Original Article

Accident Analysis Using Case Studies of Finger Injuries at PT X Mining Company in 2020-2022

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Abstract:
Mining activities are known as high-risk working environments and operational activities, they are categorized as one of the most dangerous activities in modern industry today. The mining industry ranks among the highest producers of injuries and lost working days. There are many types of injuries that contribute to this lost working days, finger injury is one of them. Fingers are reported to be one of the most injured body parts. This research carried out on a mining company in Indonesia, PT X, within a period of three years (2020-2022). Statistical analysis was performed to look for patterns of finger injury based on year of occurrence, classification, type, and source of injury, number of lost working days, type of employee, and business unit involved. There is an alarming upward trend in the number of finger injuries and lost working days resulting from them, although overall the number of injuries has decreased. This calls for immediate preventive measures to focus on finger injuries and focuses on changing worker behavior towards safe work behavior, applied to both permanent employees and contractor employees.

Keywords: finger injury, lost working day, contractor, behavior, mining

Introduction
Mining industry is one of the most dangerous types of industry, especially underground mining operations which are affected by lack of natural lighting, fresh air, open spaces, high temperatures, humidity, dust, noise and falling rocks. This condition can trigger work accidents if serious and continuous preventive measures are not taken. Based on national data in India, mining accidents have a high injury rate per 1000 workers, fatalities and serious injuries in 2005 were 0.30 and 0.35 respectively, and in 2006 were 2.78 and 1.84 respectively (Paul, 2009). In Turkey, mining industry ranks first in cases of occupational diseases and causes of permanent disability, in third place in fatal accidents, and in fourth place in most work accidents (Ural & Demirkol, 2007). According to U.S. Bureau of Labor Statistics, 2017 is the highest lost working days due to accidents in the mining industry, at 32 days compared to other industries. Another cause of the high accident rate in the mining industry is...
due to the dangerous activities that mine workers carry out every day, such as operating and maintaining heavy equipment, including excavators, bulldozers, haul trucks and roof bolters. Mining workers also perform work at high risk of finger injuries involving power tools (such as electric saws and drills) and manual tools (such as axes, hammers, and wrenches) (Alessa et al., 2020).

Not much research has been conducted in Indonesia to analyze accidents that result in finger injuries, especially in mining industry. According to Masiha (2023), injury statistics recorded at International Association of Oil & Gas Producers (IOGP) show a fairly large increase between 2020 and 2022 of 10% and one of the incidents that often occurs is hand and finger injuries. Kusumawati (2021) states that in upstream oil and gas industry around 50% of injury cases are hand and finger injuries. In an analysis carried out at IOGP member companies, more than 80% was caused by human factors. Jesslyn (2016) stated that finger and hand injuries are very common in maintenance division of mining companies, because the work carried out is installation and removal of large components, the work is carried out during production process using complicated machines and works under time pressure.

Research on a global scale regarding finger injuries in mining industry is also minimal, one of which is Laflamme and Blank (1996) in Alessa et al. (2020) who conducted research on accidents in Swedish underground mines between 1980 and 1993 and found that wrist and fingers were parts of the body most frequently injured, 28% of all cases. Another study of injuries resulting from maintenance work in mining industry in the United States between 2002 and 2011, found that material moving activities and the use of hand tools, both powered and manual, caused one-third of all hand and finger injuries. (Pollard et al., 2014). Generally, recovery time for finger injuries is short. However, there are quite a lot of cases that require a longer recovery time and involve a rehabilitation process, some even resulting in permanent or partial disability (Alessa et al., 2020).

Due to lack of research on finger injuries in mining industry in Indonesia, we intend to conduct an analysis of accidents that cause finger injuries at one of the mining companies in Indonesia in 3-year period, between 2020 and 2022. This analysis of finger injuries is critical for preventing future injuries and to formulate targeted accident prevention programs.

