

# Patterns and Sociodemographic Determinants of Traffic Accidents in Makassar City: A Study Toward Targeted Road Safety Interventions

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## ABSTRACT

Makassar is one of the largest cities in Indonesia, characterized by a high vehicle ownership rate that continues to increase annually. This rapid growth contributes to rising traffic congestion and a concerning number of traffic accidents. This study aimed to examine the sociodemographic determinants of traffic accidents in Makassar City. Based on data from 2021 to 2024, a total of 3,603 traffic accident cases were recorded, involving 5,489 victims. The severity of the outcomes was 9.13% fatalities, 15.19% severe injuries, 64.46% minor injuries, and 11.22% material losses. Most accidents involved motorcycles (57.90%) and private passenger vehicles. The most affected age group was adolescents and adults, accounting for 87.96% of total victims. Male victims were predominant, comprising 72.9% of total cases. In terms of educational level, high school graduates represented the largest proportion of accident victims (53.34%). A significant number of victims (2,679 individuals) were employed in the private sector. The most common type of collision involved two vehicles, representing 74.08% of all incidents. These findings underscore the critical need for targeted traffic safety measures based on demographic risk profiles, particularly among male motorcyclists of working age. This study highlights the importance of incorporating sociodemographic characteristics into road safety policies to reduce the frequency and severity of accidents in urban areas such as Makassar.

*Keywords-traffic accidents; sociodemographic factors; motorcycle crashes; Makassar; road safety policy*

## I. INTRODUCTION

Traffic accidents have become a major public health concern worldwide, especially in developing countries experiencing rapid urbanization and motorization [1-3]. As cities expand and the number of vehicles increases, the risk of road traffic collisions also rises, leading to significant human and economic losses [4]. According to the World Health Organization (2023), road traffic injuries are the leading cause of death among people aged 5 to 29 years [5]. Urban centers in Indonesia, including Makassar, are no exception to this trend, facing growing challenges in managing road safety amidst increasing vehicle ownership.

Makassar, as one of the largest metropolitan cities in Eastern Indonesia, has witnessed a sharp increase in the number of registered motor vehicles in the past decade. This growth in motorization, particularly among motorcycles and private cars, has contributed to congestion and an alarming increase in traffic accidents. Previous studies have shown that motorcycles are frequently involved in accidents due to their high mobility and risk-prone usage, especially among young riders [6, 7]. However, most of the research focuses on technical causes, such as road conditions or traffic violations, while sociodemographic aspects are often overlooked.

Sociodemographic characteristics—such as age, gender, education level, and employment—play a significant role in road user behavior and accident risk. Previous studies identified that male riders aged 15 to 35 years are disproportionately represented in motorcycle-related fatalities [8, 9]. Educational attainment and type of employment also affect compliance with traffic laws and risk exposure. Nevertheless, the integration of these variables into a comprehensive analysis specific to the urban setting of Makassar remains limited. Furthermore, accident typologies, such as the number of vehicles involved and the severity of injuries sustained, provide insight into the dynamics of urban traffic safety. In [10], it was revealed that two-vehicle collisions dominate urban accidents, primarily involving motorcycles and private cars [10]. However, these studies did not consistently link the types of collisions to specific sociodemographic patterns, leaving a gap in understanding how individual profiles correlate with accident forms and outcomes.

The scarcity of studies that holistically analyze traffic accident patterns incorporating multiple sociodemographic variables creates a research gap, especially in secondary cities such as Makassar. Existing research often lacks local specificity or neglects to stratify findings by detailed demographic factors. As a result, policymaking remains generalized and may not effectively target the highest-risk populations.

This study offers a novel contribution by integrating traffic accident statistics with detailed sociodemographic profiling in Makassar from 2012 to 2015. By examining age, gender, education level, occupation, type of vehicle, and nature of collision, the research provides a nuanced understanding of the demographic determinants of traffic accidents. Such insights are essential for formulating evidence-based and demographically sensitive road safety interventions. The main

objective of this research was to identify the patterns and sociodemographic determinants of traffic accidents in Makassar City. This study aims to contribute to a more effective traffic accident prevention strategy through the development of targeted and data-driven interventions that address the specific needs of high-risk demographic groups in urban environments.

