International Journal on Advanced Technology, Engineering, and Information System
https://ojs.transpublika.com/index.php/IJATEIS
Online ISSN 2828-5425

https://doi.org/10.55047/ijateis.v4i2.1809

Original Article

Identification of Variables Affecting the Number of Traffic Accident Casualties (Intersections (4 and T) in Yogyakarta)

Ari Tri Kusuma Dewi[1*], Martha Leni Siregar[2], Sutanto Soehodho[3]

[1-3]Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Depok, Indonesia
Email: [1)] aritrikusumadewi@gmail.com, [2)] leni@eng.ui.ac.id, [3)] sutantos@ui.ac.id

Received : 15 May - 2025
Accepted : 17 June - 2025
Published online : 24 June - 2025

Abstract

Yogyakarta has recorded a relatively high rate of traffic accidents, with a consistent trend throughout 2024. This condition is influenced by high traffic density, a consequence of increased activity in the education, tourism, and economic sectors, despite the implementation of various mitigation efforts. The aim of this study is to identify the variables that potentially influence the number of traffic accident casualties at (4 and T) intersections in Yogyakarta. The study utilized initial data collection through CCTV recordings at accident locations, data from the Integrated Road Safety Management System (IRSMS), Google Street View observations, and multiple linear regression analysis combined with variable reduction based on Variance Inflation Factor (VIF) values. The results indicate that eight variables significantly influence the number of traffic accident casualties in Yogyakarta. However, limited Smart City CCTV coverage restricts comprehensive analysis. Future research requires expanded intersection monitoring and extended study scope to enhance validity and representation.

Keywords: Number of Traffic Accident Casualties, Traffic Accidents, IRSMS, VIF, Road Intersections.

1. Introduction

In line with the growth of the transportation sector in major cities, Yogyakarta has also experienced rapid development in this area. Changes in travel patterns, such as the shift from public transportation to private vehicles, have contributed to increased traffic volume and congestion at various strategic points in the city (Firdausy et al., 2019). Without integrated measures, the surge in vehicle numbers may worsen traffic congestion, increase fuel consumption, and raise the risk of traffic accidents, ultimately impacting road safety and the quality of life for the public (Said et al., 2019). In the city of Yogyakarta, traffic accidents have become a serious issue, as evidenced by the available accident data in the region, as shown in the table below.

Table 1. Traffic Accident Data by Type of Incident and Impact (January–November 2024)

Traffic Accidents											
Description	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**
Number of Incidents	568	548	576	609	570	605	627	651	638	639	323
Fatalities (F)	51	36	41	47	42	52	40	47	50	35	14
Serious Injuries (SI)	0	0	1	0	1	0	0	1	0	0	3
Minor Injuries (MI)	713	779	774	783	782	845	844	855	852	870	439
Material Losses (Rp '000)	397,625	345,620	331,051	388,289	376,800	396,305	318,000	465,775	4,536,075	446,350	275,100
Single-Vehicle Accidents											
Description	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**
Number of Incidents	126	123	114	86	76	88	81	84	85	70	43
Fatalities (F)	4	5	2	4	2	4	2	2	2	0	0
Serious Injuries (SI)	0	0	0	0	1	0	0	0	0	0	1
Minor Injuries (MI)	160	216	151	110	105	124	101	116	104	92	58
Material Losses (Rp '000)	80,600	88,250	39,968	35,400	28,600	68,300	31,355	33,725	4,056,600	37,900	91,750

This study aims to broaden the scope of analysis by integrating multiple contributing factors to traffic accidents and assessing the role of smart city technologies—such as data-driven traffic management systems and real-time monitoring—as a means of reducing accident rates and enhancing road safety, specifically in Yogyakarta. Thus, this study not only seeks to advance the understanding of accident causality but also to propose technology-based solutions that could improve safety and quality of life for the residents of Yogyakarta.

The central research question addressed in this study is: What are the contributing factors to traffic accidents at the two types of intersections (4-way and T-junctions) in Yogyakarta? To explore this question, the study tests the hypothesis that average vehicle speed and the type of violation committed by the perpetrator are variables that significantly influence the number of casualties resulting from traffic accidents at 4-way and T-intersections (Rizki, 2019; Sabrina et al., 2022; Saprollah et al., 2022; Sisra, 2022). The novelty of this research lies in its comprehensive scope, which integrates various contributing factors to traffic accidents and examines the implementation of smart city technologies—such as data-driven traffic management systems and real-time monitoring—to reduce accident rates and enhance road safety, specifically in Yogyakarta.

2. Literature Review

Traffic accidents are incidents that occur on public roads involving motor vehicles colliding with other objects, resulting in damage to vehicles or other property (Zein et al., 2024). These events often lead to injuries or even fatalities, affecting both humans and animals. Another definition describes a traffic accident as a sudden and unintentional incident on the road, involving vehicles and possibly other road users, which results in casualties or material losses.

According to the Law of the Republic of Indonesia Number 22 of 2009 concerning Road Traffic and Transportation, traffic accidents are classified into three categories: minor, moderate, and severe accidents. Minor accidents result in damage to vehicles and/or goods. Moderate accidents cause minor injuries in addition to vehicle and/or property damage. Severe accidents involve fatalities or serious injuries.

2.1. Traffic Accident

Traffic accidents can also be categorized into four types based on various criteria (Prasetyanto & Santosa, 2011): accidents based on the victims, accidents based on the position of the vehicles, accidents based on the number of vehicles involved, and accidents based on the characteristics of the road users involved. The severity level of an accident can be determined according to the specific category of the accident type.