Methods

Dataset

Based on Decree of Minister of Energy and Mineral Resources of Republic of Indonesia Number 1827K/30/MEM/2018 regarding Guidelines for Implementing Good Mining Engineering Principles, no matter how small an injury that occurs in a mining area must be reported by Mine Technical Head to Ministry of Energy and Mineral Resources through Mining Inspector and recorded in the mining accident register book. (MESDM, 2018). Apart from having obligation to report mining accidents to government, PT X also has obligation to report accidents to its parent company which refers to regulations issued by the Mine Safety and Health Administration (MSHA, 2017), United States Department of Labor, Code of Federal Regulation Title 30: Mineral Resources Part 50: Notification, Investigation, Reports and Records of Accidents, Injuries, Illnesses, Employment, and Coal Production in Mines (30 CFR Part 50). Accident data is recorded in company’s internal Incident Management System database, after an internal investigation is carried out to determine the facts relating to each accident.

In this study, incident reporting data from 2020 to 2022 was collected, totaling 3,732 reports. Dataset was then sorted by removing categories of illness, near miss, and reports of witness, resulting in total of 2,502 reports. Since many accidents also involved other workers who were not injured, re-sorting was carried out to eliminate involvement of other workers and resulted a total of 441 injury cases.
1. Data Coding

Final dataset is then classified into several categories based on 30 CFR Part 50 document which is standardized in PT X’s internal document which is part of its Mining Safety Management System (SMKP) entitled Accident Management. This dataset has several other information such as incident type, business units involved, type of incident, location, probability of recurrence, severity, source of injury, company, and others. For the purposes of this research, only eight variables were considered: year of incident, body part injured, injury classification, type of injury, number of lost working day, source of injury, type of employee, and business unit involved.

1.1. Injury Classification

Injury classification of PT X are as follows: First Aid (FA), treatment for minor injuries that do not require professional medical treatment; Medical Treatment (MT), injury that is not classified as LT or RD but requires medical treatment; Restricted Duty (RD), injury where an employee can return to work, but is unable to carry out all his normal daily work or is assigned to another job temporarily; Lost Time (LT), injury where the employee is unable to return to work at the next work schedule; and Fatality, injury or incident that results in death without considering the time of occurrence. Based on the accident classification above, finger injuries can fall into all categories except fatality or death.

1.2. Type of Injury

Every injury that occurs must be referred to company hospital so that adequate follow-up treatment can be carried out, continuing from first treatment from nurse or emergency response team who responded to the accident. PT X divide types of injuries based on information received from company doctor. There are many types of injuries based on their severity, but for purposes of this research anything that does not result in lost workdays is considered a minor injury, such as abrasions, bruises, blisters, and others. Therefore, types of injuries can be divided into: Fracture, Wound, Cut/Laceration, and Amputation.

1.3. Lost Working Day

Calculation of lost working day is carried out based on the MSHA category, if the category is fracture or wound it is calculated based on actual lost working day, if involves amputation then it is calculated based on MSHA Tables of Scheduled Charges for Injuries. (MSHA, n.d.). Calculation of actual working day for cases other than amputation is carried out by company hospital, provided that the employee is treated at the company hospital. Because there is a possibility that employees will carry out treatment at other hospitals, especially contractor employees.

1.4. Source of Injury

Internal SHE Incident Investigation Report form used by PT X classifies sources of injury involved in an accident incident into several types: Potential, Thermal, Chemical Exposure, Electrical, Gravitational, Kinetic, Hydraulic, Mechanical, Noise, Pneumatic, Behavioral, Energy Natural, Radiant, and Stored Energy. Each type of source has several levels: Negligible, Low, Medium, Substantial, and High. Classification determined following classification made by parent company in America, so that adequate analysis can be carried out and comparisons can be made with other mines owned by parent company in the United States.

1.5. Employee Type

As with most mining companies, not all of employees who work at PT X are permanent employees, most of them are contractor employees which can be divided according to type of work and contracts made. Therefore we can divide employee types
as follows: Permanent; Privatization, employees of contractor companies who carry out business processes that are very different from PT X core business such as health management, accommodation, food and power generation; Labor Supply Contractor, employees of outsourcing companies who work as part of and under the supervision of permanent employees; Service Contractor, employees of companies that perform certain services that are part of core business processes, such as maintenance, mining, and security; Project Contractor, employees of companies that carry out a particular project. This contract is short-term and employees will be demobilized as soon as the project being carried out is declared complete.