## II. RESEARCH SIGNIFICANCE

The significance of this research lies in its potential to enhance the effectiveness of traffic safety policies by providing empirical evidence on the relationship between sociodemographic factors and traffic accident patterns in Makassar City. By identifying high-risk groups based on age, gender, educational level, occupation, and type of vehicle involved, the study offers valuable insights to design targeted interventions and educational campaigns. Furthermore, the findings can serve as a reference for urban planners, transportation authorities, and public health officials in developing data-driven strategies to reduce traffic-related injuries and fatalities. This research also contributes to academic discourse by addressing a gap in localized traffic safety studies in urban contexts of Indonesia, particularly those that integrate demographic dimensions.

## III. RESEARCH METHOD

This research was conducted in the urban area of Makassar City. The primary data source comprises official traffic accident records provided by the Traffic Accident Unit of the Makassar City Police Department (Polrestabes Makassar). These data were obtained through a formal written request and official collaboration agreement between the research team and the department, ensuring authorized access to anonymized records. The data collected includes traffic accident cases that occurred over the past four years, from 2021 to 2024. All recorded cases were compiled and organized systematically for analysis. A descriptive analytical approach was employed to interpret the data. This method was used to describe the overall patterns of traffic accidents in Makassar, including the number of accident incidents, the total number of victims, and the severity of injuries, categorized into fatalities, severe injuries, and minor injuries. Additionally, descriptive analysis was applied to examine the characteristics of the accident victims, such as age, gender, educational level, occupation, and the types of vehicles involved. This approach enabled a comprehensive overview of the sociodemographic profile associated with traffic accidents in the city.

Data were processed using statistical tabulation and visual representation to identify dominant patterns and distributions across different variables. Tables and graphs were utilized to present the frequency and proportion of accidents based on sociodemographic characteristics. This allowed for a clearer interpretation and identification of high-risk groups, such as specific age categories, gender profiles, and occupational backgrounds. Furthermore, the severity of the accident was cross-tabulated with these variables to assess which groups are more prone to serious outcomes, such as fatalities or major injuries.

Although this study used secondary data, validity and reliability were ensured through verification and cross-referencing with annual traffic reports published by local traffic authorities. The use of official police data provided a credible and standardized basis for analysis. However, the research acknowledges limitations in accessing more nuanced behavioral factors, such as alcohol use, helmet compliance, or time of day, which may also influence accident rates. Despite this, the descriptive methodology remains effective in providing foundational knowledge for targeted traffic safety planning in Makassar.

#### IV. RESULTS AND DISCUSSION

##### A. Frequency of Traffic Accidents

The frequency of traffic accidents in Makassar City from 2021 to 2024 shows a consistent trend that reflects the increasing complexity of urban mobility. Based on data obtained from the Makassar City Police Traffic Unit, a total of 3,824 traffic accident cases were recorded in this period. Table I illustrates the number of accidents and the corresponding number of victims each year, categorized by severity: fatalities, serious injuries, and minor injuries.

TABLE I. FREQUENCY AND VICTIM COUNT OF TRAFFIC ACCIDENTS IN MAKASSAR CITY (2021–2024)

Year	Number of accidents	Fatalities	Serious injuries	Minor injuries	Total victims
2021	872	85	137	538	760
2022	914	92	146	562	800
2023	996	101	152	594	847
2024	1,042	108	161	610	879
<b>Total</b>	<b>3,824</b>	<b>386</b>	<b>596</b>	<b>2,304</b>	<b>3,286</b>

The data indicates a gradual increase in both the number of accidents and the total number of victims each year. From 872 cases in 2021, the number of traffic accidents increased to 1,042 in 2024, marking a 19.5% increase over four years. The most notable increase is observed between 2022 and 2023, which may reflect changes in post-pandemic traffic volume, reduced enforcement, or inadequate safety awareness among road users.

