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Analysis of the causes of mining accidents in trucking activities: Southeast Sulawesi Province 2021-2023

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Abstract

Background: Mining accidents in truck transportation activities are the most common accidents in the mining industry in Southeast Sulawesi Province in the last 3 years and often cause fatalities. Previous studies have not identified all types of dominant causes of mining accidents in truck transportation activities, be it direct causes, basic causes, or lack of management control. The purpose of this study is to analyze the causes of mining accidents in truck transportation activities in the Southeast Sulawesi Region in 2021-2023.

Method: The research used is qualitative phenomenology to understand and describe the dominant accident-causing factors from mining accident phenomena in transportation activities using trucks.

Results: The dominant causes of mining accidents in truck transportation activities in Southeast Sulawesi Province in 2021-2023 were: driving above the speed limit; drivers not wearing safety belts and helmets; downhill road conditions with a grade above 12% and long; drivers lack knowledge/skills; lack of supervision; and inadequate SOP and HIRA.

Conclusion: Corrective actions that can be taken to minimize the occurrence of mining accidents in truck transportation activities are: increasing supervision and socialization related to speed limits, as well as the use of safety belts and helmets; striving for engineering, maximizing supervision and completing road signs on downhill road segments with grades above 12% and long; implementing new worker training and annual refresher courses with output in the form of SIMPER which is valid for a maximum of 1 year; meeting the needs/ratio of operational supervisors, and ensuring that SOP and IBPR are adequate for truck transportation activities.

Keywords: Accidents; OSH; Transportation; Trucks

1. Introduction

Mining Operation Safety is all activities to guarantee and protect safe, efficient, and productive mining operations through efforts, including system management and implementation of maintenance/care for Mining facilities, infrastructure, installations, and equipment, installation security, feasibility of Mining facilities, installation infrastructure, and equipment, technical personnel competence, and evaluation of Mining technical study report results. Assessment of Mining Safety performance achievement level is part of the initial review process that must be carried

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out by mining companies and mining service companies in the Mining Safety Management System planning stage. These levels include: basic level, reactive level, planned level, proactive level, and resilient level (1).

The audit of the Mineral and Coal Mining Safety Management System aims to obtain an overview of the level of implementation of the mineral and coal mining safety management system, assess the ability of the mining system to meet the provisions of laws and regulations, evaluate the effectiveness of the mining system in achieving the set targets and identify the potential for implementing the Mineral and Coal Mining Safety Management System (2).

Research on mining accidents is widely discussed by mining safety practitioners. One of them is mining accidents during truck transportation activities. The interesting thing is that mining accidents during truck transportation activities are the most common accidents in the mining industry in Southeast Sulawesi Province in the last 3 years and often cause fatalities. Based on data from the accident investigation results of the Directorate of Engineering and Environment team, it is known that in the period from 2021 to 2023, mining accidents during truck transportation activities in Southeast Sulawesi Province have claimed 6 lives out of 10 incidents reported by companies holding IUPs. The number of mining accidents during truck transportation activities in this 3-year period could of course be much greater considering the reluctance of workers and companies to report incidents to the government for fear that their production operations will be disrupted or even stopped.

The main problem related to efforts to prevent mining accidents in transportation activities using trucks is the failure to identify gaps that are direct causal factors, basic causal factors and factors of lack of management control by mining companies which are the main causes of mining accidents. Mining accidents can cause worker injuries, equipment damage, production disruption/cessation, and even loss of life. Therefore, it is necessary to know all the causal factors so that corrective actions can be taken to prevent similar accidents from occurring.

The most dominant factor as the cause of accidents at PT. Semen Padang in 2018 was unsafe acts, the percentage of accidents in 2018 for unsafe acts was 80% and for unsafe conditions was 20% (3). (4) stated that the factors causing accidents that occurred at PT. Sumbar Calcium Pratama were generally caused by unsafe actions (87%) and unsafe conditions (30%). In another study (5) shows a relationship between length of service, use of PPE, and supervision with work accidents.

