# Analysis of Workplace Safety at the Musoshi Mine in Katanga Province, 1970-2010

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**Abstract**

Occupational injuries and fatalities pose significant societal concerns. This article analyzes the workplace injury patterns and causative factors at the Musoshi mine in the Katanga province. On average, 71.52 accidents occurred per year for every 1000 workers at the Musoshi mine. In Japan, the average severity rate was 2.94 per 1000 workers per year, whereas in the DRC, it was 3.1. In total, 23% of deaths resulted from handling heavy machinery, 23% from worker falls, and 21% from block falls. In addition, 30% of the workers' hands and 20% of their legs were injured in the accidents. Miners in the DRC have a higher accident rate than Japanese miners. Heavy machinery and worker falls caused approximately 46% of the fatal accidents at the Musoshi mine.

**Keywords:** Katanga, mining industry, Musoshi mine, occupational fatality

## 1. Introduction

This article investigates the injuries and their underlying causes at the

Musoshi mine in the Katanga province of the Democratic Republic of the Congo (DRC). Mining operations have long been associated with high accident frequency, severe injuries, and fatalities (Lööw & Nygren, 2019). Protecting both physical capital and workers' lives is a priority for both employers and employees in maintaining workplace safety. In both developing and advanced countries, the safety of employees and the associated costs for employers and the economy have taken on increased significance. Occupational injuries and diseases have emerged as major concerns for workers in less developed nations (Abbas, 2015).

Mining is the deadliest work environment globally with a substantial number of deaths, injuries, and illnesses among workers (Karmel, 2017). Workplace hazards significantly contribute to injuries and illnesses among employees. Workers' occupations play a crucial role in shaping the social determinants of health (Marica et al., 2015). Those with greater health and safety risk exposure than most workers, yet unable to modify hazardous conditions, are defined as contemporary occupational health and safety vulnerability cases (Yanar et al., 2019). The field of professional practice is expansive.

Effective preventive measures should safeguard employees from work-related injuries and illnesses that adversely impact businesses and employees themselves (Tamers et al., 2020). Work-related death represents a social issue (Annan et al., 2015). An occupational accident refers to an incident that occurs during employment. This incident could result in injury, illness, or death. An accident resulting in death either immediately or within a few days is referred to as fatal. Therefore, work-related death is a social problem (Perotti & Russo, 2018). Globally, migrant workers encounter unfavourable work environments and occupational hazards compared with the general population (Moyce & Schenker, 2018).

Understanding the causes of occupational accidents is crucial for policymakers to develop effective preventive measures. Despite mining companies' efforts to enhance worker safety and health, incidents persist.

Two prominent companies, one government-owned and the other a Japanese joint venture, monopolized copper extraction in the DRC from the 1960s to 1990s (Kalenga et al., 2018). In collaboration with the Congolese government, Japanese investors established the Musoshi consortium to mine and process copper metals in the Kinsenda and Musoshi underground mines. From 1965 to 1984, Japanese engineers and managers resided and worked in the Katanga province of the DRC. Accidents and fatalities in copper mining firms in Katanga escalated among Congolese workers.

This article provides information on the development of worker injury rates and fatal accidents in the DRC. This study adds to the scholarly understanding of worker fatalities by examining injury trends and root causes in the Congolese and Japanese mining industries.

## 2. Materials and Methods

This study, using a new dataset, examines Musoshi mine's occupational accident trends by a retrospective analysis. The primary datasets are not publicly accessible. This study collected data on workplace accidents leading to a minimum absence of 4 days. An accident could only be reported if the injured person returned to work on the fifth day following the incident.

The accident frequency rate was calculated on the basis of the total number of deaths and injuries in occupational accidents per 1 million work hours. The rate was calculated by dividing the total number of deaths and injuries per million work hours during the survey period by the number of work hours for all workers who were exposed during that time.

