Risk Mitigation Analysis in Truck Accidents Using Australian Maritime and Safety Authority (AMSA) Risk Matrix

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Abstract. This study examines the risk factor of human error as the leading cause of truck traffic accidents in Indonesia, using the Australian Maritime and Safety Authority (AMSA) risk matrix. Data from NTSC investigation reports were used to identify 12 human factors that contribute to accidents. The analysis showed that seven factors were in the high-risk category (red area), requiring immediate mitigation, while two factors were in the medium category and 3 in the low category. Some of the recommended solutions include improved SOPs, safety training and restrictions on working hours. The study also suggests further cost analysis to measure the economic impact of such risk mitigation.

Keywords: Truck accident, human error, risk mitigation, risk matrix, AMSA.

1 Introduction

The Global Report on Road Safety reports that in Asia, Indonesia is the third country with the highest number of deaths caused by traffic accidents, with a total of 38.279 deaths [1]. The proportion of causes of traffic accidents in Indonesia consists of 92% human factors, 5% vehicle factors, and 3% road infrastructure and environmental factors [2]. *Human error* is still the cause of accidents with the highest percentage. This is in line with the vital role of humans in the transportation process, making them prone to errors.

Today's development is directly proportional to the increase in demand for transportation facilities to meet the mobilization needs of the general public [3]. This also increases the level of air pollution and traffic density, which has an effect on the level of traffic accidents if road users do not follow safety standards when driving. One of the frequently used means of transportation is trucks. The Indonesian National Police Traffic Corps (NPTC) reports that freight cars are the third most frequently used land vehicle. Freight cars refer to four-wheeled vehicles whose primary function is transporting

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goods such as trucks, pick-ups, and other commercial vehicles [4]. This number is followed by the number of truck accidents that occur. According to the Central Statistical Agency (CSA), Indonesia reported an increase in the number of traffic accidents by an average of 6,26% per year from 2018 to 2022 [5]. NPTC also reported that the total number of truck accidents in 2018 touched 4.487, while in 2017, the total was 4.398 cases [6].

According to the Statistical Book of the National Transportation Safety Committee (NTSC), human error is the leading cause of traffic accidents [7], [8]. Human error is a performance performed by humans that can negatively affect the system and reduce effectiveness and efficiency [9]. The losses caused by human error can greatly impact the system regarding both productivity and material.

Given this phenomenon, risk mitigation analysis is needed to reduce the level of risk posed by human error in traffic accidents. Risk management is the process of identifying and managing internal events and potential external threats that affect an organization's success rate [10]. This process can provide output in the form of continuous improvement and is often related to the decision-making process in an organization [11].

Therefore, this study was appointed to identify and manage the risks arising from human error in traffic accidents as a form of risk mitigation analysis using the Australian Maritime and Safety Authority (AMSA).

2 Methods

2.1 Australian Maritime and Safety Authority (AMSA)

In this research, the risk matrix standard used as a risk mitigation step is the AMSA standard. AMSA itself is a risk matrix that considers the relationship between two main things, namely likelihood and consequence. Likelihood is the frequency of failure of a particular event within one year. Table 1 explains each frequency value from the AMSA *risk matrix* [12].

Table 1. AMSA Risk Matrix Frequency

Category	Description	Percentage	Opportunities per Year
Almost Certain	Common occurrences	95%	Weekly events
Likely	Known events that occurred	60%	Monthly occurrence
Possible	Events that can happen and have happened	40%	Occurrence up to three times in one year
Unlikely	Events that may have happened	20%	Once a year
Rare	Events that are practically impossible to occur	5%	Never happened

Frequency values are obtained by looking at the contribution of the occurrence of each factor in each year. This value will later be averaged considering the data that will be used in the interval 2009-2023. Important note, the average is done on each factor that occurs at least once a year so that when the factor does not appear in a particular year, it will not be included in the average calculation process. The last step is to group each of the factor frequency values into the AMSA standard based on Table 1.

Meanwhile, *consequences are a category of consequences that can be caused by these failures. An explanation of each AMSA consequence category* follows.

a. *Catastrophic*

Human : Many victims
Financial : Total loss
Reputation : Stalled operations and reputation badly damaged
Environment : Environmental damage that very extensive

b. *High*

Human : Death
Financial : Big loss
Reputation : Disrupted operations and temporary loss of income
Environment : Environmental damage that great

c. Medium

Human : Severely injured
Financial : Significant loss
Reputation : Operations were significantly disrupted, and reputation impacted
Environment : Significant Environmental damage

d. Minor

Human : Minor injuries
Financial : Small loss
Reputation : Minor disruptions occurred in operations
Environment : Little environmental damage

e. Negligible

Human : No injuries
Financial : Losses are negligible
Reputation : No side effects on operation
Environment : Environmental damage can be ignored

The value of the relationship between frequency and consequence will be grouped into boxes that are distinguished by the color of the box as a sign of how urgent the factor needs improvement. The form of the AMSA matrix and the description of each color are shown in Table 2.

Table 2. AMSA Risk Matrix

Likelihood	*Consequences*				
	Negligible	Minor	Medium	High	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely					
Rare					

Block Color : : *Extreme*
: *High*
: *Moderate*
: *Low*
: *Very Low*

Based on the above information, it can be seen that the lowest level of emergency repair is the dark green color to the highest in color

3 Results

3.1 Factors Causing Incidents

This study used data from the NTSC LLAJ crash investigation report. A total of 36 data points were reported, with trucks being the leading cause of incidents. Although the amount of data is limited, the KNKT report has gone through a very detailed investigation and analysis, resulting in a comprehensive report. This research focuses on human factors, which are summarized in Table 3.