Some other studies more specifically mention unsafe actions and conditions that cause accidents. One of these studies (6) which concluded that the main factors causing fatal accidents involving transport trucks were fatigue and the use of mobile phones while driving. Other studies (7) showed that inadequate or improper pre-operational inspections and poor truck maintenance were the two most common root causes of these accidents. The study (8) discuss the identification of unsafe conditions and actions in the hauling area of the West Banko Mine Pit 1 East PT. Bukit Asam, Tbk. Study (9) previously discussed the geometry of PT Citra Nursa Persada's haul roads related to the smoothness and safety of hauling operations on the road. In another study (10) discuss the influence of road service levels on occupational safety in coal mines. Furthermore (11) discusses the Influence of Mine Road Geometry from the Mining Front to the Stockpile on Occupational Safety at PT Caritas Energi. Research related to the basic causes of accidents can be seen in the study (12) which discusses work, non-work and social psychology factors as causes of decreased reaction time/driver fatigue which can result in accidents.

Previous studies mostly focus on the direct causes of accidents which generally consist of unsafe acts and unsafe conditions. As for the basic causes of accidents and factors of lack of management control, only a few have discussed them. Improvements to the basic causes of accidents and lack of management control will be more effective in preventing accidents than just fixing the direct causes of accidents.

2. Material and methods

This research is qualitative phenomenological research. Phenomenological research aims to interpret and explain the experiences that a person experiences in this life, including experiences during interactions with other people and the surrounding environment (13). This qualitative phenomenological research is to understand and describe the dominant accident-causing factors of mining accident phenomena in transportation activities using trucks.

Data was obtained by collecting minutes/reports of Mining Accident Investigations conducted by Mining Inspectors and by companies holding Mining Business Permits independently. Number of minutes/reports of Mining Accident Investigations: 10 documents. The criteria for minutes/reports of Mining Accident Investigations: 1. Mining accidents during truck transportation activities; 2. Accidents in the Southeast Sulawesi Province; 3. Occurred within the period 2021-2023.

The analysis instrument uses an application to calculate the percentage of the frequency of occurrence of accident-causing factors from the results of mining accident investigations in transportation activities using trucks, both those carried out by the Mining Inspector and those carried out by the IUP holding company independently. The stages of data analysis are as follows: Grouping the causes of accidents into direct causal factors, basic causal factors, and factors lacking management control; Sorting the causal factors from the most frequent/dominant of each group.

3. Result

The results of the identification of the causes of mining accidents in truck transportation activities in Southeast Sulawesi Province in 2021-2023 can be seen in Table 1. The results of the grouping of direct causal factors, basic causal factors, and factors lacking management control can be seen in Table 1.

Table 1 Factors causing mining accidents during truck transportation activities in Southeast Sulawesi Province in 2021-2023

No	IUP Holding Company	Causes of Accidents
1	Company A, 2021	Unsafe Action: Exceeding the speed limit, not using a safety belt Unsafe Condition: Narrow road, no median, minimal signs Personal Factors: Rushing at the end of the shift, over confidence, lack of knowledge work factors: inadequate operational supervisor Lack of management control: inadequate SOP and HIRA.
2	Company B, 2023	Unsafe Action: forcing to drive an unworthy vehicle Unsafe Condition: Road grade 17% with a road length of 1400m, unworthy vehicle Personal Factors: chasing a license, lack of knowledge Work Factors: lack of supervision Lack of management control: inadequate SOP and IBPR. Poor license system, the company does not provide training and does not provide company driving license
3	Company C, 2021	Unsafe Action: Not using seat belt Unsafe Condition: Road grade 17%, vehicle not roadworthy Personal Factor: lack of knowledge Work Factor: lack of supervision, no commissioning/p2h Lack of management control: SOP and HIRA are inadequate. There are no standard requirements for the units used (Unit purchasing/procurement system is inadequate)
4	Company D, 2021	Unsafe Action: via a road not recommended by the Mining Engineering Chief; failed to secure the unit Unsafe Condition: Road grade + 40% and long, no signs Personal Factors: lack of knowledge, rushing to enter break time Work Factors: lack of supervision, no socialization/p5m Lack of management control: inadequate SOP and IBPR. No Operational Responsible Person, No contractor management system, Inadequate emergency management. not providing company driving license.
5	Company E, 2022	Unsafe Action: exceeding speed limit, failure to secure Unsafe Condition: Inadequate safety berm Personal Factor: lack of knowledge Occupational Factor: - Lack of management control: inadequate SOP and HIRA. Inadequate emergency response management
6	Company F, 2023	Unsafe Action: Exceeding the speed limit, not wearing a helmet and safety belt