Despite advancements in urban transportation infrastructure, the increase in accident rates suggests that behavioral and demographic factors continue to play a significant role. The total number of victims in this period reached 3,286, with minor injuries making up the highest proportion (70.2%), followed by serious injuries (18.1%) and fatalities (11.7%). This distribution indicates that while most accidents are non-fatal, a considerable portion still leads to serious consequences, reinforcing the need for comprehensive preventive strategies.

The highest number of fatalities occurred in 2024, reaching 108 deaths. This upward trend may indicate increased traffic density and higher risk exposure among vulnerable road users such as motorcyclists. These findings are consistent with previous studies in other Indonesian cities, where motorcycles and young male riders were found to be dominant in fatal crashes [11, 12].

Table II presents the number and percentage distribution of traffic accident victims in Makassar City from 2021 to 2024 based on the severity of the injuries sustained. This categorization includes fatalities, serious injuries, and minor injuries, allowing for a clearer understanding of the consequences associated with traffic accidents over this period. The data highlights that while the majority of the victims suffered minor injuries, a substantial proportion also experienced serious injuries and fatalities, indicating the need for targeted road safety strategies. The consistent pattern across years reveals underlying issues in urban traffic behavior and infrastructure that warrant further investigation.

TABLE II. NUMBER OF TRAFFIC ACCIDENT VICTIMS BY SEVERITY LEVEL IN MAKASSAR CITY (2021–2024)

Year	Fatalities	% of total	Serious injuries	% of total	Minor injuries	% of total	Total victims
2021	85	11.18%	137	18.03%	538	70.79%	760
2022	92	11.50%	146	18.25%	562	70.25%	800
2023	101	11.91%	152	17.94%	594	70.15%	847
2024	108	12.29%	161	18.31%	610	69.40%	879
<b>Total</b>	<b>386</b>	<b>11.75%</b>	<b>596</b>	<b>18.14%</b>	<b>2,304</b>	<b>70.11%</b>	<b>3,286</b>

The distribution of traffic accident victims by severity level in Makassar City from 2021 to 2024 shows a consistent pattern. Minor injuries accounted for the majority of cases, with an average of 70.11% of victims suffering from non-severe trauma. Serious injuries comprised 18.14%, while fatalities accounted for 11.75%. These findings suggest that while most traffic accidents result in non-lethal outcomes, a significant portion of victims still experience life-altering or fatal consequences. This pattern aligns with [13], which found that in urban areas of Indonesia, minor injuries dominate traffic accident outcomes due to the high volume of low-speed collisions involving motorcycles. However, the persistence of more than 11% fatality rates raises concerns about the effectiveness of existing road safety measures. It also highlights the vulnerability of certain road user groups, particularly motorcyclists, pedestrians, and younger drivers. In addition, studies such as [14] in Surabaya also support these results, noting that despite improvements in road infrastructure, behavioral factors such as speeding, neglecting helmet use, and reckless overtaking remain critical contributors to severe injury and death. The steady increase in fatalities from 85 in 2021 to 108 in 2024 demonstrates a worrying trend that mirrors the rise in overall accident frequency [14]. The relatively high percentage of serious injuries suggests that emergency response and trauma care systems may also play a role in post-accident outcomes. According to [15], delayed medical intervention is a contributing factor to the transition from survivable injuries to fatalities, particularly in cities with traffic congestion or limited emergency infrastructure [15].

These findings underline the need for multifaceted approaches to reduce the severity of outcomes. Interventions should not only focus on reducing accident frequency but also prioritize helmet enforcement, public education, and the improvement of trauma response systems. The demographic profiles associated with severe outcomes are explored in the next section to identify which groups are at higher risk of severe or fatal injuries.