Types of accidents based on the victims, as stipulated in Government Regulation of the Republic of Indonesia No. 43 of 1993 Article 93 Paragraph 1, include the following: a fatality refers to an individual who is confirmed to have died as a result of a traffic accident within a maximum of 30 days after the incident; a seriously injured victim is an individual who suffers permanent disability or requires medical treatment for more than 30 days following the accident; while a minor injury victim is someone who does not fall into the category of either a fatality or a seriously injured person.

Based on the position of the vehicles at the time of the accident, traffic accidents can be classified into six types. A head-on collision occurs when two or more vehicles collide at the front sections while moving in opposite directions. A rear-end collision happens when the front part of one vehicle strikes the rear of another vehicle, both moving in the same direction and lane. A side-front or side collision involves the side of one vehicle crashing into the front or side of another vehicle, which may be traveling in the same or opposite direction but in a different lane. A backing collision takes place when a vehicle is moving in reverse and hits another vehicle. An angle collision refers to a crash involving two vehicles traveling in different, but not opposite, directions, forming an angle at the point of impact. Lastly, a loss-of-control accident occurs when the driver is unable to maintain control of the vehicle, causing it to overturn or veer off the road.

According to Law Number 22 of 2009 concerning Road Traffic and Transportation, various types of traffic violations are regulated. These violations may be subject to penalties in the form of fines, traffic tickets, or imprisonment, in accordance with legal provisions. Violations that can be identified through Smart City CCTV and IRSMS monitoring include the following: Speed-related offenses, such as illegal street racing or reckless speeding; helmet violations, including failure to wear a helmet that meets national standards or passengers not wearing helmets; concentration-related violations, such as using a mobile phone while driving or driving under the influence of alcohol or when drowsy; driving against the flow of traffic; documentation violations, such as not possessing or carrying a driver's license (SIM) or vehicle registration certificate (STNK); overloading, particularly carrying more than one passenger on a motorcycle; traffic sign violations, including turning or changing lanes without signaling, and running red lights; headlight violations, such as not turning on headlights at night; equipment violations, which include driving without technical equipment like mirrors, lights, or a horn; and other offenses such as riding on sidewalks, entering BRT (Bus Rapid Transit) lanes, failing to yield to priority vehicles, obstructing traffic by parking or stopping improperly, and hit-and-run incidents.

2.2. Variables Affecting the Number of Traffic Accident Casualties

Variables Affecting the Number of Traffic Accident Casualties can be defined from Literature Review. The most important variable is traffic intersections, or junctions, are essential elements within the road network system, particularly in urban areas where multiple roads converge. Intersections provide drivers with the option to either continue along the same route or turn onto another road. An intersection serves as a node within the road network where different roads meet, allowing vehicles from various directions to cross paths. The traffic flow on each approach of an intersection interacts with flows from other approaches.

Based on their physical form, intersections can be categorized into T-intersections, four-leg intersections, and roundabouts. However, this study focuses only on T-intersections and four-leg intersections. The next Variable is Road geometry (Feryanti & Mulyono, 2019; Pujiastutie et al., 2015). Road geometry refers to the physical design and dimensions of a roadway, encompassing the cross-sectional and longitudinal profiles, as well as other features related to the road's physical structure, such as road type. In this study, the road geometry also includes observations on the presence of road markings, signage, traffic signals, and medians.

The types of vehicles involved as perpetrators and victims are also considered factors influencing the number of traffic accident casualties. Vehicle types are classified into several categories as Unmotorized (UM), Motorcycle (MC), Light Vehicle (LV), and Heavy Vehicle (HL). Unmotorized vehicles (coded UM) refer to those powered by human or animal force, such as bicycles, pedicabs, horse carriages, and pushcarts. Motorcycles (MC) include motorized two- or three-wheeled vehicles like motorcycles, scooters, and three-wheeled vehicles such as *bajaj* and three-wheeled Vespas. Light vehicles (LV) are motorized four-wheeled vehicles with two axles and an axle distance between 2.0 and 3.0 meters; examples include cars, sedans, minibuses, pickups, small buses, and small trucks. Heavy vehicles (HV) consist of motorized vehicles with more than four wheels and an axle distance greater than 3.5 meters, such as buses, two-axle trucks, three-axle trucks, combination trucks, and articulated trucks. This classification helps in analyzing how different vehicle types contribute to accident severity and casualty numbers.

Traffic speed is defined as the space mean speed, representing the average speed of vehicles along a specific road segment (Prasetyanto & Santosa, 2011; Yandi et al., 2020). This space mean speed is calculated based on the speeds of vehicles passing through the segment within a certain time, reflecting the overall operational conditions of the road. Speed varies according to vehicle type—for example, light vehicles (cars), heavy vehicles (trucks, buses), and motorcycles typically travel at different speeds on the same road segment. Average traffic speed is also considered to have an influence on the number of traffic accident casualties. In addition to traffic speed, traffic volume is also considered to have an influence. Traffic volume can be defined as the number of vehicles passing a specific point on a road segment or intersection within a certain time, usually expressed in vehicles per hour (vehicles/hour). Traffic volume reflects the flow of vehicles passing an observation point during a given time, such as peak hours or the average daily volume.

2.3. Previous Research

Several studies have examined the issue of traffic accidents and the various contributing factors. Nevertheless, despite the findings of prior research (Chand et al., 2021; Fadhil & Susanto, 2023; Radam et al., 2022; Rifai & Aulia, 2019; Touahmia, 2018; Wang et al., 2023), there remains a lack of detailed analysis regarding the causal factors of traffic accidents through a holistic approach. Existing research does not thoroughly explore the factors contributing to traffic accidents at the two types of intersections in Yogyakarta, which are the focus of this study.