		<p>Unsafe Condition: Road grade 16% with a road length of 900m, very dense vehicle convoy, dark</p> <p>Personal Factors: chasing retase, lack of knowledge</p> <p>Work Factors: lack of supervision</p> <p>Lack of management control: HIRA is inadequate. Poor retase system, Company does not provide training for new workers</p>
7	Company, 2023	<p>Unsafe Action: Wrong lane selection, not wearing helmet and safety belt</p> <p>Unsafe Condition: inadequate safety berm and road median, minimal signs, inadequate road width</p> <p>Personal Factor: lack of knowledge</p> <p>Occupational Factor: No daily check and maintenance</p> <p>Lack of management control: inadequate SOP and HIRA. Inadequate emergency management.</p>
8	Company, 2023	<p>Unsafe Action: Failed to secure the unit, driver carries passengers</p> <p>Unsafe Condition: Unsafe unit (brake settings are not hard enough), downhill road with a grade above 12%</p> <p>Personal Factor: lack of skills</p> <p>Work Factor: Lack of supervision during daily check and maintenance</p> <p>Lack of management control: -</p>
9	Company, 2023	<p>Unsafe Action: Operating an unsafe unit</p> <p>Unsafe Condition: Unsafe unit (worn out brake pads), dusty road</p> <p>Personal Factor: lack of skills</p> <p>Job Factor: Lack of supervision during daily check and maintenance</p> <p>Lack of management control: -</p>
10	Company, 2023	<p>Unsafe Action: Exceeding the speed limit</p> <p>Unsafe Condition: Unsafe unit (brakes not functioning properly), downhill road with a grade above 12%</p> <p>Personal Factor: Over confidence</p> <p>Work Factor: Lack of supervision during daily check and maintenance</p> <p>Lack of management control: Inadequate SOP and HIRA</p>

Source: Minutes of the Southeast Sulawesi Province Mining Inspector's Accident Investigation Report (2023)

Table 2 Direct causal factors, underlying causes, and lack of management control of the underlying causes of mining accidents in trucking activities in Southeast Sulawesi Province in 2021-2023

Types of Accident Causes	Description	Amount
Basic Causes		
Unsafe actions	Exceeding the speed limit	4
	Not wearing a helmet and safety belt	4
	Using an unsuitable unit	2
	Via roads/routes not recommended by the Mining Engineering Chief	2
	Failed to secure unit	3
	Carrying passengers	1
Unsafe conditions	Narrow street	2

	There is no road median	2
	The road conditions are downhill with a grade above 12% and long	6
	Unit not eligible	5
	Minimal Signs	3
	Safety berm is inadequate	2
	The convoy of vehicles was very dense	1
	Dark	1
	Dusty road	1
Basic Causes		
Personal Factors	End of shift/break rush	2
	Over confidence	2
	Lack of knowledge/skills	9
	Chasing hacks	2
Work Factors	Lack of supervision	8
	No commissioning / daily check and maintenance	2
	There is no socialization / daily check and maintenance	1
Lack of Control	SOP and HIRA are inadequate	8
	Bad hack system	2
	Not conducting training and providing company driving licenses based on training results	3
	Inadequate unit purchasing/procurement system	1
	There is no contractor management system and Operational Manager	1
	Emergency management is inadequate	3

Source: Primary Data, 2023

From the grouping of direct causal factors, basic causes, and lack of management control of the basic causes of mining accidents in trucking activities in Southeast Sulawesi Province in 2021-2023, the most dominant causes of accidents were then determined from each type of accident-causing factor. The results can be seen in Table 3.