1.6. Business Unit

Mining operations of PT X are large scale that are divided into several business units to make coordination and business processes easier. Business units can be grouped based on the type of activities carried out as follows: Surface Operations, Underground Operations, Concentrating, Maintenance, Construction, and Support. Mining operations divided into surface mining and underground mining because activities involved are very different. Meanwhile, maintenance, construction and support processes conducted in surface mines and underground mines involve similar activities.

Results

1. Finger Injury Incidents

Throughout 2020 to 2022, based on results of investigation reports submitted to Mining Safety Division of PT X, there were a total of 94 cases of finger injuries. In Table 1 we can see that there is a pattern of increase in number of cases since 2020 (27 cases), an increase of 4 cases in 2021, and another increase of 5 cases in 2022, so that period between cases is getting closer from year to year. Where in 2020 cases of finger injuries occurred almost every 2 weeks (14 days), increasing to every 12 days in 2021, and increasing again in 2022 to every 10 days. Even the percentage of finger injury incidents when compared to all cases that occurred in the same year also experienced a surprising increase, increasing from 18% in 2020 to more than 21% in 2021, and finally to 26% in 2022.

Table 1. Statistics of finger injuries.

<table>
<thead>
<tr>
<th>Year</th>
<th>Case</th>
<th>Percentage</th>
<th>Period (Week)</th>
<th>Period (Day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>27</td>
<td>17.65%</td>
<td>1.93</td>
<td>13.52</td>
</tr>
<tr>
<td>2021</td>
<td>31</td>
<td>21.23%</td>
<td>1.68</td>
<td>11.77</td>
</tr>
<tr>
<td>2022</td>
<td>36</td>
<td>25.53%</td>
<td>1.44</td>
<td>10.14</td>
</tr>
</tbody>
</table>

Trend of finger injury incidents that occurred in each period from 2020 to 2022 can be seen in Figure 1, the percentage is calculated to compare finger injuries with all injuries reported in current month. Trends for 2020 and 2021 are almost the same with average monthly percentage of around 21%, to be precise 20.67% in 2020 and 21.37% in 2021. However, in 2022 there is a high increase with an average percentage of 33%, even in February only finger injuries occurred. Even though there was a visible decline until May 2022, after that there was another high increase, up to 50% in December 2022.
2. Injury Classification

Classification of finger injuries based on severity can be seen in Figure 2. For each type of injury there has been an increase since 2020, except for the Medical Treatment which experienced a decrease in 2021 although there was an increase again in 2022. Based on accident data for these three years, most finger injuries fall into First Aid with an average percentage of 42% and almost the same number of incidents each year. The increase in Restricted Duty incidents is at the same rate, around 2 cases per year, however Lost Time cases increase 3 times from 2020 to 2021 and decrease by only 1 case in 2022. Medical Treatment and Restricted Duty show average percentage of cases almost the same in three-year period, around 22%.

3. Type of Injury

Types of injuries experienced by victims of finger injuries very diverse, ranging from minor injuries to amputations. From overall pattern in Figure 3, there is an increasing trend in almost all types of injuries except for Cut/Laceration. This type of injury has a significant decrease of more than half in 2021 but increased again in 2022. Meanwhile, for Fracture and Minor injuries, although there was a decrease in 2022, there was only one case in each. However, increase in Fracture in 2021 is quite high, almost doubling. Wound showed a significant increase, from only 1 case in 2020 to 4...
cases in 2022. Likewise with Amputation, from zero cases in 2020 it jumped to 3 cases in 2022.

Figure 3. Distribution of injury type in 2020 - 2022. Number of cases is plotted using columns and Y-axis on the left, and percentages are plotted using lines and Y-axis on the right.