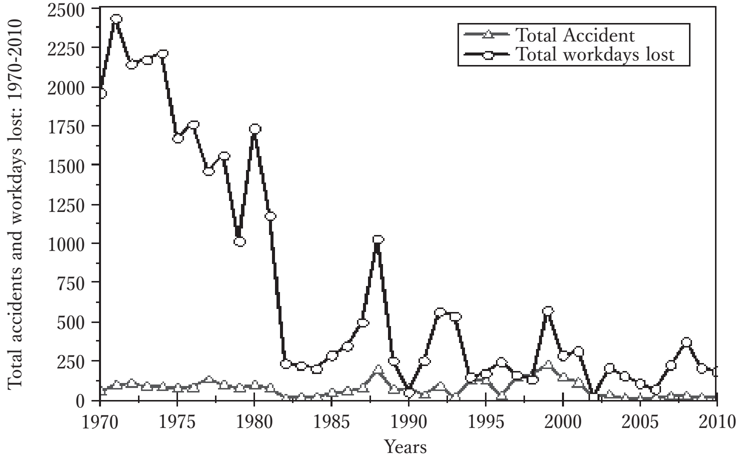
The accident severity rate was measured by calculating the number of lost workdays per 1,000 work hours. The rate of lost workdays per 1,000 work hours due to occupational accidents during the survey period was calculated by dividing the total number of lost workdays by the total number of work hours for all workers at risk.

The Musoshi mine's frequency, severity, and fatality rates in the Katanga province are compared with those of the Japanese mining industry in this study. In the third part, the Musoshi mine workers' injury statistics are expressed in figures and tables.

## 3. Results

The injury rates at the Musoshi mine in the Katanga province are detailed in this third section, with a focus on current trends. Workers may prefer safety, but accidents can still surprise them. The Musoshi mine workers were at risk of accidents during both underground mining and surface processing of the copper concentrate. Figure 1 shows the Musoshi mine total number of accidents and workdays lost from 1970 to 2010.

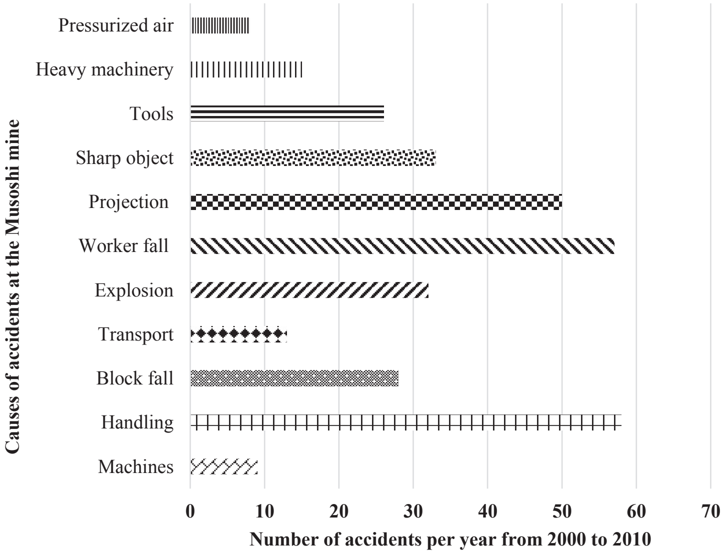
**Figure 1 Total accidents and workdays lost at the Musoshi mine from 1970 to 2010.**




Source: Authors' collation from the calculation of the data.

The 40-year study period at the Musoshi mine is shown in figure 1, which compares both the trend of total accidents and the corresponding workdays lost. During the early copper production era, Musoshi mine workers endured lengthy work absences due to injuries. Ninety-five accidents in 1971 accounted for 2433 lost days at the Musoshi mine. In the initial stages of mining, workers encountered a considerable risk of injury. From 1973 to 1984, improved working conditions at the Musoshi mine lowered the rate of worker injuries. During the 1985-1995 period, rising accident risk negatively impacted workers' expectations of a safe working environment. The number of injuries at the Musoshi mine remained low between 1997 and 2010. Suspending the production of copper concentrate and metal in 2002 minimized activities and exposed the workforce to potential accidents. Figure 2 illustrates the annual occurrences of mining accidents in the Musoshi mine between 2000 and 2010.