Table 3 Dominant Causal Factors of Mining Accidents in Truck Hauling Activities in Southeast Sulawesi Province in 2021-2023 Based on Type

Types of Accident Causes	Description	Amount	Percentage
Unsafe actions	Driving over the speed limit, and not using a safety belt or helmet	4 out of 10 cases	40%
Unsafe conditions	The road conditions are downhill with a grade above 12% and long	6 out of 10 cases	60%
Personal Factors	Lack of knowledge/skills	9 out of 10 cases	90%
Work Factors	Lack of supervision	8 out of 10 cases	80%
Lack of Control	SOP and IBPR are inadequate	8 out of 10 cases	80%

Source: Research data

Based on the analysis of the dominant causes of mining accidents in hauling activities with trucks in Southeast Sulawesi Province in 2021-2023 based on their type, it is known that there are 6 dominant causes of accidents, namely: driving over the speed limit (40%), drivers not wearing safety belts and helmets (40%), downhill road conditions with a grade above 12% and long (40%), drivers lack knowledge/skills (90%), lack of supervision (80%), and inadequate SOP and IBPR (80%).

4. Discussion

Occupational Safety and Health in Mining is all activities to guarantee and protect workers to be safe and healthy through efforts to manage occupational safety, occupational health, the work environment, and occupational safety and health management systems. The work process in mining has high potential for danger and risk, therefore aspects of safety, occupational health, and the environment are requirements that must be met in every work activity (14).

Mining companies are required to develop and implement an effective mining safety management system (SMKP), which includes risk identification, hazard evaluation, and implementation of appropriate mitigation measures. In the Decree of the Director General of Mineral and Coal, 2019, there are objectives to reduce work accidents, minimize environmental impacts, and improve worker welfare in the mining sector. Companies must involve all levels of the organization in efforts to improve safety culture, including regular training and awareness of the importance of safety in the workplace. In addition, safety performance reports must be prepared periodically to ensure compliance with regulations and create a safe and healthy working environment, as well as support the sustainability of mining industry operations in Indonesia (15).

The main problem related to efforts to prevent mining accidents in trucking activities is the failure to identify gaps in direct causal factors, basic causal factors and factors lacking management control by mining companies which are the main causes of mining accidents. Based on the analysis of the dominant causes of mining accidents in truck hauling activities in Southeast Sulawesi Province in 2021-2023 based on their type, it is known that there are 6 dominant causes of accidents, namely: driving over the speed limit (40%), drivers not wearing safety belts and helmets (40%), downhill road conditions with a grade above 12% and long (40%), drivers lack knowledge/skills (90%), lack of supervision (80%), and inadequate SOP and HIRA (80%).

The two most dominant unsafe acts for the type of direct cause of accidents were driving over the speed limit and not using a seat belt and helmet, which were 4 out of 10 cases each. This finding supports previous findings from (5) which concluded that there was a relationship between length of service, use of PPE, and supervision with work accidents. This finding is also in line with the study (8) who found that driving over the speed limit is a hazard with the highest risk value in truck transportation activities, namely at the extreme level. The conclusion (7) that inadequate or improper pre-operational inspections and poor truck maintenance are the two most common root causes of accidents, not being one of the direct causal factors of accidents from dominant unsafe acts in truck hauling activities in Southeast Sulawesi Province in 2021-2023. Likewise with the conclusion (6) which states that one of the main factors causing fatal accidents involving transport trucks is the use of mobile phones while driving. Furthermore, an effective way that can be done to minimize unsafe actions carried out by workers is to routinely inform and remind workers about the importance of obeying speed limits and the importance of using safety belts and helmets through socialization of working safely. Furthermore, increasing supervision, especially in certain areas that require more supervision based on the results of mapping from the company. Of course, maximum collaboration is needed between operational supervisors and the mining K3 section so that the supervision and socialization functions can function optimally. Engineering control through vehicle speed restrictions is still difficult to implement in mining companies in Southeast Sulawesi Province with domestic investment status and is not effective in overcoming driving actions exceeding the speed limit in conditions and areas where the maximum speed limit is lower than the maximum speed limit that generally applies in the company.

The downhill road segment with a grade above 12% and length is the most dominant area for mining accidents in hauling activities with trucks, namely 6 out of 10 cases. The results of this study support the conclusions of the study (10) which states that road grade affects the safety of truck transportation activities. Risk control measures are carried out by following the hazard control hierarchy consisting of engineering, administration, work practices, and personal protective equipment (16). The most effective way to overcome this danger is of course by trying engineering in the form of elimination, substitution or isolation. Furthermore, maximizing supervision and completing road signs on each road segment with similar specifications. Good risk management should be able to identify hazardous conditions like this and produce good mitigation steps so that transportation work can still be carried out safely.