Based on the review conducted by Fadhil & Susanto (2023); Hu et al. (2023); Kusumaningrum & Widyaningsih (2023); Li et al. (2023); Pop & Proştean (2018); Radam et al. (2022); Saputra et al. (2022); Silaban et al. (2023); Wahyudin (2018); Wang et al. (2023); Yunus (2022), on various methods employed in transportation and smart city research, it can be concluded that the analytical approaches used are highly diverse and multidisciplinary in nature. Previous studies have utilized quantitative methods such as road capacity calculations based on the Indonesian Highway Capacity Manual (IHCM) 1997, statistical analysis using

3. Methods

This study will be conducted at two major intersections in Yogyakarta City, namely the Four-Leg Intersection and the T-Intersection. These locations were selected due to their high traffic volumes and frequent congestion, which increase the risk of traffic accidents. The selection of these sites was based on several considerations. The Four-Leg Intersection is one of the busiest in Yogyakarta, connecting several main roads frequently used by motor vehicles, particularly four-wheeled vehicles. This intersection often experiences traffic congestion during peak hours and has recorded a number of traffic accidents. The T-Intersection, located in the city center, plays a crucial role in the distribution of traffic between different areas. The road conditions and intersection design—comprising a straight road and a sharp turn, often influence driver behavior and potentially contribute to a higher incidence of accidents.

3.1. Data Collection

This study begins with the identification of the problem, namely the high number of accidents occurring at intersections. It then proceeds with the formulation of the research problem and the establishment of research objectives. A literature review is subsequently conducted to provide the theoretical foundation that supports the study, prior to the data collection phase.

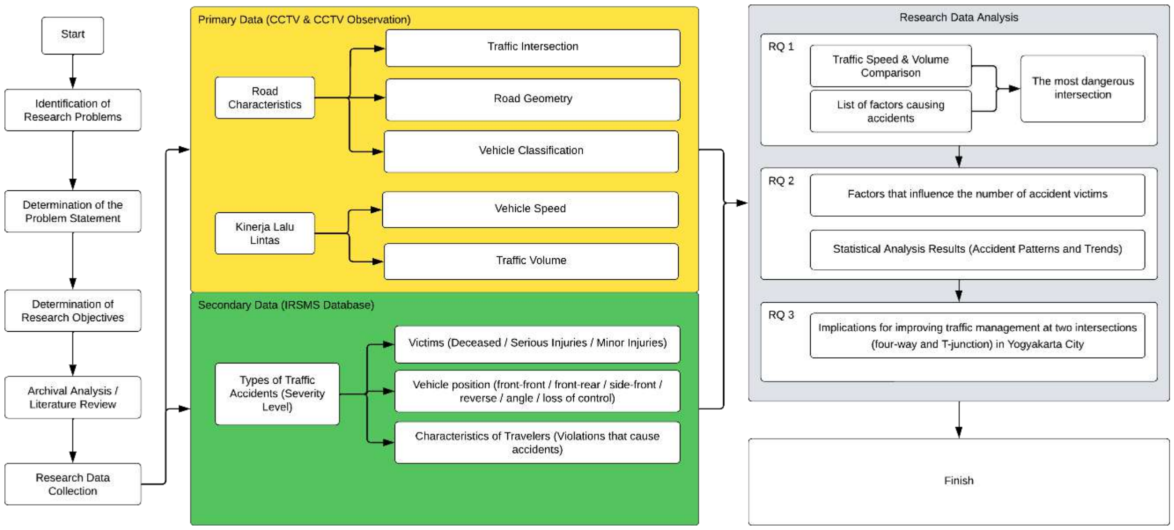

Figure 1. Research Flowchart

Data collection in this study is divided into two categories: primary data and secondary data. Primary data collection was carried out through direct surveys at three intersections monitored by the Smart City CCTV system, as well as direct observation of driver behavior at the three main intersections in Yogyakarta City, namely four-leg and T-intersections. Primary data were collected on weekdays and during peak hours to capture driver behavior during high-traffic periods that are considered to reflect normal traffic patterns. Secondary data were obtained from traffic accident reports (IRSMS) recorded over the past four months (January–April 2025) at each intersection. The purpose of collecting secondary data is to identify traffic accident trends at the three major intersections, including the number of accidents, accident severity, and the chronology of each incident.

In this study, the researchers used CCTV as a visual observation tool, which was highly relevant for improving the accuracy and objectivity of the data, especially in the analysis of accidents without witnesses and the real-time observation of traffic patterns. These data were integrated with the Integrated Road Safety Management System (IRSMS), an integrated road safety management system utilized by the Traffic Corps of the Indonesian National Police (Traffic Corps – INP) to collect, analyze, and process traffic accident data across Indonesia. Additionally, geometric data from the Department of Transportation (DOT) of Yogyakarta City and Sleman City were integrated with Google Street View analysis to complement the research data.

In collaboration with the District Police of Yogyakarta City and Sleman City, the researchers collected accident data that occurred at four-way intersections (X junctions) and T-junctions. These data were then sorted; only accident data from four-way and T-junctions equipped with CCTV and recorded in the IRSMS were included in the analysis. The data were then transformed from their original measurement scales into other forms appropriate to the data conditions to meet the assumptions of statistical analysis.

3.2. Data Analysis

Based on the established literature review and the defined research stages (Research Flowchart), several variables will be involved in this study (Table 2).