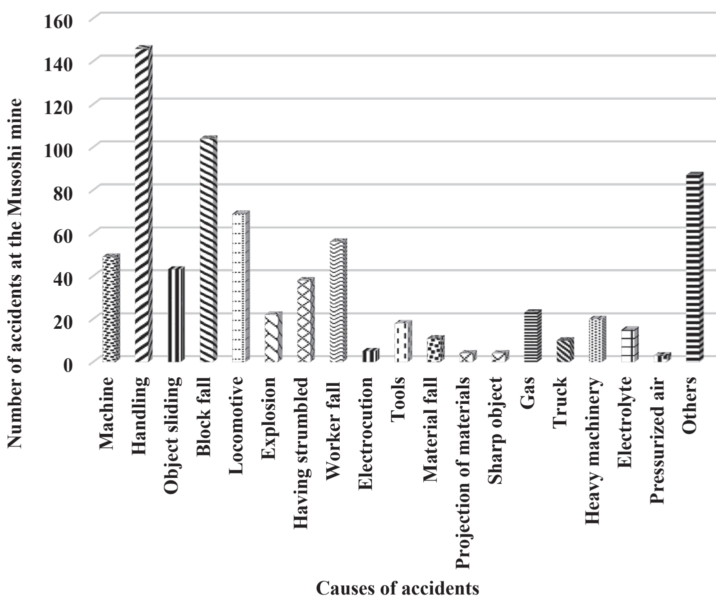
**Figure 2 Causes of accidents per year at the Musoshi mine from 2000 to 2010**




Source: Authors' collation from the calculation of the data.

Approximately 35% of the injured workers at the Musoshi mine from 2000 to 2010 were due to human errors in handling of heavy machinery and worker falls. In the early 1970s, dominant factors accounted for 28% of accidents, while worker projections contributed an additional 15%. Approximately 28% of the miners experienced injuries from explosions, sharp objects, and block falls during the 2000s. Approximately 5% of the Musoshi mine worker accidents are caused by pressurized air. Heavy machinery caused 7% of the injuries during the preceding period. The accident rate dropped to approximately 4.5% during the second period. Instead of open pits, most underground mine workers are trained, thereby increasing their risk of accidents. The prevention of accidents varies between the 2 working conditions. Figure 3 depicts the Musoshi mine accidents that resulted in at least a four-day absence or hospitalization from 1973 to 1980.

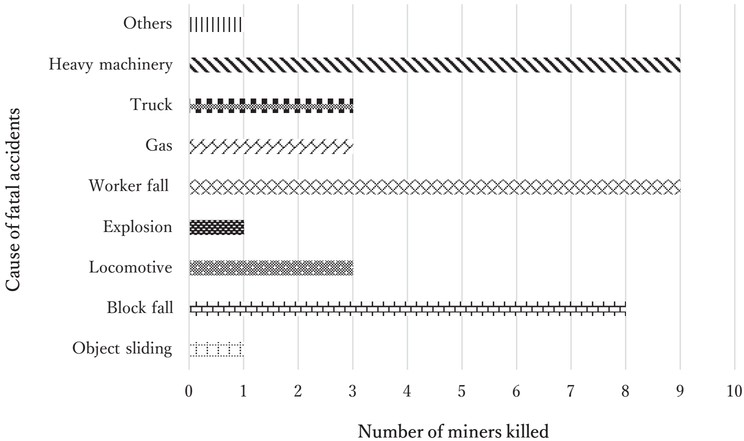
**Figure 3 Causes of accidents during the Japanese management at the Musoshi mine from 1973 to 1980**




Source: Authors' collation from the calculation of the data.

Figure 3 illustrates the Musoshi mine primary reasons for the major accidents between 1973 and 1980. The Musoshi mine experienced most of its accidents due to handlings and falls during this time. Another factor leading to accidents among workers is the transportation of minerals. Among miners, accidents caused by pressurized air were the least frequent. During the same period, other factors increased the number of injured workers at the Musoshi mine. From 1973 to 1980, Figure 4 shows the primary causes of the fatalities at the Musoshi mine.

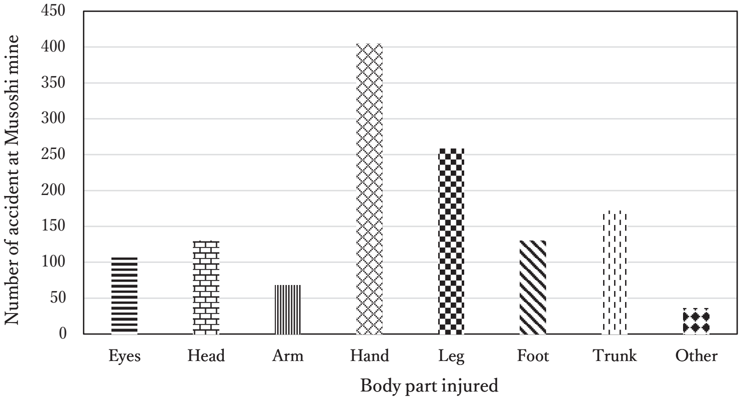
**Figure 4 Causes of fatalities at the Musoshi mine from 1973 to 1980**




Source: Authors' collation from the calculation of the data.