Drivers' lack of knowledge/skills is the most dominant cause of basic accident causes from personal factors, namely 9 out of 10 cases. Conclusion (6) which states that one of the main factors causing fatal accidents involving transport trucks is fatigue, not being one of the basic factors causing accidents from dominant personal factors in hauling activities with trucks in Southeast Sulawesi Province in 2021-2023. Lack of knowledge/skills can cause workers to make wrong decisions or be overconfident which leads to accidents. For this reason, training is needed to improve the competence of truck drivers in truck transportation activities and it must be ensured that only competent drivers work. The company is required to provide education and training according to needs and based on the consideration of the Head of Mining Engineering to comply with laws and regulations. New worker training and annual refresher training must be provided by companies holding Mining Business Permits to their workers (17). Specifically for truck drivers, the final result of the training can be an operating permit (SIMPER) issued by the Head of Mining Engineering and is valid for a maximum of 1 year. Vehicles in the mine can only be operated by workers who have a Driving License (SIMPER) issued by the company (16).

The dominant work factor causing mining accidents in truck transportation activities in Southeast Sulawesi Province is inadequate supervision, which is 8 out of 10 cases. This inadequate supervision can be in the form of supervisor negligence, the number of supervisors is still minimal compared to the number of units and/or the area they supervise, and incompetent supervisors. Therefore, the company must provide a number of supervisors that are in accordance with the number of units and/or the area they are responsible for, and ensure that each supervisor is competent in carrying out their supervisory activities. This is in accordance with the direction of mining safety regulations where all surface mining operational activities carried out must pay attention to the ratio of operational supervisors (17).

The dominant factor of lack of management control causing mining accidents in trucking activities in Southeast Sulawesi Province is inadequate SOP and HIRA, which is 8 out of 10 cases. Inadequate IBPR causes many hazards and risks that are not identified and/or not controlled properly. The number of accidents that occur on the downhill road segment with a grade above 12% and length is one example of the inadequacy of HIRA carried out by the company. Surface mining operations carried out must pay attention to hazard and risk control (17). This hazard and risk control is part of risk management which includes the following stages of activities: communication and consultation with all stakeholders, setting the context related to determining the limits of hauling activity risks, both internal and external, identifying hauling activity hazards, especially critical hazards, assessing and controlling hauling activity risks to ensure all risks are acceptable, as well as periodic monitoring and review (16).

Inadequate procedures are also a dominant factor of lack of management control causing mining accidents in trucking activities in Southeast Sulawesi Province in addition to inadequate HIRA. The head of mining engineering is responsible for ensuring that every activity in the mine is carried out safely (17). Therefore, every mining business activity must have an SOP/procedure as a reference for safe working methods. Good procedures can be produced through formulation, determination, implementation, and maintenance carried out continuously. The Head of Mining Engineering must determine standard procedures for transportation, maintenance and care of transportation routes, arrangement of transportation routes, and transportation equipment with trucks including maintenance and care of trucks (16). In addition, worker awareness and involvement in OSH management need to consider the management approach two-way communication, meaning that all levels of office actively participate in efforts to create a safe, comfortable, healthy and secure work environment (18).

5. Conclusion

The dominant causes of mining accidents in truck transportation activities in Southeast Sulawesi Province in 2021-2023 include driving above the speed limit; drivers not wearing safety belts and helmets; downhill road conditions with a grade above 12% and long; drivers lack knowledge/skills; lack of supervision; and inadequate SOP and HIRA.

Recommendations for corrective actions that can be taken to minimize the occurrence of mining accidents in truck transportation activities are: increasing supervision and socialization related to speed limits, as well as the use of safety belts and helmets; striving for engineering, maximizing supervision and completing road signs on downhill road segments with grades above 12% and long; implementing new worker training and annual refreshment with output in the form of SIMPER which is valid for a maximum of 1 year; meeting the needs/ratio of operational supervisors, and ensuring adequate SOP and HIRA for truck transportation activities.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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