821	0.603	0.912	
RSE	-0.228	-0.207	-0.198	0.642	0.546	0.754	0.488	0.795	0.94

4.5.2 Formative Hierarchical Component Model

The relevance of outer weights in formative measurement models was first determined by establishing the acute level of collinearity assessment [37]. As a result, collinearity issues for the second order (road factors) are found. Table 7 shows the constructs of road signs (RSS), lighting (LTG), surface (RSE), alignment (RAC), intersection (ISN) and road marking (MKG) as predictors for collinearity in the inner model. The variance inflation factor (VIF) values for each construct are smaller than the threshold value of 5. Thus, these constructs are independent and measure various aspects of road characteristics to the risk of traffic accidents [37]. The RSS gave the highest VIF value (4.573), indicating that further action must be taken by the local authorities in Perlis, considering the sustainable safety planning for township and infrastructural modification of SS methods planning to further assist in decreasing the rate of road accidents.

Table 7 - Collinearity assessment of factor of road

Constructs	VIF
RSS	4.573
LTG	3.558
RSE	3.069
RAC	2.825
ISN	3.916
MKG	2.864

4.5.3 Structural Model to Test the Hypothesis

Table 8 shows the direct effects test of the selected factors of human, vehicle, environment and road to the causes of traffic accidents. Once the reliability and validity of the constructs have been established, structural model analysis is performed to test the hypotheses. This step concludes the identification of causes of accidents on the particular road. Three significant positive relationships were found to the cause of traffic accidents. The relationships are the road factors with difference relative value (t) = 6.166, and p-value = 0.000, vehicle factors (t = 4.339, p-value = 0.000) and human factors (t = 2.893, p-value = 0.005). However, the relationship between an environmental factor and the cause of traffic accidents was not significant with t = 0.769 and p = 0.443.

Table 8 - Direct effect validity test

Relationships	t-statistics	p-value
Human Factors	2.893	0.005
Vehicle Factors	4.339	0
Environment Factors	0.769	0.443
Road Factors	6.166	0

These findings agree with those previous researchers who used six years of data throughout all states in Malaysia. They concluded that road quality of particular area is the main cause of road accidents using one-way multivariate analysis of variance [27]. In this case, other than an appropriate road design, the local authorities should closely monitor the abundance of uneven roads in Perlis that need regrading. Uneven roads could cause the vehicle tires to be unable to grip the road surface and drivers to lose control. Furthermore, dark road conditions without lighting are dangerous for road users.

5. Conclusion

CST results show a significant relationship in accident trends between the severity of the crash and the age of driver and type of vehicles. However, no significant relationship is found between the severity of the crash and gender of the drivers. The results of the service quality of the road show an unpredictable result, where LOS on evenings of Monday and Friday leads to unstable flows, high volumes, extended delays at critical intersections and exceedingly slow urban street flow that will increase the risk of traffic accidents. For the causes of accident analysis, the structural model result indicated that the significant causes of road accidents are road, vehicle and human factors, where the p-value is less than the designated value of 0.05. Environmental factor that has been evaluated is not significant at a p-value of more than 0.05. These value are significant because the reliability and validity of data are obtained from measurement model and formative hierarchical component model test. The obtained results are important to increasing knowledge in assisting various government bodies such as the Department of Road Transport and MOT. The best countermeasure evaluation can be assessed and suggested to the authorities. the possible countermeasures include offering adequate road safety understanding via literacy campaigns, enhancing behavioural transformations and stern enforcement of current traffic laws to reduce the risk of traffic accidents.

Acknowledgement

The authors would like to thank the Police Station of Kangar, Perlis for providing the accident data for this research. We are grateful for the willingness of road users to answer the questionnaires and give their honest opinions during the survey.