Heavy machinery malfunctions and worker falls were the major causes of fatalities from 1973 to 1980 at the Musoshi mine. Indeed, these factors killed approximately 46% of the workers. In addition, the falling blocks killed approximately 20% of the miners. Besides, 9% of the workers were killed because of explosions, object sliding, and related incidents. The Musoshi mine's workplaces are indicated as unsafe by these numbers. The optimal work environment results in no fatalities annually. The injured body parts of the Musoshi mine workers from 1975 to 1980 are illustrated in Figure 5.

**Figure 5 Workers' body parts injured per accident at the Musoshi mine from 1975 to 1980.**




Source: Authors' collation from the calculation of the data.

Approximately 30% of accidents at the Musoshi mine from 1975 to 1980 resulted in hand injuries, whereas 20% involved leg injuries. Among workers, 13% of workplace injuries involved trunk injuries. In approximately 10% of the accidents, workers sustained head injuries. Among all parts of the human body, the head is the most sensitive. A minor head injury can inflict serious harm. Workers should wear helmets for head injury prevention. The 5-year injury rate for body parts other than the one specifically mentioned was below 2.74%. From 1970 to 2010, the data below outlines the fundamental statistics of mining accidents in Japan and the DRC.

The median frequency rate at the Musoshi mine was 10.47 per 1000 workers, whereas the average was 36.07. The severity rates contributed an average of 2.94 per 1000 workers. The fourth part explores Musoshi mine's workers' injury and fatality rates in relation to international standards.

## 4. Discussion

This article investigated the injury rates and causal factors leading to worker fatalities. From 1970 to 2010, the mining industries in Japan and the DRC had vastly different injury rates. Indeed, the DRC recorded an average of 71.52 per 1000 workers and Japan's 18.21 per 1000 workers. The average severity rates in Japan and the DRC were 2.94 and 3.1 per 1000 workers, respectively. The average and median frequency rates of injuries at the Musoshi mine from 1970 to 2010 were 36.07 and 10.47 per 1000 workers, respectively. On average, 2.94 workplace accidents per 1000 workers occur annually. The coefficient of variation was 0.76, indicating a moderate degree of homogeneity. Thirty-nine fatal accidents occurred at the Musoshi mine between 1973 and 1980. Workplace culture influence workers' values, beliefs, and attitudes, resulting in specific behaviors. Health and safety are an integral component of their work (Corrigan et al., 2019).

The fiscal year of 1972 marked the beginning of production at the Musoshi mine, but the working conditions were stressful. The Musoshi mine accidents caused by production pressure injured and killed several workers. The need to enhance profits and efficiency compels an organization to meet operational goals under production pressure. Research indicates a negative impact on employees' health and safety due to a production-centric organizational focus (Probst & Graso, 2013). During the period from 1970 to 1983, the frequency and severity rates for injured workers were 48.14 and 4.97 per 1000 employees, respectively. Understanding their time constraints, Japanese managers focused on maximizing production. In the tent camps, they extracted the ores to process the copper concentrate for exportation to Japan quickly. In Japan during the 1960s and 1970s, overwork leading to feelings of inescapable trap and powerlessness contributed to the phenomenon known as "Karoshi." Indeed, sudden death can result from accumulated chronic fatigue due to high-stress work (Bo-fan et al., 2019). The Japanese workplace offers a safer work environment than this one, with the latter causing a higher suicide rate. Japanese managers maintained strict control over the local workforce. The Japanese managers of the Musoshi mine funded education for its workers' offspring. The Japanese held weekend festivals at the Musoshi mine. During these events, team leaders across sectors were required to dine and socialize with both local miners and workers. Rapid economic growth, such as that Japan experienced in the 1960s, requires a stable supply and consumption of metals to build various infrastructure (Ussif, 2004).

In Italian firms, poor working conditions are the most significant determinants of accidents and illnesses occurring at work (Xiao et al., 2019). Poor working conditions in the underground caused several accidents at the Musoshi mine. Japanese engineers constructed the Musoshi mine with traditional techniques using wood for beams, props, and corridors instead of using modern mining techniques. Musoshi mine's galleries are narrow. Miners extracted the heart from the copper vein continually. Because of the excessive number of landslides, making solid support beams was unnecessary for wood construction. Japanese mining techniques at the Musoshi mine are hazardous. Workers navigate through confined spaces littered with decaying wooden shovels. Initially, miners carried manual devices as they explored the mines. Workers at the Musoshi mine lugged jackhammers, like how a soldier ascends a hill. Frequently, workers succumbed to falls. These factors are important causes of injury incidence at the Musoshi mine.