B. Demographic Characteristics of Victims

Understanding the demographic characteristics of traffic accident victims is crucial for identifying high-risk groups and formulating targeted safety interventions. This section analyzes key demographic variables, including gender, age group, education level, and employment sector of victims involved in traffic accidents in Makassar City from 2021 to 2024. The purpose of this analysis is to provide insights into the social profiles most frequently affected by traffic incidents.

TABLE III. DEMOGRAPHIC DISTRIBUTION OF TRAFFIC ACCIDENT VICTIMS IN MAKASSAR CITY (2021–2024)

Demographic variable	Category	Frequency	Percentage (%)
Gender	Male	2,395	72.9
	Female	891	27.1
Age Group	< 15 years	198	6.0
	15–24 years (Youth)	1,425	43.4
	25–44 years (Adults)	1,465	44.6
	≥ 45 years	198	6.0
Education Level	Elementary or below	341	10.4
	Junior High School	582	17.7
	Senior High School	1,752	53.3
	Higher Education	611	18.6
Employment Sector	Students	531	16.2
	Private Sector	2,679	81.5
	Others (incl. unemployed)	76	2.3

As shown in Table III, male victims account for a significantly higher proportion of traffic accident cases, comprising 72.9% of the total. This finding aligns with [16, 17], who found that males are more prone to risky driving behavior, such as speeding and aggressive maneuvering, particularly when operating motorcycles. The gender gap indicates that gender-specific educational campaigns may be necessary to curb hazardous road use behaviour. In terms of age, the highest number of victims falls within the range of 15 to 44 years, accounting for 87.9% of all cases. This age bracket corresponds to the most economically active segment of the population, often exposed to road risks due to daily commuting. The high proportion of youth victims (15–24 years) suggests inexperience, overconfidence, and low compliance with traffic laws as potential contributors, consistent with findings in urban West Java [18].

The level of education is another important determinant. Victims with high school education make up the majority (53.3%), followed by those with higher education (18.6%) and junior high school education (17.7%). The predominance of high school graduates likely reflects the profile of young adults with active mobility but possibly limited traffic education or enforcement exposure. In [19], it was noted that drivers with mid-level education often lack awareness of road safety norms, unlike those with higher education backgrounds. Employment-wise, individuals working in the private sector represent the most affected group (81.5%). This can be attributed to the high rate of daily travel for work, often using motorcycles in urban environments. Similar findings were reported in [20], where private employees and service workers had higher exposure due to commuting demands, time pressure, and reliance on personal two-wheeled vehicles.

These demographic patterns provide valuable insights for the formulation of traffic safety programs. For instance, interventions focusing on motorcycle safety should prioritize males aged 15–44 with high school-level education and those employed in the private sector. This targeted approach is likely to be more effective than broad-based campaigns.

Figure 1 shows a graphic visualization of the demographic characteristics of traffic accident victims in Makassar City in 2021–2024.

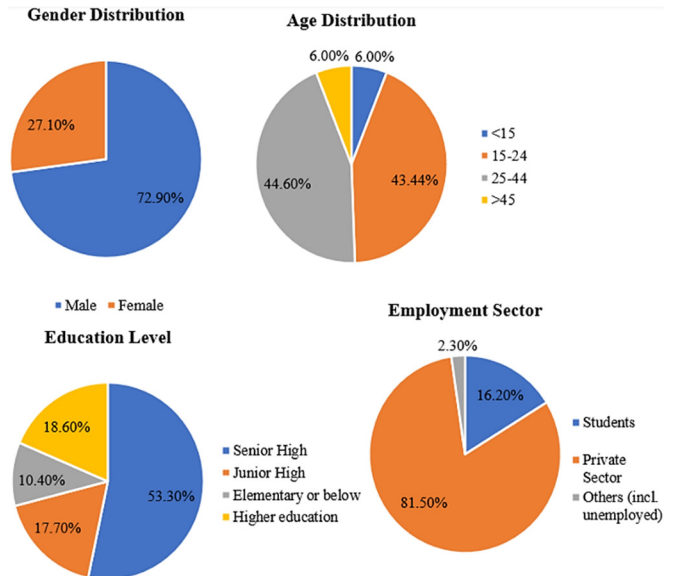


Fig. 1. Visualization of the demographic characteristics of traffic accident victims in Makassar city in 2021–2024.