Table 3. Human Factors

Code	**Factors Contributing to Accidents**
H1	Braking failure
H2	Ineffective coordination and communication
H3	Gear replacement failures and mistakes
H4	Do not use low-gear transmission.
H5	Nor applying the defense driving method.
H6	Not considering hazards due to familiarity with work.
H7	Pre-inspection, testing, and maintenance are not optimal.
H8	The ability and experience of drivers who are not yet qualified
H9	Great panic
H10	Work not by existing standards or rules.
H11	Situational awareness
H12	Sleepiness due to poor sleep quality

3.2 Risk Matrix Construction Results

As explained in the previous section, the frequency value is taken from the average contribution of each factor in the period 2009-2023. This average result then became the first data required for the construction of the AMSA risk matrix which were demonstrated in Tabel 4.

Table 4. Frequency Value

Factor Code	**Frequency Value**	**Clustering Result**
H1	2,286	Possible
H2	2	Possible

Factor Code	Frequency Value	Clustering Result
H3	2	Possible
H4	2	Possible
H5	1,5	Unlikely
H6	1	Unlikely
H7	1,67	Unlikely
H8	1,286	Unlikely
H9	1,33	Unlikely
H10	1	Unlikely
H11	1,2	Unlikely
H12	1	Unlikely

The consequence value of each factor was carried out by interviewing experts (*expert judgment*) who are experienced in the field of traffic. This process needs a help of expert to analyze and select the relevant consequences of each factor based on AMSA consequence categories through questionnaire. The questionnaire also adopts the matrix form to get clear and precise construction results. The expert used in this research is a POLRI (Indonesian National Police) with the position of BA Directorate of Traffic who has 20 years of experience in his field, which can be seen in Table 5.

Table 5. Consequence Value

Factor Code	Consequence Number Selected	Category of Consequence
H1	1	Catastrophic
H2	4	Minor
H3	5	Negligible
H4	1	Catastrophic
H5	4	Minor
H6	2	High
H7	2	High
H8	1	Catastrophic
H9	1	Catastrophic
H10	1	Catastrophic
H11	1	Catastrophic
H12	1	Catastrophic

The interview results were directly constructed into a risk matrix with AMSA standards where the selection of this standard is due to the simplicity and accuracy of the AMSA risk matrix to analyze the risks that can be caused by truck accident factors by looking at the correlation between the frequency of these factors occurring in each year and the consequences caused when these factors cause accidents, which can be seen in Table 6.

Table 6. Risk Matrix Construction Results

Likelihood	*Consequences*				
	Negligible	Minor	Medium	High	Catastrophic
Almost Certain					
Likely					
Possible	H3	H2			H1,H4
Unlikely		H5		H6,H7	H8, H9, H10, H11, H12
Rare					

4 Discussion

Of the 12 existing human factors, two factors, H1 and H4, fall into the Possible category with Catastrophic consequences, and H8, H9, H10, H11, and H12 belong to the Unlikely frequency category with Catastrophic consequences. All of these factors fall into the red area, which means that improvements and solutions are needed to reduce the risk level to a more acceptable level.

This proves the importance of conducting pre-inspections to ensure that all machines are in optimal condition and the vehicle is ready for use. For example, "braking failure" can occur due to brakes that are not functioning properly because they are not checked before operating. In addition, it can be triggered by not using a low gear transmission on downhill and uphill road contours. This serves to help reduce vehicle speed without having to use the main brake system multiple times. In addition, this is also influenced by the experience and skills of the driver. hence the importance of clear and qualified qualifications when selecting driver candidates in order to ensure safety and security at work. this is also useful to avoid the behavior of certain drivers who do not drive according to applicable standards due to their qualified knowledge and skills. later, all of this can lead to increased public safety and reduce economic losses to both the organization and the driver.

As for the other factors, they still fall into the tolerable areas, namely the yellow and green areas, such as H2 and H3 into the Possible frequency with Minor and Negligible consequences, respectively, H5 into the *Unlikely* frequency with *Minor* consequences and H6 and H7 into the *Unlikely* frequency with *High* consequences. This proves that although the frequency of these factors causing accidents is still relatively rare, the consequences are substantial and can result in fatalities with significant losses and many victims when these factors contribute to accidents that occur. Therefore, all existing factors will still be necessary to develop solutions.
Based on the results of the AMSA risk matrix construction, this study recommends several alternative solutions to reduce the risk level of all these factors, namely:

a. Clarify and reinforce Standard Operating Procedures (SOPs), including pre-work inspections and vehicle maintenance. Set consequences for violating or not implementing existing SOPs.
b. Determining the qualifications of drivers must have a driver's license as the main requirement for workers. There is no tolerance for those who do not have a

driver's license

c. Organize regular driving safety training every certain period of time. Emphasize the consequences of not riding according to the rules.
d. Setting working hours in optimal time intervals without disadvantaging drivers.

5 Conclusions

Human error is still the most dominant factor causing truck accidents. This study aims to mitigate the risk of human factors as the cause of truck accidents through risk analysis using the AMSA *risk matrix*. The results show that out of 12 factors, seven fall into the red area, 2 fall into the yellow area, and three fall into the green area. Some solutions are also suggested to reduce the potential consequences that can be caused by those 12 human factors.

For future research, cost analysis of risk mitigation results can be an interesting new finding to see what percentage of maximum cost savings can be achieved.

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Institutional Review Board Statement

This study was conducted by the ethical guidelines and regulations applicable and approved by the Ethics Commission for Social Humanities–National Research and Innovation Agency [Number: 223/KE.01/SK/05/2023, Date of Approval: 12 May 2023].

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