Table 2. Research Variables

Variable Type	Variable Name
Y	Number of Victims
X1	Geometric Form
X2	Road Function
X3	Road Class
X4	Road Type
X5	Road Status
X6	Speed Limit
X7	Road Markings
X8	Traffic Signs
X9	Traffic Signal
X10	Median
X11	Lighting Conditions
X12	Average Speed
X13	Average Volume
X14	Offending Vehicle
X15	Victim Vehicle
X16	Accident Type (Collision Position)
X17	Type of Violation

In this study, a nominal scale of measurement is employed for analytical purposes. The nominal scale serves to identify and differentiate data that are classified and categorized based on names or symbolic labels. This scale is characterized by the absence of mathematical operations, ordering, or ranking. Specifically, it is used to classify the types of traffic violations committed by drivers, such as failure to wear a helmet, violation of road markings, or driving against the flow of traffic. Each category represents a distinct class without any inherent order or measurable difference beyond the presence or absence of the attribute. Furthermore, the nominal scale is utilized to classify intersections according to their types, as these categories are not amenable to numerical ordering.

The measurement scale used fulfills the assumptions for statistical analysis, which are: In this dataset, the range of victims per case is 1–3. Intersection types in the road system are classified into two categories: 4-way (X-type) intersection (1) and three-way (T-type) intersection (2). This grouping helps in understanding how intersection configuration affects accident occurrences. As for another scale that is used, it is:

Table 3. Nominal Scale of Road Function Types

Measurement Scale	Road Function	Description
1	Neighborhood Road	Roads within residential or limited-access areas
2	Local Road	Serves access to neighborhoods or residential zones
3	Collector Road	Connects local roads to arterials; medium traffic volume
4	Arterial Road	Serves long-distance travel; high volume and speed

Table 4. Nominal Scale of Road Class

Measurement Scale	Road Class	Description
1	Class III	Collector roads, for single-axle vehicles; width ≥ 5–6 m
2	Class II	Arterial roads for medium-heavy vehicles; width ≥ 7 m
3	Class I	Expressways for large and long vehicles; width ≥ 11 m

Table 5. Nominal Scale of Road Status

Measurement Scale	Road Status Category	Description
1	Regency/City Road	A road that connects district centers, villages, and local areas within regencies
2	Provincial Road	A road that connects provincial capitals with regency/city capitals
3	National Road	A road that connects provincial capitals or major national corridors

Table 6. Nominal Scale of Road Type

Measurement Scale	Road Category	Description
1	2/2 UD	2-lane / 2-way road without median separation (undivided)
2	4/2 UD	4-lane / 2-way road without median separation (undivided)
3	4/2 D	4-lane / 2-way road with median separation (divided)
4	6/2 D	6-lane / 2-way road with median separation (divided)

Table 7. Nominal Scale of Vehicle Types

Measurement Scale	Code	Vehicle Type	Description	Main Example
1	UM	Unmotorized	Vehicles powered by human or animal force	Bicycles, pedicabs, horse-drawn carriages, pushcarts
2	MC	Motorcycle	Two- or three-wheeled motor vehicles	Motorcycles, scooters, three-wheeled vehicles (*bajaj*, three-wheeled vespa)
3	LV	Light Vehicle	Four-wheeled motor vehicles, two axles, axle distance 2.0–3.0 meters	Cars, sedans, minibuses, pickups, *oplets*, microbuses, small trucks
4	HV	Heavy Vehicle	Motor vehicles with more than four wheels, axle distance >3.5 meters	Buses, two-axle trucks, three-axle trucks, combination trucks, trailers/semi-trailers

Table 8. Nominal Scale of Road Markings, Signs, Traffic Signals, and Medians

Measurement Scale	Category	Description
0	Not Present	The element/violation/facility is completely absent
1	Present but Unclear	Presence cannot be confirmed with certainty; partially visible, vague, or incomplete
2	Present	The element/violation/facility is clearly and definitely present

Table 9. Nominal Scale of Violation Types

Measurement Scale	Category	Description
1	Speed	Illegal street racing / reckless speeding
2	Helmet	- Not wearing a helmet that meets national standards - Motorcycle passenger not wearing a helmet
3	Concentration	- Using a mobile phone while riding - Riding while intoxicated or drowsy
4	Wrong-Way Driving	Driving against the direction of traffic
5	Documents	- Not having/carrying a driver's license (SIM) - Not carrying vehicle registration (STNK)
6	Excess Passengers	Carrying more than one passenger on a motorcycle
7	Road Markings	- Turning/changing lanes without signaling - Running a red light
8	Headlights	Not turning on headlights at night

Measurement Scale	Category	Description
9	Equipment	Riding without required technical equipment (mirrors, lights, horn)
10	Others	- Riding on the sidewalk - Entering BRT (Bus Rapid Transit) lanes - Not yielding to priority vehicles - Obstructing traffic (illegal parking or stopping) - Hit and run

Table 10. Nominal Scale of Lighting Conditions

Measurement Scale	Category
1	Bright / Clear
2	Dim / Unclear

Table 11. Nominal Scale of Accident Type (Collision Position)

Measurement Scale	Category	Description
1	Head-On Collision	Two vehicles collide front-to-front from opposite directions.
2	Rear-End Collision	The front of a vehicle hits the rear of another vehicle in the same lane and direction.
3	Side-Front Collision/ Angular Collision	A vehicle's side collides with the front of another vehicle.
4	Reverse Collision	Collision occurs while a vehicle is reversing.
5	Angle Collision	Two vehicles moving in different (non-opposite) directions collide at an angle.
6	Loss of Control	Vehicle veers off course, overturns, or becomes uncontrollable.

