Analysis of Accident Risk Assessment on Prof. Muhammad Yamin Road Tegal Regency Using the HIRARC Method

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ABSTRACT: *Prof. Muhammad Yamin Street in Tegal Regency is a primary collector road with a two-lane, two-way undivided configuration, stretching for 2.2 kilometers. This road serves as a connector between sub-districts and is frequently used by the public, especially during school rush hours. The increase in traffic activity in this area creates potential conflicts between vehicles and pedestrians, particularly students. This study aims to identify the level of traffic accident risk along this road segment. The method used is HIRARC (Hazard Identification, Risk Assessment, and Risk Control), which allows for a systematic analysis of potential hazards, risk assessment, and control strategies. Survey results indicate that the condition of road markings and traffic signs falls into the moderate-risk category, while physical road damage such as ravelling, cracking, and potholes is classified as extreme risk. Several signs were also found to be covered by vegetation or vandalized. Recommended control measures include repainting road markings, maintaining traffic signs, and repairing pavement damage. These findings are expected to contribute to tangible improvements in road safety and serve as a consideration for policymakers in managing safer and more sustainable road infrastructure.*

Keyword: *Inspection; Inventory; HIRARC*

I. INTRODUCTION

Traffic as a public facility plays a significant role in driving regional development. However, one of the most significant challenges in traffic is the risk of accidents [1]. A traffic accident can be defined as an unexpected and unintentional event that can occur on the road involving vehicles and road users resulting in death or property damage [2]. Traffic accidents are an issue that requires serious attention and handling because the resulting losses can be significant [3].

Traffic accidents are a transportation problem that can have detrimental impacts on society, including vehicle damage, injuries, and even loss of life [4]. One factor that can influence accident risk is the condition of road infrastructure [5]. Although not always the main cause, elements such as sub optimal geometric conditions, lack of road safety equipment, or lack of activity planning around the road can increase the potential for danger, especially in locations with heavy traffic interaction [6]. The severity of the consequences of an accident can also vary, from mild to moderate, depending on the type of conflict and the road environment where the accident occurs [7].

Prof. Muhammad Yamin Street located in Slawi District, Tegal Regency, is a collector road that plays an important role in supporting community mobility. This road connects several activity centers ranging from educational areas, residential areas, to access to commercial areas. In general, the physical condition of the road is still considered good and decent, but along with the increasing intensity of traffic, especially during school hours, there is a need to improve traffic safety [8]. Several points along this road section show intensive interaction between motorized vehicles and pedestrians, especially students crossing the road, as well as the use of part of the road by parked vehicles or shop activities adjacent to the school [9].

In an effort to consider the level of accident risk that falls into the moderate risk category, a systematic approach is needed to identify hazards, assess risk, and control potential traffic risks. This study uses the HIRARC method to obtain a comprehensive overview of factors that can affect road safety, particularly in school environments [10]. A similiar approach has proven effective in the context of road

infrastructure. For example, a study on Kapten Piere Tendean Street, Ambon City applied HIRARC to evaluate various potential risks – roadside trees and intersection visibility were categorized as high risk, while signs, drainage, and pedestrian were categorized as medium, and surface road damage was categorized as low – and produced safety improvement recommendations that focused on high-risk issues first [11]. In addition, a risk assessment on a road improvement project in Gunungsari-Cipanas implemented HIRARC to classify hazards and establish control strategies based on a hierarchy of controls, including elimination, engineering, and administrative controls that successfully reduced significant risks [12].

II.   THEORETICAL FRAMEWORK

Road Traffic Safety

Road traffic safety is a condition in which road users are protected from the risk of accidents that can cause injury, property damage, and even death. According to Government Regulation of the Republic Indonesia Number 37 of 2011 concerning the Traffic and Road Transportation Forum, traffic safety is an effort to avoid accidents through comprehensive traffic palnning, operation, and supervision. Road safety indicators are usually indicated by the number of accidents, the fatality rate, and the type and number of victims. Road safety is highly dependent on three main factors, namely road user behavior, vehicle conditions, and adequate road infrastructure [13].

Collector Road Characteristics

Collector roads are roads that function to connect local roads with arterial roads or other collector roads, as well as collect traffic from the surrounding environment to be channeled to a higher road system. According to Minister of Public Works Regulation No. 03/PRT/M/2012, collector roads are devided into two types, namely primary collectors and secondary collectors. Primary collector roads usually connect primary activity centers with higher technical standards, while secondary collectors connect secondary activity centers. Prof. Muhammad Yamin Street in Tegal Regency is classified as a primary collector, but has environmental characteristics that resemble secondary functions due to the dominance of local activities such as schools, shops, and residental areas. This creates the potential for higher traffic conflicts, especially during rush hours [14].