4. Lost Working Day

Incidents related to lost working day fall into Restricted Duty (RD) and Lost Time (LT) categories, although sometimes RD incidents do not require hospital admission. Table 2 shows total number of lost working days (LWD) due to quite large finger injuries over a 3-year period, 773 days. The increase in LWD is consistent with increase in number of RD and LT cases over time. However, increase in number of LWD from 2020 to 2021 is more than threefold due to an increase LWD in LT cases of more than six times.

Table 2. Lost working days based on injury classification.

<table>
<thead>
<tr>
<th>Year</th>
<th>Restricted Duty</th>
<th>Lost Time</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>59</td>
<td>36</td>
<td>95</td>
</tr>
<tr>
<td>2021</td>
<td>59</td>
<td>236</td>
<td>295</td>
</tr>
<tr>
<td>2022</td>
<td>87</td>
<td>296</td>
<td>383</td>
</tr>
<tr>
<td>Total</td>
<td>205</td>
<td>568</td>
<td>773</td>
</tr>
</tbody>
</table>

Increase in LWD in 2021 is because of several major incidents: 1 case of Amputation with 60 LWD, 2 cases of Fracture with 75 LWD and 50 LWD, and 1 case of Wound with 50 LWD. This high LWD still does not include one case of LT which cannot be calculated because it was treated outside company hospital. Meanwhile, increase in total LWD in 2022 (30%), not only due to increase in number of LT and RD incidents, but also due to 3 cases of amputation with LWD of 75 days, 135 days, and 50 days respectively. Decrease in the number of LWD in Fracture, which was almost half from 2021 to 2022, apparently cannot reduce increase in total LWD because of the amputation cases.

Table 3. Lost working days by injury type.

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Case 2022</th>
<th>Case 2021</th>
<th>Case 2020</th>
<th>Lost Working Day 2022</th>
<th>Lost Working Day 2021</th>
<th>Lost Working Day 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture</td>
<td>10</td>
<td>11</td>
<td>6</td>
<td>96</td>
<td>185</td>
<td>85</td>
</tr>
</tbody>
</table>
5. Source of Injury

Of the 14 injury source categories used by PT X in accident reporting, only 5 categories were recorded as injury sources based on accident investigation carried out, they are: Behavior, Gravity, Hydraulic, Kinetic and Mechanical. As seen in Figure 3, in 2020 there were no recorded sources of finger injuries resulting from Hydraulic. The number of incidents due to hydraulics was only recorded once in 2021 and 2022 and only accounts for around 3% of all finger injuries each year. Injuries due to Gravity were the same in all three years, although the percentage decreased due to increasing number of finger injury incidents from year to year. Kinetic experienced an increase in 2021 but fell again to the same number as 2020 in 2022, while Mechanical experienced an increase by the same amount in 2021 and 2022, 2 incidents per year. And what is most striking is the number of injuries resulting from unsafe Behavior, which was almost the same in 2020 and 2021, 21 incidents and 20 incidents respectively, and increased to 25 incidents in 2022, although the percentage shows a decrease which is a result of increase in overall finger injury cases. The average finger injury resulting from Behavior is around 71% of all cases over a three-year period.

Figure 4. Distribution of injury source in 2020 - 2022. Number of cases is plotted using columns and Y-axis on the left, and percentages are plotted using lines and Y-axis on the right.

6. Employee Type

Types of employees who experience finger injuries can be seen in Figure 4, that show there is no significant change in several types. For Permanent employees there was no significant change in three-year period, for Privatization employees there was also the same trend and even showed an encouraging decline with final number only being one case, and for Labor Supply employees there was also a decline, one case per year. These trends different with Service Contractors and Project Contractors who have shown quite significant increase, in fact the number of Service Contractors has started with more than ten cases. For Service Contractor employees, there was a surprising increase from only 41% in 2020 to 50% in 2022, even though there had been a decline in 2021 to 23%. Meanwhile, for Project Contractor employees, there was a drastic increase of more than three times from 2020 (2 employees) to 2021 (11 employees), in 2023 there was a decrease but only in 2 cases.
Figure 5. Distribution of employee types in 2020 - 2022. Number of employees is plotted using columns and Y-axis on the left, and percentages are plotted using lines and Y-axis on the right.