Table 12. Nominal Scale of Speed Limits

Measurement Scale	Category	Speed Range
1	Low Speed	40 km /h
2	Moderate Speed	50 km/h
3	High Speed	60 km/h

Table 13. Nominal Scale of Average Speed

Measurement Scale	Category	Speed Range	Description
1	Low Speed	< 30 km/h	Commonly occurs in dense or slow traffic conditions
2	Moderate Speed	30 – 40 km/h	Typical speed in urban areas/busy intersections
3	High Speed	> 40 km/h	Normally occurs on arterial roads, highways, or due to negligence

Table 14. Nominal Scale of Average Traffic Volume

Measurement Scale	Volume Category	Degree of Saturation (DS)	Volume Characteristics (veh/hr)	Description
1	Low Volume	DS < 0,55	< 1500	Smooth flow, high and stable speed
2	Moderate Volume	0,55 ≤ DS < 0,80	1500 - 2400	Stable flow, speed starts to be limited
3	Heavy Volume	0,80 ≤ DS ≤ 1,00	2400 - 3000	Congested flow, decreasing speed
4	Very Heavy / Saturated	DS > 1,00	> 3000	Jammed traffic, very low speed

Following the data collection process, the subsequent step is data transformation. Data transformation is the process of converting data from its original measurement scale into another form to meet the assumptions of statistical analysis. With the Accident Data List and Road Geometry Accident Data that have been collected, the data is sorted according to the date of the incident.

After the initial data transformation, multiple linear regression analysis was performed using SPSS 25 software. Multiple linear regression is a statistical technique used to analyze the relationship between a single dependent variable and two or more independent variables. This method allows researchers to predict the value of the dependent variable based on the values of the independent variables, while also assessing the individual contribution of each independent variable.

Insignificant regression coefficients may have resulted from the small sample size or the limited number of four-way (X) and T-junctions with CCTV in Yogyakarta. To identify variables influencing the number of victims, iterative analysis and reduction of variables with a Variance Inflation Factor (VIF) >10—indicating high multicollinearity—were conducted. The iteration and variable reduction were stopped once the VIF values for all variables fell below the critical threshold of 5.

4. Results and Discussion

4.1. Research Results

From the initial data processing, a total of 14 traffic accident cases (January–April 2025) were identified that met the research criteria.

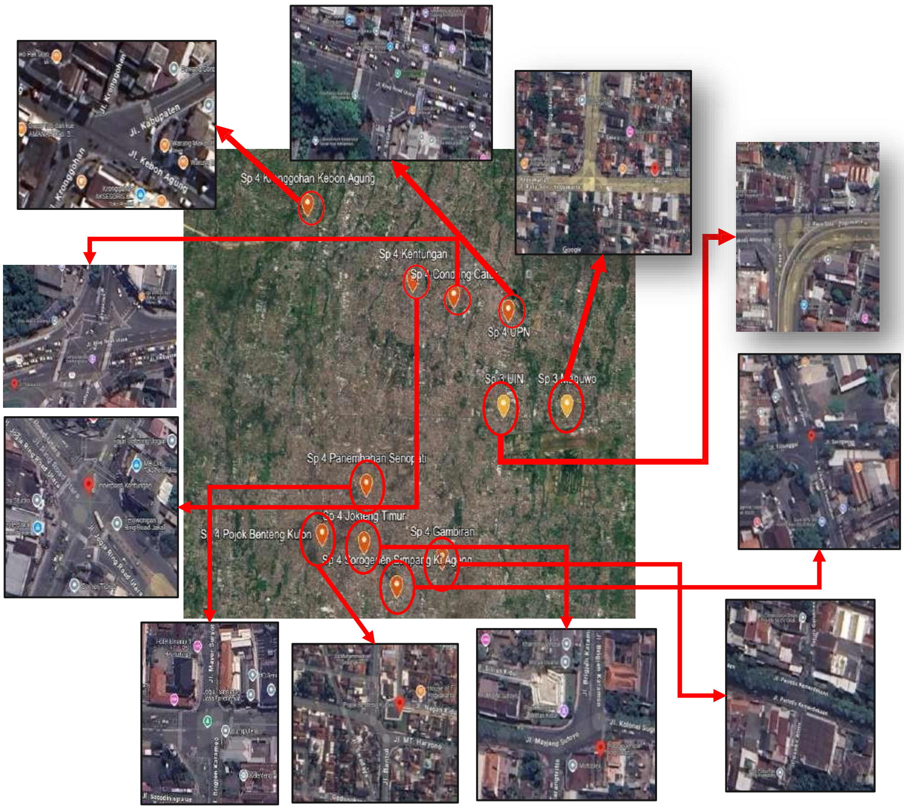

Figure 2. Location of Data Collection

4.1.1. Transformed Accident Case Data

The 14 traffic accident cases included detailed information that was translated into the study's analytical variables.