Risk Factors For Traffic Accidents In School Areas

Traffic accidents in school areas often occur due to several factors, including a lack of driver awareness of the existence of school zones, the absence of road safety facilities, risky behavior by road users, and a lack of supervision of children. School areas that do not have road safety facilities such as traffic markings and signs tend to have higher accident rates [15].

Risk And Danger Concept

In the context of transportation safety, a hazard is anything that has the potential to cause harm or accident, while risk is the possibility of the hazard occurring multiplied by its severity (likelihood x severity) [16]. Road safety risk assessment aims to identify potential hazards along the road and assess their likelihood and impact on road users. This assessment can be conducted qualitatively, semi-quantitatively, or quantitatively, depending on the objectives and data availability. In this context, risk assessment is important to understand the interactions between traffic elements and provide control recommendations based on the level of risk found. Roads with intensive interaction between pedestrian and vehicles such as in educational areas, require more attention because the potential for injury is generally higher.

HIRARC Method (Hazard Identification, Risk Assessment, and Risk Control)

The HIRARC method is a systematic approach to risk management that consists of three main stages [17]. Hazard Identification is the process of identifying all potential hazards in an area or activity. In the context of a school area, hazards can include high-speed vehicles, the absence of zebra crossings, or illegally parked vehicles that obstruct visibility. Risk Assessment determines the level of risk based on two main parameters, namely likelihood (likelihood of occurrence) and severity (severity of

consequences). Risks are categorized into low, medium, and high levels to assist in judicial decision-making. Risk Control determines the steps that need to be taken to eliminate or minimize risks. Control measures can include traffic engineering, installing signs, or outreach to road users.

Review of Previous Research

Several previous studies have discussed traffic accident risk assessment, particularly in urban and high-traffic areas. Riani's (2020) study on road safety audits in urban areas focused solely on geometric technical parameters without detailed pedestrian interactions [18]. Meanwhile, Aditya's (2021) study used a quantitative approach to assess accident risk levels [19]. However, it was limited to data on past accidents rather than potential hazards. Both studies failed to focus on collector roads in semi-urban areas with multiple activities, such as education and commerce.

Current Research Position and Novelty

This study presents a more adaptive approach to field conditions on primary collector roads in semi-urban areas. Unlike previous studies that focused on historical accident data or technical aspects alone, this study combines direct observation of road conditions with the HIRARC method. By focusing on Prof. Muhammad Yamin Street, this study broadens the scope of road safety studies by comprehensively identifying potential hazards and providing practical recommendations based on actual risk assessments. This study offers a novel contribution to the development of risk-based traffic safety strategies in socially and economically active collector road environments.

III. METHODS

The survey section was conducted on Prof. Muhammad Yamin Street located in Slawi District, Tegal Regency as can be seen in Figure 1. This road is a primary collector road with a 2-lane 2-way type without a median. Prof Muhammad Yamin Street has a length of approximately 2.2 km, with a road width of 9.5 meters, consisting of two lanes each 4.75 meters wide.
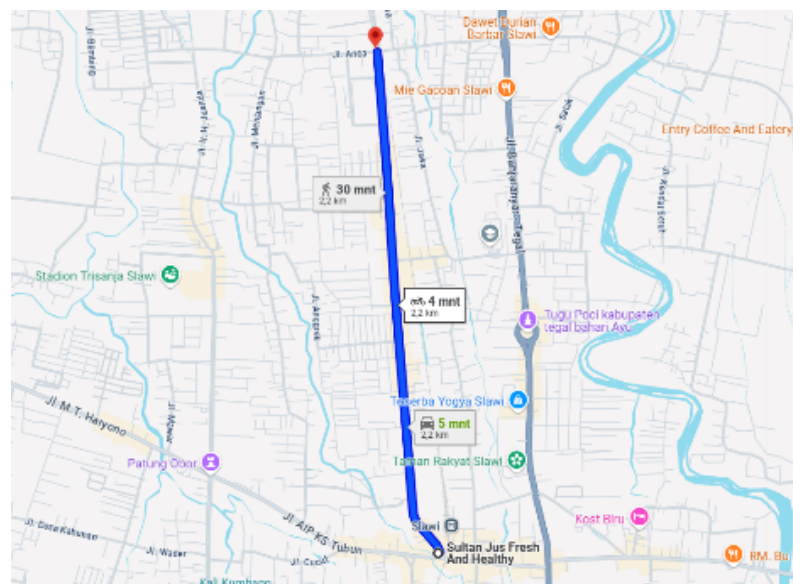