7. Business Unit

The number of cases per business unit fluctuates greatly for each of them. Business unit that consistently has a large number of incidents is Support, where in 2021 (23%) and 2022 (31%) it ranks highest compared to other business units, although in 2020 it ranks second highest, but in terms of number (9 cases) still more than the most cases in 2021 (7 cases). In Construction there has been an increase of more than two-fold from 2020 to 2021 and the number of cases remain the same in 2022. Maintenance started with a high number of cases in 2020 with 10 cases and the largest number of cases, but succeeded in reducing almost half in 2021, although this number remain the same in 2022. Meanwhile, a drastic increase in number of cases occurred in Concentrating, from 1 case in 2020, it rose to 7 cases in 2021, although in 2022 it was successfully reduced to 3 cases, but still not back to the number of cases in 2020.

Figure 6. Distribution of business units in 2020 - 2022. Number of cases is plotted using columns and Y-axis on the left, and percentages are plotted using lines and Y-axis on the right.

There is an increase in cases every year in the Underground Operation, increasing by 1 case in 2021 (6 cases) from 5 cases in 2020, but in 2022 it increases drastically to 10 cases, almost twice. Surface Operation went from having no cases in 2020 and 2021 to contributing one case in 2022 even though mining operations have been stopped. This case occurred in an area outside the open pit mine, in a residential area.
Discussion

Main objective of this research is to study finger injuries in mining industry, especially at PT X from 2020 to 2022, in order to find out types of injuries that occur, their consequences, causes, and employees and business units involved. This analysis can be used as a basis for information on how finger injuries experienced changes in trends in these three years, which is quite interesting to study further. There is an increase in number of finger injury cases even though total number of injuries recorded is decreasing every year, this makes percentage of finger injury cases compared to total injuries increase drastically by 8%. The decrease in the total number of injuries is in line with results of similar research which shows success in efforts to reduce number of injuries in mining industry (Groves et al., 2007, Nasarwanji et al., 2018, and Poplin et al., 2008). However, increase in finger injuries is strange because it contradicts findings of these studies.

In PT X, the mining safety work program carried out has shown encouraging results for total number of injury cases that occurred, this work program is stated in the Mining Safety Objectives, Targets and Program (OTP) document. The goal of OTP is to ensure employees are protected with safe operations and achieve zero fatalities, as well as reducing serious incidents, with strategic goals focused on high risks. Based on this goal, several derivative programs were created, they are: Prevention of Fatal Accidents and Serious Injuries; Mining Safety Management System; Operational Safety; Industrial Hygiene and Occupational Health; and Contractor Safety Management System. As seen in OTP, the focus is on fatal accidents and serious injuries and PT X has successful in achieving objectives of its mining safety program. However, the increase in minor injuries such as finger injuries is a surprising condition, possibly due to the lack of programs specifically designed to focus on this type of injury.

If we look at statistics on LWD as a result of finger injuries, this has resulted in a significant increase in total number of LWD of almost 4 times due to serious cases such as amputation. These several amputation cases resulted in LWD in Lost Time category increasing more than 8 times. Therefore, finger injuries that are considered minor should be one of the focuses of PT X’s mining safety program.

Total number of LWD during this three-year period was dominated by cases of computations and fractures, which increased significantly from year to year. This is in line with results of several previous studies which stated that bone fracture injuries are the most common injuries in mining workers and several other industrial workers. (Nowrouzi-Kia et al., 2018, and Lind, 2008). While Pollard et al. (2014) stated that fractures and cuts were the largest contributor to the number of LWD. However, in this study it was found that the number of working days lost for cases of cut/laceration was the smallest contributor. Findings on cut/laceration are in line with Alessa et al. (2020) which found that LWD in cases of cut/laceration was around 16.3% of the total lost working days overall.