References

[1] World Health Organization (2018), https://www. int/news-room/fact-sheets/detail/road-traffic-injuries, accessed online 6 April 2022.
[2] World Health Organization (2013), Global status report on road safety.
[3] Kamarudin, M. K. A., Wahab, N. A., Umar, R., Saudi. A. S. M., Saad, M. H. M., Rosdi, N. R. N., Razak, S. A. A., Merzuki, M. M., Abdullah, A. S., Amirah S. & Ridzuan, A. M. (2018). Road traffic accident in Malaysia: Trends, selected underlying, determinants and status intervention, International Journal of Engineering & Technology, 7(434), 112-117. https://DOI:10.14419/ijet.v7i4.34.23839
[4] Babar, M. A. R., Musarat, M. A., Alaloul, W. S., Ayub, S., Buhkhari, & Altaf, M. (2022). Road accident data collection systems in developing and developed countries: A review, International Journal of Integrated Engineering, 14(1), 336-352. https://DOI: https://doi.org/10.30880/ijie.2022.14.01.031
[5] Wei, F., Cai, Z., Wang, Z, Gou, Y., Guo, Li, X., & Wu, X. (2021). Investigating rural single-vehicle crash severity by vehicle types using full bayesian spatial random parameters logit model, Applied Sciences, 11(7). https://doi.org/10.3390/app11177819
[6] Md Isa, Z., Ismail, N. H., Ismail, R., Mohd, T. A., Ja'afar, M. H., Mat N. N., Miskan, M., Zainol, A. N., Ab Razak, N. H., & Yusof, K. H. (2022). Assessing factors associated with non-fatal injuries from road traffic accidents among Malaysian adults: A cross-sectional analysis of the PURE Malaysia Study. International Journal Environmental Research of Public Health, 19, 8246. https://doi.org/10.3390/ ijerph19148246
[7] Ministry of Transport Malaysia Official Portal Malaysia Road Fatalities Index. Available online: https://www.mot.gov.my/en/land/safety/malaysia-road-fatalities-index, accessed on 18 August 2022.
[8] Al-Bdairi, N. S. S., & Hernandez, S. (2020). Comparison of contributing factors for injury severity of large truck drivers in run-off-road crashes on rural and urban roadways: Accounting for unobserved heterogeneity. International of Journal Transportation Science Technology,9(2),116–127. https://doi.org/10.1016/j.ijtst. 2020.01.004
[9] Cicek, Z., & Ozturk, A. (2018). Importance of road parameters on traffic accidents. Transist Istanbul Transport Congress and Exhibition, Istanbul, Turkey.
[10] Musa, M. F., Hassan, S. A., & Mashros, N. (2020). The impact of roadway conditions towards accident severity on federal roads in Malaysia. PLoS One,15, (7), 1-12. https://doi.org/10.1371/journal.pone.0235564
[11] Perlis Strategic Development Plan 2012-2030 (2013), https://www.perlis.gov.my/image/pekeliling/perlis accessed online Nov. 2022.
[12] Manan, A.M.M. (2014). Motorcycles entering from access points and merging with merging traffic on primary roads in Malaysia: behavioral and road environment influence on traffic conflicts, Accident Analysis & prevention, 70, 301-313. https://doi: 10.1016/j.aap.2014.04.009
[13] Darma, Y., Karim, M. R., & Abdullah, S. (2017). An analysis of Malaysia road traffic death distribution by road environment. 42, 1605–1615. https://doi.org/10.1007/s12046-017-0694-9
[14] Che-Him, N., Roslan, R., Rusiman, M. S., Khalid, K. Kamardan, M. G., Arobi, F. A., & Mohamad, N. (2018) Factors affecting road traffic accident in Batu Pahat, Johor, Malaysia. Journal of Physic Conference Series, *995*, 12033
[15] Mahat, N., Jamil, N., & Raseli, S. S. (2020). Analysing road accident triggers in Malaysia by using analytical hierarchy process, GADING Journal of Science and Technology, 3, 2
[16] Shaadan, N., Azhar Suhaimi, M. I. K., M I Hazmir, M. I., & Hamzah, E. N. (2021). Road accidents analytics with data visualization: a case study in Shah Alam Malaysia, Journal of Physics: Conference Series, 1988 (2021) 012043, https://doi:10.1088/1742-6596/1988/1/012043
[17] Gopalakrisnan, S. (2012) A public health perspective of road traffic accidents, Journal Family Medicine Primary Care, 1(2), 144-150, https://doi: 10.4103/2249-4863.104987
[18] Department of Statistic Malaysia (2021) https://www.dosm.gov.my/ accessed online 16 Oct 2022.
[19] Malaysian Institute of Road Safety Research, Pelan Keselamatan Jalan Raya Malaysia 2022-2030. Selangor, Malaysia: Ministry of Transport Malaysia, https://www.miros.gov.my/xs/dl.php?filename=PKJRM_Sequence_ HiRes%20r.pd accessed online 6 April 2022.
[20] Retallack, A. E., & Ostendorf, B. (2020). Relationship between traffic volume and accident frequency at intersections. Internation of Journal. Environmental Research Public Health, 17(4). https://doi: 10.3390/ijerph17041393
[21] Yasin, Y. J., Grivna, M., & Abu-Zidan, F. M. (2021). Global impact of COVID-19 pandemic on road traffic collisions. World Journal of Energy Surgery, 16, 5. https://doi.org/10.1186/s13017-021-00395-8