Table 15. Transformed Accident Case Data

Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17
2	1	4	3	4	3	3	3	1	3	3	1	3	4	3	2	3	7
2	1	3	1	1	1	1	1	1	3	1	1	3	1	3	2	3	7
1	1	3	2	1	1	1	3	2	3	1	2	1	1	2	2	3	10
3	1	4	3	2	1	1	3	3	3	3	1	1	3	2	3	5	7
2	1	3	2	3	1	1	3	3	1	3	1	3	1	3	2	2	3
2	1	4	2	3	1	1	3	2	3	3	1	3	2	2	2	2	7
1	1	4	3	4	3	3	3	3	3	3	1	3	3	2	2	5	7
1	1	4	2	3	3	3	1	1	3	1	1	3	1	2	2	3	7
1	1	4	2	3	3	3	3	3	3	3	1	1	1	2	2	5	7
2	1	3	2	2	1	1	3	3	3	3	1	2	2	2	2	2	10
3	2	4	2	1	3	2	2	3	3	3	1	1	3	2	2	5	7
1	2	4	2	3	3	2	2	3	3	3	1	1	3	2	3	1	7
1	2	4	3	4	3	3	2	3	3	3	1	1	1	2	2	3	7
1	2	4	2	3	3	2	2	3	3	3	1	1	3	2	2	5	7

Description:

Y (Number of Victims)
X1 (Geometry Type)
X2 (Road Surface)
X3 (Road Class)
X4 (Road Type)
X5 (Road Status)
X6 (Speed Limit)
X7 (Road Markings)
X8 (Traffic Signs)
X9 (Traffic Signals)
X10 (Signal Medium)
X11 (Lighting Condition)
X12 (Average Speed at Intersection (km/h))
X13 (Average Traffic Volume (PCU/hour))
X14 (Vehicle Type - Perpetrator)
X15 (Vehicle Type - Victim)
X16 (Accident Type)
X17 (Violation Type)

4.1.2. Multi Linear Regression

Using multiple linear regression analysis, it was found that the Variance Inflation Factor (VIF) values indicate high multicollinearity, especially in variables X8 (VIF = 19.932), X9 (VIF = 20.726), and X17 (VIF = 18.074). Thus, even though the coefficient results suggest possible directions of influence, the model cannot be validly interpreted due to the high multicollinearity and the absence of statistical significance values, a result of the limited data in this study.

Table 16. Multiple Linear Regression Coefficient Results

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	6.865	.000	–	–	–	–	–
	X1	.500	.000	.315	–	–	.091	11.027
	X3	1.000	.000	.777	–	–	.230	4.357
	X4	-1.000	.000	-1.452	–	–	.131	7.607
	X6	-.125	.000	-.154	–	–	.224	4.472
	X7	.625	.000	.634	–	–	.094	10.642
	X8	-.562	.000	-.643	–	–	.050	19.932
	X9	-.115	.000	-.082	–	–	.048	20.726
	X11	-2.500	.000	-.897	–	–	.160	6.253
	X13	-3.582E-16	.000	.000	–	–	.214	4.665
	X14	-.250	.000	-.143	–	–	.245	4.079
	X15	-.250	.000	-.122	–	–	.216	4.627
	X16	-.263	.000	-.117	–	–	.133	7.504
	X17	-.146	.000	-.315	–	–	.055	18.074

a. Dependent Variable: Y

To improve the model, the researcher reduced the number of variables by removing those with high VIF values.

Table 17. Multiple Linear Regression Coefficients – Iteration 1 (Reducing Variables X8, X9, X17)

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.333	.000	–	–	–	–	–
	X1	-.719	.000	-.453	–	–	.031	32.716
	X2	1.035	.000	.651	–	–	.174	5.737
	X3	1.491	.000	1.159	–	–	.059	16.963
	X4	-1.000	.000	-1.452	–	–	.131	7.607
	X5	.947	.000	1.306	–	–	.006	161.570
	X6	-1.298	.000	-1.598	–	–	. 006	159.223
	X7	.158	.000	.160	–	–	.127	7.850
	X11	-2.053	.000	-.736	–	–	.360	2.778
	X12	-.035	.000	-.047	–	–	.072	13.826
	X13	-.211	.000	-.303	–	–	.128	7.836
	X14	.825	.000	.471	–	–	.384	2.601
	X15	-.772	.000	-.376	–	–	.152	6.580
	X16	-.193	.000	-.361	–	–	.231	4.334
a. Dependent Variable: Y								

After reducing variables based on the multicollinearity threshold (VIF > 10), the new regression model still shows serious multicollinearity, as reflected by very high VIF values, particularly for variables X5 (VIF = 161.570), X6 (VIF = 159.223), X1 (VIF = 32.716), and X3 (VIF = 16.963). This indicates that even after eliminating several variables, the multicollinearity structure within the data remains very strong, which can affect the stability and interpretation of the coefficient estimates.

Table 18. Multiple Linear Regression Coefficients – Iteration 2 (Reducing Variables X5, X6, X1, X3)

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-2.548	6.566	–	-.388	.724	–	–
	X2	.792	.869	.499	.911	.429	.202	4.944
	X4	-.816	.303	-1.184	-2.690	.074	.312	3.202
	X7	.269	.752	.273	.358	.744	.104	9.621
	X10	.402	.994	.459	.404	.713	.047	21.307
	X11	-.588	2.479	-.211	-.237	.828	.077	13.064
	X12	.280	.534	.374	.523	.637	.118	8.446
	X13	-.030	.311	-.043	-.096	.930	.302	3.309
	X14	.621	.639	.355	.972	.403	.454	2.203
	X15	.234	.838	.114	.279	.798	.363	2.754
	X16	-.002	.216	-.004	-.010	.993	.371	2.696
a. Dependent Variable: Y								

The results of this iteration still indicate a serious issue with multicollinearity. Several variables, such as X10 (VIF = 21.307) and X11 (VIF = 13.064), exhibit very high Variance Inflation Factor (VIF) values, exceeding the commonly accepted threshold of 10. This suggests a high degree of correlation among the independent variables.