Adopting a company-wide safety culture minimizes the number of employees who encounter accident hazards (Cioni & Savioli, 2016). The Musoshi mine, which is modelled after the Kosaka copper mine in Japan's Akita Prefecture, was built using the same design and materials. At the Musoshi mine, injuries resulted from several factors such as block falls, loose machinery, ores haulage, truck traffic, poor signals, and insufficient lighting. Implementing a culture of safety at the firm level is a way of reducing the number of workers exposed to the risk of accidents (Tetzlaff et al., 2021). The workplace accident rates in advanced countries are lower than those in developing countries. In contrast to Canada, Ontario's legislation enforces safety regulations and factory inspections. The failure of this strategy to decrease accident rates is evident (Silvestre, 2010). In 2011, the incidence rate of non-fatal accidents in Spain was 35.9 per 1,000 workers—3.9 and 2.8 times higher than that in Australia and Canada (Bande & López-Mourelo, 2014). Although Spanish construction industry data reveal that older workers experienced fewer accidents (González et al., 2022), the severity of their occurrences was greater. Since the establishment of the work safety division at the national level through regulations in 1974, the number of accidents at the Musoshi mine and Gecamines has decreased. Injuries in the copper industry of Katanga declined.

Sociological research asserts that technological and organizational failures, rather than human error, play a predominant role in industrial accidents. However, worker negligence and compliance with safety rule disregard also play a role (Gualmini, 2008). The declining work environment led to an average of 80.16 injuries and a severity rate of 1.75 per 1000 workers. The rates during the preceding period were lower than these. In fact, sociological research argues that technological and organizational failure, rather than human error, are key factors that significantly contribute to industrial accidents. Workers' imprudent attitudes and passive acceptance of non-observance of safety regulations played a part in the occurrence of accidents (Tappura et al., 2014). The primary cause of accidents in the Musoshi mine is human error. Miners, despite safety training, sustained injuries and fatalities due to mistakes. The rotation of workers across departments increased the need to learn and adapt quickly. In Finland, the pressure to save time, cramped schedules, and carelessness are major contributors to accidents (Minchin, 2021). Copper industry workers in Katanga now enjoy better working conditions thanks to the new regulations.

Between 1988 and 2010, there were on average 21.05 injuries per 1000 workers each year, with each injury having a severity level of 1.90. In 1990, 2 workers were killed in a road accident while transporting copper ores from the Kinsenda mine to the Musoshi plant for processing. Block falls, electrocution, blasting, haulage accidents, and heavy machinery malfunctions were the leading causes of death. Dead workers' compensation differed according to their role, tenure, and expertise. The family received funeral expenses and termination salary from the company. In the United Kingdom, skilled workers' compensation depends on their union membership. Unionized workers having greater wealth, not knowledge, are the reason for their placement in safer jobs. In the automobile industry, union workers receive 20% more compensation for accidents than non-union workers (Minchin, 2021). In 2007, 5.6 thousand fatal accidents occurred in the US, resulting in $6 billion in damages. However, non-fatal injuries were estimated at 8.5 million workers and cost about $186 billion. Workers' compensation covers less than 25% of these costs, so all members of society share the burden (Leigh, 2011). At the national level, the findings show that in New Zealand, approximately 700 deaths occur annually from work-related diseases and approximately 100 deaths from work-related injuries (Mannetje & Pearce, 2005). In 2015, there were 19 fatal accidents in Mexico's underground mining industry. The principal causes of death included block falls, electrocution, blasting, haulage, heavy machinery, and other factors (Domínguez et al., 2019).

In the late 1990s, the Musoshi mine entered partnerships with investors for the extraction of copper and cobalt from small deposits using open pit mining. At the Musoshi mine, the 2004 production collapse led to fewer injuries. Fewer workers were exposed to the risk of accidents due to the theoretical closure of underground mines. Despite the suspension of copper concentrate production at the Musoshi plant, workers at the mine site still endured several severe accidents. In the US, quarry workers identify hazards and improve their safety performance by translating the safety knowledge learned from training into practice to reduce the occurrence of accidents (Bae et al., 2021).