Figure 1. Survei Location

Data Collection Technique

Primary data obtained on Prof. Muhammad Yamin Street located in Slawi District, Tegal Regency as can be seen in figure 1 in a direct survei and secondary data obtained from the Tegal Regency Transportation Agency obtained in the research include :

a. Geometric road conditions (road width, number of lanes, presence of medians, road surface conditions, shoulder or sidewalk conditions)

b. Inventory of road equipment (traffic signs, road markings, street lights, zebra crossings, and other safety equipment).
c. Traffic activity around the school area, such as student crossing behavior, parking locations for pick-up and drop-off vehicles, and vehicle accumulation points.

HIRARC Method

HIRARC (*Hazard Identification, Risk Assessment and Risk Control*) a method for identifying problems in an activity in a detailed, thorough , and orderly manner. To identify problems that can hinder the implementation of activities and risks that can harm humans and the environment, and explain how to overcome these risks. The level of implementation of a program based on HIRARC is the level of a program that can be considered effective or not, which is determined by a combination of the level of performance and the level of risks of accidents.

a. Hazard Identification (*Hazard Identification*)

Hazard identification is one of the first steps in risk management. The purpose of hazard identification is to identify the potential hazards that could occur at a location. Without prior hazard identification, risk management cannot be effective.

b. Risk Assessment (*Risk Assessment*)

Risk assessment is an assessment step to identify the risk of danger that will occur. This risk assessment has 2 types, namely Likelihood (L) and Severity (S). Likelihood is the level of opportunity for the risk of danger can be seen in Table 1 and the level of severity of the accident that occurs can be seen in Table 2. The Risk Matrix is the result of multiplying the level of opportunity for the risk of danger that may occur with the value of the severity of the accident that accurs, which can be seen in Table 3.

Table 1. Likelihood Criteria [20]

Level	Criteria	Explanation
5	*Almost certain*	Can occur at any time or frequently at any time
4	*Likely*	Can occur in almost any situation
3	*Moderate*	Can occur in certain situations
2	*Unlikely*	May occur in special situations and is unlikely
1	*Rare*	Almost impossible

Table 2. Severity Criteria [20]

Level	Criteria	Explanation
1	*Insignificant*	No injuries, minor financial loss
2	*Minor*	On-site treatment with first aid, moderate financial loss
3	*Moderate*	Medical treatment required, on-site treatment, major financial loss
4	*Major*	High injuries, requiring hospitalization, major financial loss
5	*Catastrophic*	Death or inability to be rescued, major financial loss

Table 3. Risk Matriks

Likelihood	Consequence				
	1 *Insignificant*	2 *Minor*	3 *Moderate*	4 *Major*	5 *Catastrophic*
5 *Almost Certain*	H	H	E	E	E
4 *Likely*	M	H	E	E	E
3 *Moderate*	L	M	H	E	E
2 *Unlikely*	L	L	M	H	E
1 *Rare*	L	L	M	H	H

Information:

E = *Extreme Risk* (extreme risk and can cause death)

H = *High Risk* (high risk and serious injury)

M = *Moderate Risk* (medium risk and moderate injury)

L = *Low Risk* (low risk and low injury)

c. Risk Control (*Risk Control*)

Risk control is an effort to minimize potential hazards so they don't pose a risk to anyone. Risk control recommendations are based on research findings, such as improvements to traffic facilities and infrastructure at specific locations.

HIRARC Method Research Flow

This research begins with the two main approaches: field study and literature study. The field study aims to collect primary data from the actual site conditions, while the literature review provides theoretical foundations and insights from previous studies. The outcomes of these activities lead to the formulation of a clear and systematic problem statement.

Following that, the formulation of research objectives is conducted, setting the overall direction of the study. The next step is data collection, which includes field observations and hazard identification. This data is then analyzed using the HIRARC method, consisting of three main stages: Hazard Identification (through safety analysis), Risk Assessment (using a risk matrix to determine the level of risk), and Risk Control (applying mitigation strategies such as elimination, substitution, redesign, administrative controls, and the use of personal protective equipment).