Table 19. Multiple Linear Regression Coefficient Results – Iteration 3 (Reducing Variables X10 and X11)

Coefficients[a]									
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-4.033	3.934	–	-1.025	.352	–	–
	X2	.988	.935	.622	1.057	.339	.206	4.848
	X4	-.668	.307	-.970	-2.180	.081	.360	2.775
	X7	.397	.327	.403	1.214	.279	.648	1.544
	X12	.201	.288	.269	.696	.518	.479	2.088
	X13	.083	.262	.120	.318	.763	.505	1.982
	X14	.776	.687	.444	1.130	.310	.463	2.158
	X15	.260	.724	.127	.360	.734	.573	1.744
	X16	-.009	.195	-.016	-.044	.967	.535	1.867
a. Dependent Variable: Y								

After reducing variables X10 and X11, which previously exhibited high multicollinearity issues (VIF > 10), the multiple linear regression model improved. The VIF values for all variables are now below the critical threshold of 5, indicating that there is no longer a high correlation among the independent variables. However, the regression results show that none of the independent variables are statistically significant at the 5% significance level ($p > 0.05$).

The insignificance of the regression coefficients may be due to the small or limited sample size in this study. Although the model shows good statistical multicollinearity conditions, from the perspective of substantive meaning and significance, the model cannot yet be used to fulfill the objectives of this research.

4.2. Discussion

Based on the results of the stepwise multiple linear regression analysis using variable reduction through Variance Inflation Factor (VIF) evaluation, eight variables were identified as significantly contributing to the number of traffic accident victims in the Yogyakarta region. These variables include road function (X2), road type (X4), and the presence of road markings or signage (X7), which represent road infrastructure factors. In addition, the average vehicle speed at intersections (X12) and average traffic volume (X13) reflect dynamic traffic operation conditions. Vehicle characteristics involved in accidents also play a critical role, as indicated by the type of vehicle of the victim (X14) and the type of vehicle of the perpetrator (X15). Finally, the type of accident based on the collision position (X16) also influences the number of casualties resulting from a given incident.

This study is limited by the small number of intersections equipped with CCTV, which hinders the analysis of the effects of average speed and real-time traffic volume on accidents. Although the IRSMS provides records of all accidents at each intersection, these records are not accompanied by available CCTV footage or real-time traffic speed data. Even with an extended research period, the limited variation in the number of 4-way and T-junctions makes it difficult to apply any regression analysis methods. To optimize future studies, it is necessary to increase the number of monitored intersections equipped with CCTV and real-time traffic speed recording systems throughout the Yogyakarta area.

5. Conclusion

In this study, 17 variables were identified as having potential influence on the number of accident victims. Using multiple linear regression analysis, only 8 variables met the required VIF thresholds. These variables—X2 (road function), X4 (road type), and X7 (presence of signage markings) as infrastructure-related factors; X12 (average vehicle speed at intersections) and X13 (average traffic volume) representing traffic operational conditions; X14 (victim vehicle type) and X15 (perpetrator vehicle type) reflecting vehicle characteristics; and X16 (type of accident based on collision position)—were found to be significant.

However, due to the limited number of intersections monitored by Smart City CCTV, further research to obtain more comprehensive results or development is not feasible. Therefore, it is necessary to increase the number of intersections equipped with Smart City CCTV, particularly at T-intersections in the Yogyakarta area. This would enable more comprehensive research in the future regarding variables that contribute to or influence the number of accident victims. In addition, expanding the scope and duration of the study to include all types of intersections throughout the year, rather than only Four-Leg and T-intersections over a few months, could enhance both representation and validity.

5.1. Acknowledgments

This study represents a form of appreciation for the close collaboration between the Traffic Corps of the Indonesian National Police (Korlantas POLRI) and the Faculty of Engineering, Universitas Indonesia, as outlined in Agreement No. B/22/IV/2016 and 197/PKS/FT/UI/2016 concerning Education, Training, Research, and Expertise Support. This partnership has fostered progress in human resource development, knowledge dissemination, and skills enhancement, particularly in the fields of traffic and transportation management.

6. References

Chand, A., Jayesh, S., & Bhasi, A. B. (2021). Road traffic accidents: An overview of data sources, analysis techniques and contributing factors. *Materials Today: Proceedings*, *47*. https://doi.org/10.1016/j.matpr.2021.05.415

Fadhil, M. K., & Susanto, T. D. (2023). Success Factors for Smart City in Urban Design Models: A Systematic Review. *Indonesian Journal on Computing (Indo-JC)*, *8*(2). https://doi.org/10.34818/INDOJC.2023.8.2.731

Feryanti, I. K., & Mulyono, G. S. (2019). *Analisis Kecelakaan Lalu Lintas di Kota Surakarta*. Universitas Muhammadiyah Surakarta.

Firdausy, C. M., Suryana, A., Nugroho, R., & Y.B. Suhartoko. (2019). Revolusi Industri 4.0 Dan Pembangunan Ekonomi Berkelanjutan. *Pusat Penelitian Badan Keahlian DPR RI*, *22*(1).