The study period saw a reduction in the number of workers injured in the Japanese and Congolese mines. In total, 2826 workers, including locals and expatriates, were employed at the Musoshi mine in 1972. The workforce rose to a peak of 3805 employees in 1977. In 1983, the Musoshi mine employed 2632 workers after the Japanese left the extraction project.

Occupational and personal factors have been linked to a higher occurrence of work-related accidents (Hägg et al., 2015). Worker injuries and fatalities at the Musoshi mine primarily stemmed from handling incidents, heavy machinery mishaps, worker falls, and locomotive incidents. Injuries caused workdays to be lost because of home recovery or hospital treatment until full medical recovery was certified. Employers in the DRC are mandated to cover medical expenses for injured employees.

Mining firms in the Katanga province provide medical services or hospitals to their workers and relatives. The Musoshi mine operates a hospital that offers comprehensive healthcare services. Firm-built schools offer education from kindergarten to high school for the benefit of workers' children and families.

Severe accidents requiring extended rest or hospitalization occurred among mine workers in Japan and the DRC. Reforming and harmonizing legal frameworks for safety in low-income countries will benefit employees, employers, and regulatory authorities. Some injured workers lost their ability to work permanently. 1991–2008 saw a consistent, low occurrence of severe accidents among workers. During the last 2 years between 2008 and 2010, there was a significant spike in the number of severe accidents.

In this study, heavy machinery and worker falls were identified as the primary causes of fatal accidents at the Musoshi mine. Haulage and locomotives are the primary causes of fatalities in open pits, underground mines, and Gecamines processing plants in Katanga (Kalenga et al., 2016). While accidents in this study are primarily attributed to causes other than small-scale underground mining, Ghana faces numerous unsafe acts and conditions such as stope collapse, unsuitable equipment choices, lack of personal protective equipment, and land degradation (Bansah et al., 2016). Inadequate human resource capital and expertise in occupational health and safety are significant obstacles to the effective implementation and adherence to health and safety regulations in the Southern Africa region at the workplace (Moyo et al., 2015). However, to increase safety at the workplace, improving the quality of equipment training for heavy machinery operators is a critical task in eliminating equipment-related injuries in the mining industry (Zujovic et al., 2021). Furthermore, in low-income countries, the legal frameworks of safety require reformation and harmonization for the collective benefit of employees, employers, and regulatory authorities (Ncube & Kanda, 2018). This study is concluded in the fifth section.

## 5. Conclusion

This article analyzes the Musoshi mine's worker fatalities and injury rates, and their causes. For decades, protecting both physical investments and human resources has been a critical global concern for employers and workers in the realm of occupational safety. An incident causing injury or death to a worker while on the job is classified as a workplace accident. Workers frequently feel powerless to change unsafe working conditions when they work in dangerous environments.

From 1970 to 2010, Japan's frequency rate averaged 18.21 per 1000 workers, whereas the DRCs averaged 71.52 per 1000 workers. The average severity rates were 2.94 in Japan and 3.1 per 1000 workers in the DRC. Approximately 30% of the injuries were to the hands and 20% to the legs. A coefficient of variation of 0.74 indicates the degree of homogeneity. On average, 2.94 cases of severity occurred among every 1000 workers. In total, 39 people lost their lives at the Musoshi mine from 1973 to 1980. Pressure to meet production targets leads to workplace accidents resulting in injuries and fatalities. The second half of the decade saw a significant decrease in mining accidents due to effective legislation.

In 1984, Canadian managers assumed the role of trustees from the Japanese. During their three-year tenure, injuries and fatalities were recorded among the Congolese miners. The injury and severity rates both showed significant increases, with the injury rates reaching 80.16 per 1000 workers and the severity rates at 1.75 per 1000 workers. The rates during this period were greater than those in the previous period.

At the Musoshi mine, injuries were most likely caused by block falls, loose machinery, hauling ores, truck traffic, misuse of individual equipment, and insufficient lighting. By enforcing regulations that limit human error in mining operations and providing proper training, safety can be significantly enhanced. Enhancing training for heavy machinery operators to increase equipment quality is crucial for preventing mining injuries.

In developing countries, these research findings inform stakeholders and policymakers to prevent accidents. This study focuses on calculating accident rates and determining the contributing factors. The copper industry's injured workers' compensation schemes require further investigation.

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