After applying the HIRARC method, the process continues with analysis and discussion, in which all findings are evaluated to understand the causes and patterns of risk. The final phase involves drawing the conclusion and recommendation, summarizing the research outcomes and offering technical advice to relevant stakeholders. The process concludes with the "Finish" stage, marking the end of a structured and comprehensive research journey.
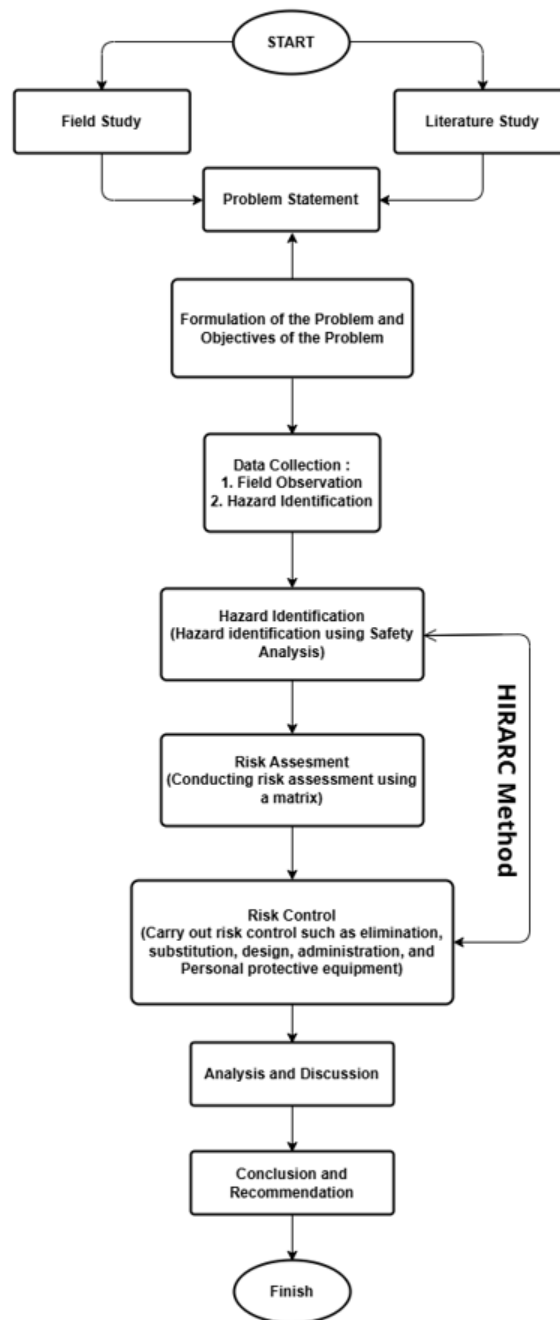
Figure 2. Research Flow

The research flowchart in the figure 2 is illustrates the stages of the HIRARC (Hazard Identification, Risk Assessment, and Risk Control) method used in this study. This approach is systematic and consists of three main, logically interrelated steps, culminating in the full application of the method as a basis for risk mitigation decision-making.

IV. DISCUSSION

The 2.2 kilometer stretch of Prof. Muhammad Yamin Road in Slawi District, Tegal Regency, is divided into 44 segments by 50 meters. This division is done to identify potential accident risk points and facilitate hazard mitigation in each segment. This method also simplifies locating the location points in case of damage or hazard reports and allows for more targeted action based on the needs of specific areas.

Prof. Muhammad Yamin Street faces several issues that pose a risk of accidents to pedestrians, especially schoolchildren. The majority of vehicles passing along Prof. Muhammad Yamin Street are motorcycles, private cars, and trucks. Motorcyclists are also frequently seen speeding without regard for road conditions, such as road damaged, lack of road signs, and the lack of road markings. This situation becomes even more dangerous during rainy weather and at night.

Marking Condition

On this road there are no road markings, as shown in Figure 3. There is also a marking, but it has faded to the point of being nearly gone. This makes it difficult for drivers to clearly see the lane boundaries.

Figure 3. No Markings

Furthermore, there were also road markings found on segments 5 through 9, with no markings at all, leaving drivers confused about determining lane boundaries. This situation can lead to drivers leaving their lanes, potentially leading to accidents between vehicles due to entering another lane while driving potentially leading to collisions.

Figure 4. Faded Markings

The problem of road marking conditions on Prof. Muhammad Yamin Tegal Street, which can be seen in Figure 4 is found in almost every segments. This condition is certainly quite dangerous because it makes road drivers unable to receive information about road lane boundaries. This condition also does not rule out the possibility of drivers leaving the lane which has the potential to cause accidents. One of the causes of accidents is due to the inability to see road markings so that drivers can lose control or be negligent. According to the survey, this problem has a probability value (L) of an accident of 2 which can occur under certain conditions but is unlikely and a severity value (S) if an accident occurs of 3, namely the need for medical treatment, on-site treatment, quiet large financial losses, so that the total value obtained is 6. With a value of 6 in the risk measurement, this category is included in the moderate category.