Hu, Z., Zhou, J., & Zhang, E. (2023). Improving Traffic Safety through Traffic Accident Risk Assessment. *Sustainability (Switzerland)*, *15*(4). https://doi.org/10.3390/su15043748

Kusumaningrum, R., & Widyaningsih, N. (2023). Analysis of Traffic Accidents Using the Accident Rate Method (Case Study: MT. Haryono Street – Gatot Subroto Street South Jakarta City). *Jurnal Sains Dan Teknologi Industri*, *20*(2), 818. https://doi.org/10.24014/sitekin.v20i2.22153

Li, G., Wu, Y., Bai, Y., & Zhang, W. (2023). ReMAHA–CatBoost: Addressing Imbalanced Data in Traffic Accident Prediction Tasks. *Applied Sciences (Switzerland)*, *13*(24). https://doi.org/10.3390/app132413123

Pop, M.-D., & Proştean, O. (2018). A Comparison Between Smart City Approaches in Road Traffic Management. *Procedia - Social and Behavioral Sciences*, *238*. https://doi.org/10.1016/j.sbspro.2018.03.004

Prasetyanto, D., & Santosa, W. (2011). Hubungan Perubahan Kecepatan Kendaraan Dengan Jumlah Korban Kecelakaan Lalulintas. *Jurnal Transportasi*, *11*(2). https://doi.org/10.26593/jtrans.v11i2.1844.%25p

Pujiastutie, E. T., Sazuatmo, S., & Antoro, E. D. (2015). Karakteristik Kecelakaan Dan Solusi Penanganan Untuk Mengurangi Angka Kecelakaan Di Kota Bengkulu. *Jurnal Elektronik Universitas Gunadarma*.

Radam, I. F., Harianto, D., & Narang, R. I. (2022). Factors Causing Traffic Accidents Based On The Trip Maker Perception: Comparison Between Urban And Rural Roads. *Journal of Southwest Jiaotong University*, *57*(3). https://doi.org/10.35741/issn.0258-2724.57.3.11

Rifai, A. I., & Aulia, E. S. (2019). Analysis of Factors Causing Traffic Accidents on Sultan Agung Street, Bekasi. *Neutron*, *18*(2). https://doi.org/10.29138/neutron.v18i2.73

Rizki, D. P. (2019). *Identifikasi Konflik Dan Pelanggaran Lalu Lintas Persimpangan Empat Kaki Bersinyal Jalan Nasional Di Kota Solok*. Universitas Andalas Repository.

Sabrina, D., Tinumbia, N., & Ihsani, I. (2022). Analisis Tingkat Keselamatan Lalu Lintas Pada Simpang Tidak Bersinyal Dengan Metode Traffic Conflict Technique (TCT). *Jurnal Artesis*, *2*(2). https://doi.org/10.35814/artesis.v2i2.4292

Said, L. B., Maryam, S., & Nasruddin. (2019). Pengaruh Pertumbuhan Kendaraan Dan Kapasitas Jalan Terhadap Kemacetan Di Ruas Jalan Perintis Kemerdekaan. *OSF Preprints*, *3*(1).

Saprollah, M. R., Sideman, I. A. O. S., & Rohani, R. (2022). Analisis Tingkat Keselamatan Lalu Lintas Pada Simpang Tak Bersinyal Dengan Metode Traffic Conflict Technique. *Spektrum Sipil*, *9*(2). https://doi.org/10.29303/spektrum.v9i2.233

Saputra, D. A. D., Kismartini, K., Dwimawanti, I. H., & Afrizal, T. (2022). Mewujudkan Semarang Hebat melalui Smart City (Studi Kasus pada Dimensi Smart Economy Kota Semarang). *PERSPEKTIF*, *11*(3). https://doi.org/10.31289/perspektif.v11i3.6273

Silaban, H. H., Das, A. M., & Setiawan, A. (2023). Analisa Kinerja Lalu Lintas Simpang Tiga Tidak Bersinyal Studi Kasus Jalan KH Ismail Malik-Jalan Raden Syahbudin Kota Jambi. *Jurnal Talenta Sipil*, *6*(2), 407–412.

Sisra, D. (2022). *Analisis Kecelakaan Lalu Lintas Pada Ruas Jalan Kinali-Simpang Empat Kabupaten Pasaman Barat*. Universitas Muhammadiyah Sumatera Barat.

Touahmia, M. (2018). Identification of Risk Factors Influencing Road Traffic Accidents. *Engineering, Technology & Applied Science Research*, *8*(1). https://doi.org/10.48084/etasr.1615

Wahyudin, D. (2018). Peluang Dan Tantangan "Big Data" Dalam Membangun "Smart City" Untuk Sistem Transportasi. *Jurnal Reformasi Administrasi*, *5*(2). https://doi.org/https://doi.org/10.31334/reformasi.v5i2.270

Wang, J., Ma, S., Jiao, P., Ji, L., Sun, X., & Lu, H. (2023). Analyzing the Risk Factors of Traffic Accident Severity Using a Combination of Random Forest and Association Rules. *Applied Sciences (Switzerland)*, *13*(14). https://doi.org/10.3390/app13148559

Yandi, T., Lubis, F., & Winayati. (2020). Analisis Karakteristik Kecelakaan Lalu Lintas pada Jalan Yos Sudarso Kota Pekanbaru. *Jurnal Teknik*, *14*(1), 17–21. https://doi.org/10.31849/teknik.v14i1.3141

Yunus, R. (2022). Traffic Accident Analysis Model In Traffic Accidents That Have No Witness. *Estudiante Law Journal*, *4*(2). https://doi.org/10.33756/eslaj.v4i2.16211

Zein, F. H., Muhammadun, H., & Marleno, R. (2024). Road Network Simulation Model Analysis Of Pahlawan Road Area With Traffic Management And Engineering Efforts. *INTERNATIONAL JOURNAL ON ADVANCED TECHNOLOGY, ENGINEERING, AND INFORMATION SYSTEM*, *3*(4), 408–421. https://doi.org/10.55047/ijateis.v3i4.1273