[22] Wang, F., Wang, J., Zhang, X., Gu, D., Yang, Y., & Zhu, H. (2022). Analysis of the causes of traffic accidents and identification of accident-prone points in long downhill tunnel of mountain expressways based on data mining. Sustainability, 14, 8460. https://doi.org/10.3390/ su14148460
[23] Regev, S., Rolison, J. J., & Moutari, S. (2018). Crash risk by driver age, gender, and time of day using a new exposure methodology. Journal of Safety Research, 66, 131–140. https://doi.org/10.1016/j.jsr.2018.07.002
[24] Rolison, J. J., Regev, S., Moutari, S., & Feeney, A. (2018). What are the factors that contribute to road accidents? An assessment of law enforcement views, ordinary drivers' opinions, and road accident records. Accident Analysis & Prevention. 115, 11-24. https://doi.org/10.1016/j.aap.2018.02.025
[25] Hlaing, K. P., Thwet, N., Aung, T., Hlaing, S. Z., & Ochimizu, K. (2021). Performance Variability Analysis on Road Accident in Yangon. Science Technololgy Publication, 2, In Proceedings of the 23rd International Conference on Enterprise Information Systems (ICEIS), 329–336.
[26] Termidi, W. N. S. M. A., Mashros, N., Hassan, S. A., Faiz, R. U., Mohamed, A., & Rahman, R. A. (2021). Assessment of young drivers' driving behaviour and driving speed along horizontal and vertical alignments. International Journal Integration Engineering, 13(3), 215–222. https://doi.org/10.30880/ijie.2021.13.03.026
[27] Zulhizad, M., L., & Ismail, N., M. (2021). Statistical Analysis of Road Accident in Malaysia, Proceedings of Science and Mathematics, 2, 177-185
[28] Muhammad, L. J., Salisu, S., Yakubu, A., Malgwi, Y. M., Abdullahi, E. T., Mohammed, I. A., & Muhammad, N. A. (2017). Using Decision Tree Data Mining Algorithm to Predict Causes of Road Traffic Accidents, its Prone Locations and Time along Kano–Wudil Highway. International Journal of Database Theory and Application, 10(1), 197–206. http://dx.doi.org/10.14257/ijdta.2017.10.1.18
[29] Najib, L., Abdullah, L., Abdullah, I., & Salleh, Z. (2012). Weight of road accident causes using analytic hierarchy process. ARPN Journal of Science and Technology, *2*(2), 39–44.
[30] Shen, C., Panda, S., Vogelstein, J. T. (2022). The Chi-Square Test of Distance Correlation. Journal of Computational and Graphical Statistics, 31(1), 254–62. https://doi.org/10.1080/10618600.2021.1938585
[31] Retallack, A. E, Ostendorf, B. (2019). Current Understanding of the Effects of Congestion on Traffic Accidents. International Journal of Environmental Research and Public Health, 16(3400), 1–13. https://doi.org/10.3390/ijerph16183400
[32] Transportation Research Board (2000). Highway capacity manual 2000 (HCM 2000). Environmental Protection.
[33] In, J. (2017). Introduction of a pilot study. Korean Journal of Anesthesiology, 70(6), 601–5. https://doi.org/10.4097/kjae.2017.70.6.601
[34] Jadaan, K., Al-Braizat, E., Al-Rafayah, S., Gammoh, H., & Abukahlil, Y. (2018). Traffic safety in develop and developing countries: A comparative analysis. Journal of Traffic Engineering, 6,1. https://doi: 10.18178/jtle.6.1.1-5
[35] Finch, H., Sheng, Y., Reales, J. M., Trizano-Hermosilla, I., & Alvarado, J. M. (2016). Best alternatives to Cronbach's Alpha reliability in realistic conditions:Congeneric and aymmetrical measurements. Frontier in Psychology, 7, 69. https://doi.org/10.3389/fpsyg.2016.00769
[36] Hair, J. F. J., Hult, J. F., Ringle, G. T. M., & Sarstedt, M. (2017). A primer on Partial Least Square Structural Equation Modeling (PLS-SEM), Thousand Oaks, Sage Publishing Inc.
[37] Hair, J., Hollingsworth, C. L., Randolph, A. B., & Chong, Y. L. (2017). An updated and expanded assessment of PLS-SEM in information systems research. Industrial Management and Data System, 117(3), 442-458. https://doi.org/10.1108/IMDS-04-2016-0130