To avoid and reduce the potential risk of accidents due to the lack of suitability of the marking conditions, marking painting and routine maintenance are necessary.

Sign Condition

From the survey of signs found on Prof. Muhammad Yamin Tegal Street, there is something that needs attention regarding the condition of the traffic signs. These signs are in a condition that does not meet standards. In segments (3) and (7) shown in Figure 5, the signs are covered by plants and the signs with stickers can be seen in Figure 6.

Figure 5. Signs covered by trees

Figure 6. Signs covered by stickers

Traffic signs with graffiti or obstructed by trees make it difficult for drivers to read them. Thus, the effectiveness of the sign's function is reduced. According to the survey, this problem has a probability value (L) of 2 for an accident, which can occur under certain conditions but is unlikely and a severity value (S) if an accident occurs, amounting to on-site handling, financial losses are quite large, so the total value obtained is 6. With a value of 6 in the risk level measurement, this category is included in the medium category. Therefore, it is necessary to control plants that interfere with road traffic activities by the local government responsible for their field.

Road Conditions

The results of the road condition survey obtained on Prof. Muhammad Yamin Street Tegal along 2.2 km found various types of road damage such as ravelling can be seen in Figure 7 and 8 which were found in segments (1,3,4,5,6,7,8,9,11,12,13,15,17) causing the road to be slippery during the rainy season. In addition, there were also road cracks found in segments (8,10,16,18) which made drivers less comfortable when crossing it. Meanwhile, there were holes in segment (10) which can be seen in Figure 9 from the damage of the holes found in the segment which had various variations from small to large so that it reduced comfort when driving and had the potential to cause accidents. The pressure that occurs from large vehicles such as trucks repeatedly can be a cause of the road becoming uneven so that it can cause bumps on the road.

Figure 7. Ravelling

Figure 8. Ravelling

Road damage was found in almost all segments of Prof. Muhammad Yamin Street Tegal. On this road, four types of road damage were found, namely ravelling (peeling asphalt), potholes, cracks, and asphalt bumps. Road conditions that have slippery, bumpy, and potholed road surfaces can cause traffic accidents. Road damage such as potholes and asphalt bumps is one of the potential causes of accidents. According to the survey, this problem has a probability value (L) of 4 for accidents and a severity value (S) if an accident occurs of 3, so the total value obtained is 12. With a value of 12 in the risk level measurement, this category is included in the extreme or very high category. To reduce the risk of potential accidents and improve the safety of road users, routine road repairs are needed, especially in locations with severe damage.

Figure 9. Potholes

Meanwhile, there are holes in segment 9 of the pothole damage found in the segment have various variations from small to large so that it reduced comfort when driving and has the potential to cause accidents. According to the survey, this problem has a probability value (L) of an accident of 4 and a severity value (S) if an accident occurs of 3 so that the total value obtained is 12. With a value of 12 in the risk level measurement, this category is included in the extreme or very high category. To reduce the risk of potential accidents and improve the safety of road users, regular road repairs are needed, especially in locations that have severe damage.

V.   CONCLUSION

Based on the results of the traffic accident risk assessment analysis using HIRARC method along Prof. Muhammad Yamin Street, Slawi District, Tegal Regency, findings showed that dominant risk level was classified as Moderate Risk. This risk was primarily identified in road segments experiencing light to moderate surface damage, faded road markings, and ineffective traffic signs due to being covered by unofficial stickers or obstructed by tree branches that interfere with visibility.

The moderate risk category indicates that while the likelihood of an accident is not particularly high, the impact – particularly on vulnerable groups such as pedestrians and schoolchildren – is still significant, with the potential for moderate injuries. Several vulnerable points were identified around school entrances and informal crossing zones frequently used by students during peak hours.

As a mitigation measure, routine maintenance of road infrastructure is recommended, including repairing damaged road surfaces. Repainting road markings, such as curb lines and zebra crossings, is also crucial for increased visibility, especially at night or in adverse weather conditions. Furthermore, traffic signs need to be regularly maintained and regulated, including removing illegal stickers and pruning trees that obstruct visibility.

These risk control efforts are crucial not only for reducing accident rates but also as part of a sustainable road safety improvement strategy. The implications include increased comfort and safety for road users, especially students and pedestrians. For policymakers, these results can serve as a basis for prioritizing safety interventions based on actual risk data. In the long term, these findings support the development of more targeted and efficient road safety action plans, as well as building a culture of transportation safety in urban environments with dense social activity, such as school districts.

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