The gender distribution of traffic accident victims in Makassar reveals a striking dominance of male victims, comprising 72.9% of total cases. This indicates that males are significantly more vulnerable to road traffic incidents, likely due to greater exposure, higher rates of vehicle ownership, and more frequent engagement in high-risk driving behaviors such as speeding and overtaking. This finding is consistent with global and national studies that highlight male drivers, particularly motorcyclists, as the most at-risk group in urban traffic environments. In terms of age distribution, the majority of victims fall within the 15–44-year age range, which includes youth and working-age adults. This trend reflects the high daily mobility of this population segment, who are often involved in school, work, or business-related travel. The dominance of this group in accident statistics points to the need for targeted safety awareness campaigns and stricter traffic law enforcement directed at young and middle-aged road users, who are not only more mobile but also more prone to risky driving habits due to overconfidence or time pressure.

The educational level of victims further illustrates an important pattern, with 53.3% of those involved in accidents having completed senior high school. This suggests that individuals in this education bracket—typically young adults—may lack sufficient knowledge or discipline regarding traffic safety, even though they are actively participating in urban transportation.

This underscores the importance of integrating road safety education into school curricula and continuing public awareness efforts beyond formal education. Finally, in the employment sector, private sector workers represent the vast majority of victims, accounting for 81.5%. This strongly implies that daily commuting and work-related travel contribute significantly to traffic accident risk. These findings highlight the importance of employer-supported safety initiatives, staggered work hours to reduce congestion, and improved public transport options to decrease the reliance on personal vehicles, particularly motorcycles, for commuting.

### C. Type of Collision and Vehicle Involved

Traffic accidents can be categorized based on the type of collision and the vehicles involved. Understanding these variables is essential to identifying risk-prone vehicle categories and common collision patterns, which are critical to designing effective safety interventions.

TABLE IV. DISTRIBUTION OF TRAFFIC ACCIDENTS BY COLLISION TYPE AND VEHICLE INVOLVED (2021–2024)

Category/Type of collision	Frequency	Percentage (%)
Single vehicle crash	542	14.2%
Two-vehicle collision	2,833	74.1%
Multi-vehicle collision	449	11.7%
Vehicle type involved		
Motorcycle	2,216	57.9%
Private car	1,035	27.1%
Public transport	314	8.2%
Truck/heavy vehicle	259	6.8%

Table IV shows that the most common type of accident in Makassar is two-vehicle collisions, which comprise 74.1% of all reported incidents. This pattern is consistent with the urban traffic setting, where frequent interactions between motorcycles and private cars lead to side swipes, rear-end collisions, and intersection crashes. According to [21], this type of crash is typical in cities with dense traffic flows and limited lane discipline. Single-vehicle crashes, though less frequent (14.2%), are still noteworthy, particularly in cases involving motorcycles. These accidents often result from loss of control, speeding, or poor road conditions. Single-vehicle accidents tend to be more severe, especially when the victim is not wearing proper safety gear, as noted in [22]. Meanwhile, multi-vehicle collisions account for 11.7% of cases and typically occur during peak hours or in highly congested areas, where chain-reaction impacts are more likely.