Looking at the source of finger injuries, which mostly come from unsafe, it is fitting that this should be the focus of PT X’s mining safety program. However, in OTP over the past three years, only in 2022 that management is concerned about unsafe worker behavior by implementing the Behavior Based Safety (BBS) program. This program was created based on the results of a survey conducted in collaboration with consultants in December 2021 involving 14 organizational units, by distributing questionnaires and conducting observations and interviews with managers, supervisors, and workers for 2 consecutive months. From the results of this survey, recommendations emerged for intervention actions that need to be taken to improve safety-based behavior of supervisors. This intervention action is implemented and monitored periodically by each division involved.

The types of employees involved in finger injury incidents were dominated by service contractor and followed by project contractor employees, who accounted for
61.7% of the total finger injury incidents. At PT X there is a special program that targets mining safety for all contractors, known as the Contractor Safety Management System (CSMS). Implementation of this program was strengthened in 2019 by establishing special committee to supervise and facilitate facilities and infrastructure required to make sure good implementation of this program. Mining Safety and Learning and Organizational Development Divisions acts as front gates in checking every contractor company that takes part in tender process. Once it is declared feasible and in accordance with standards, it can proceed to the next process of contract administration. Previously these two processes were carried out in parallel so that the company's safety and competency requirements were not the main determinants of contractor company's suitability.

However, based on statistical data over a period of three years, it appears that the CSMS program was not successful in identifying safety behavior among contractor employees because this program only focused on the company entity itself. What was examined was the contractor's safety documents. It would be better if BBS program was also implemented for all contractor companies, after previously carrying out a similar survey to map existing problems so that future corrective and preventive actions could be more effective.

Meanwhile, if we look at the business units involved in the finger injury incident there are three big ones, they are Support, Maintenance and Underground Operations, with each having a share of more than 20% and a total contribution of 74.47%. It is natural that these business units pay more serious attention to incidents of finger injuries in their area, especially those that occur in contractor companies working under their supervision.

Even though company's OTP is not focused on finger injury incidents, business units can develop this OTP by creating special programs within their divisions to manage finger injury incidents so that the number of cases can be reduced to a minimum. Underground mining activities are categorized as a dangerous operating area due to its high-risk conditions (Paul, 2009), so it is appropriate for underground operation business unit to pay attention to all kinds of conditions that can contribute to injury, even in the form of finger injuries which many people underestimate as minor injuries, however there have been many studies including this research which prove otherwise. Maintenance activities are also high-risk operations that result in high levels of LWD in mining industry in United States (Pollard et al., 2014 and Reardon et al., 2014) and other industries (Jesslyn, 2016), therefore this business unit must also prepare its mining safety program well and consider all types of injuries, including finger injuries.

**Conclusion**

From this research it can be concluded that behind the success of PT X's mining safety program there is an increase in incidence of finger injuries at an alarming rate with the number of total 773 LWD. Overall, it appears that the number of incidents has increased, followed by a drastic increase in percentage of injuries compared to total number of injuries reported, due to a decrease in the overall number of injuries. The interval between injuries also increases.

Each injury classification shows an increasing trend with the largest number being in the First Aid classification. Based on type of injury also shows increase in each type, except for Cut/Laceration which shows a decrease. The increase in LWD occurred over a period of three years, with a drastic increase in Lost Time category.

Meanwhile, distribution of sources of injury tends to be stable with the most common source being Unsafe Behavior. Types of employees who experienced injuries were dominated by Service Contractor and Project Contractor employees which experienced increase in number of injuries, although other types of employees...
experienced a decrease. And finally, business units saw an increasing trend, except for Maintenance and Concentrating.

**Suggestion**

This worrying condition demands that immediate preventive action be taken on a global PT X scale as well as on a small scale within each business units in order to create an anticipatory program that is effective and can be applied, especially in business units that are proven to have a high record of finger injuries. Program can take the form of socializing finger injuries that have occurred over the last few years to build employee awareness of the risks that surrounding them, making finger injuries one of the campaign themes of National K3 Month activities at PT X, creating short training discussing the risks, probabilities and consequences of finger injuries which are often considered minor. And because there has been a drastic increase in the last three years, this training has to be classify as mandatory training and requires refresher every year. Implementation of these programs must be aligned with the BBS program that is being implemented and must reach all employees in all divisions, including permanent employees and contractors of all types.

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