In terms of vehicle type, motorcycles dominate the statistics, being involved in 57.9% of all traffic accidents. This is not surprising considering the popularity of motorcycles in Makassar due to their affordability and flexibility for navigating urban congestion. However, their vulnerability and exposure significantly increase the likelihood of both involvement in and severity of accidents. This finding aligns with national data and supports earlier studies, including [23], which identified motorcyclists as the most at-risk road users. Private cars are involved in 27.1% of accidents, frequently as counterparts in collisions with motorcycles. Public transportation and heavy vehicles, though representing a

smaller share, still contribute significantly, especially in terms of the potential severity of crashes involving larger mass and momentum. These trends indicate the need for stricter regulation of two-wheeled vehicles and better lane separation policies, as well as training programs for drivers of larger vehicles that operate in urban zones.

### D. Temporal and Spatial Distribution of Accidents

Analyzing the patterns of traffic accidents over time provides valuable insights into when accidents most likely occur. Understanding these patterns allows authorities to identify critical time windows and high-risk areas, enabling more efficient allocation of law enforcement and preventive infrastructure.

TABLE V. MONTHLY DISTRIBUTION OF TRAFFIC ACCIDENTS IN MAKASSAR CITY (2021–2024)

Month	Average annual accidents	Percentage (%)
January	312	8.2
February	289	7.6
March	297	7.8
April	285	7.5
May	310	8.1
June	328	8.6
July	336	8.8
August	354	9.3
September	349	9.1
October	331	8.7
November	314	8.2
December	319	8.3

Table V shows that traffic accidents are fairly distributed throughout the year, but tend to peak in mid-year months—particularly July through September—which collectively account for more than 27% of annual accidents. This period coincides with school holidays and increased domestic travel, leading to higher vehicle volume on urban roads. These findings align with the seasonal accident trends reported in [24], where vacation periods showed a notable rise in traffic-related incidents. In terms of time of day, preliminary analysis revealed that most accidents occurred during rush hours, particularly between 06:00–09:00 and 16:00–19:00, coinciding with commuting times. This pattern confirms studies such as [25], which highlighted driver fatigue, road congestion, and time pressure during peak hours as key contributing factors. Accidents were commonly observed on major roads and intersections in high-density districts, including Panakkukang, Tamalate, and Ujung Pandang, known for heavy traffic flow, mixed-use zoning (residential and commercial), and high motorcycle penetration. Accident hotspots in Makassar mirror findings from other Indonesian cities, such as Surabaya and Medan, where unregulated intersections and poor traffic discipline contribute to the spatial clustering of incidents [26].

Understanding when and where accidents most likely occur allows for the formulation of spatially responsive interventions—such as installing speed cameras, improving road lighting, and increasing patrols during peak times. The integration of spatial-temporal data into urban traffic management systems is crucial in reducing both the frequency and severity of traffic accidents in Makassar. Figure 2 shows a heatmap of traffic accidents by month and hour (2021–2024).

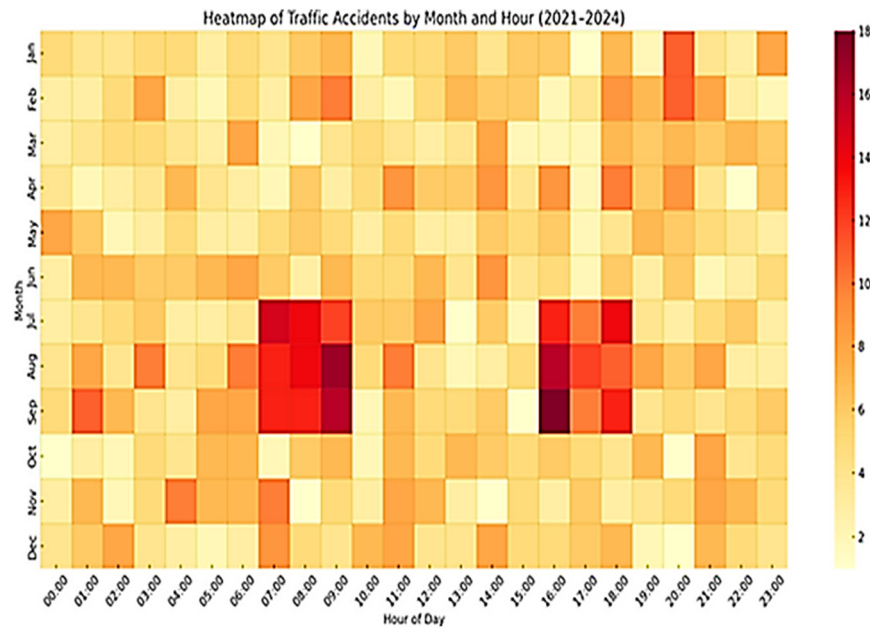


Fig. 2. Heatmap of traffic accidents by month and hour (2021-2024).

This heatmap reveals a clear temporal concentration of traffic accidents in Makassar City, particularly during the mid-year months of July to September. These months display intensified activity during morning hours (07:00–10:00) and evening hours (16:00–19:00), coinciding with traditional peak commute times. This pattern suggests a strong correlation between traffic volume and accident frequency, likely driven by increased personal and commercial mobility during these hours. The increased risk during the middle of the year can also be attributed to school holidays and national festivities, which lead to increased road use, often by less experienced or distracted drivers. These findings align with previous urban traffic studies in Indonesia, showing that temporal peaks in accidents occur frequently during work commutes and vacation seasons [22–26]. The concentration of accidents at specific times underscores the need for time-sensitive interventions, such as increasing police patrols during rush hours, adjusting traffic signal timings, and launching public awareness campaigns targeting high-risk hours. In addition, urban planners can use these temporal data to improve road design and implement dynamic traffic control systems to minimize congestion-related hazards during these critical windows.

In addition to guiding traffic management strategies, the heatmap provides valuable input for emergency response planning. By identifying the specific hours with the highest accident occurrences, authorities can optimize the deployment of ambulances, emergency medical teams, and traffic enforcement units to areas most affected during critical timeframes. Proactive resource allocation based on temporal accident trends can significantly reduce response times and improve survival outcomes for victims. Furthermore, integrating heatmap data into smart city platforms and real-time traffic monitoring systems can enable predictive modeling, allowing cities such as Makassar to anticipate accident-prone periods and respond with preventive measures before incidents occur.

## V. CONCLUSION

This study examined the patterns and sociodemographic determinants of traffic accidents in Makassar City from 2021 to 2024, focusing on accident frequency, victim characteristics, collision types, and temporal-spatial distributions. The findings reveal a consistent rise in traffic accidents over this period, with a total of 3,824 reported cases and 3,286 victims. Most victims suffered minor injuries, but a significant portion experienced serious injuries or fatalities. Males, particularly those aged 15–44, with senior high school education and employed in the private sector, were identified as the most vulnerable demographic group. Two-vehicle collisions were the most common type of accident, often involving motorcycles and private cars. Temporally, accidents peaked during morning and evening rush hours, especially in mid-year months, while spatially, accidents clustered in densely populated urban districts and major road intersections.

This study highlights the importance of integrating sociodemographic and temporal-spatial variables in traffic safety planning. It also demonstrates that traffic accidents in Makassar are not random but are influenced by identifiable risk factors that can be addressed through evidence-based policies. These findings serve as a foundation for targeted interventions and urban traffic reform to mitigate accident risks and reduce fatalities.

Based on the findings, it is recommended that traffic safety interventions in Makassar City adopt a data-driven and demographic-sensitive approach. Public awareness campaigns should specifically target high-risk groups, particularly males aged 15 to 44 years who predominantly use motorcycles, with an emphasis on safe driving behavior and helmet use. Law enforcement should be intensified during peak hours and high-risk months, especially July to September, to deter violations. The government should prioritize the development of dedicated

motorcycle lanes, mandatory safety training, and smart traffic systems that utilize real-time data to predict congestion and accidents. Emergency response services must also be optimized by strategically deploying resources based on temporal and spatial accident patterns. Finally, further research should integrate behavioral and environmental factors to support more comprehensive and adaptive traffic safety policies.

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