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EVALUATION OF COMPLIANCE WITH THE OCCUPATIONAL HEALTH AND SAFETY REGULATIONS IN REDUCING ACCIDENTS

EVALUACIÓN DEL CUMPLIMIENTO DE LA NORMATIVA DE SEGURIDAD Y SALUD EN EL TRABAJO EN LA REDUCCIÓN DE ACCIDENTES

Autores:

Maximiliano Yaulilahua Huacho
Licenciado en Administración
Maestro en Gestión Pública
🔾 https://orcid.org/0000-0002-7064-0375
E-mail: myh2021oro@gmail.com
Afiliación: Universidad Nacional de Huancavelica
País: Huancavelica – Perú

Russbelt Yaulilahua Huacho
Ingeniero Ambiental y Sanitario
Maestro en Ecología y Gestión Ambiental
🔾 https://orcid.org/0000-0002-7007-3059
E-mail: russbelt.yaulilahua@unh.edu.pe
Afiliación: Universidad Nacional de Huancavelica
País: Huancavelica – Perú

Víctor Marcelino López Lino
Licenciado en Administración
Maestro en Gestión Pública
🔾 https://orcid.org/0000-0003-1638-4662
E-mail: victor.lopez@unh.edu.pe
Afiliación: Universidad Nacional de Huancavelica
País: Huancavelica – Perú

Erick Zenon Gutiérrez Quispe
Contador Público
Maestro en Gestión Pública
🔾 https://orcid.org/0000-0002-3006-4895
E-mail: erick.gutiérrez@unh.edu.pe
Afiliación: Universidad Nacional de Huancavelica
País: Huancavelica – Perú

Abstract

The primary purpose of this research was to determine whether the Occupational Health and Safety Regulations influence worker accidents at the gold mining company Retamas S.A. during the period from 2018 to 2022. Methodologically, this study is non-experimental, applied research with an explanatory level and longitudinal design. The population consisted of 4,829 workers with a non-probabilistic sample, incorporating the entire workforce of the mining company. Data collection was documented for the period from January 2018 to December 2022 using a flash report documentation technique. The statistical package IBM SPSS Statistics version 25 was used at a 95% confidence level, with the Kolmogorov-Smirnov test conducted to assess normality. The results showed the highest number of minor accidents occurred in 2019 (165 cases), followed by 2018 (158 cases), and 2021 (153 cases), while fewer accidents were reported in 2020 (129 cases) and 2022 (109 cases) ($p<0.05$). For disabling accidents, the highest occurrences were in 2018 and 2019 (both 101 cases), and 2021 (93 cases), with fewer cases in 2020 (55 cases) and 2022 (50 cases) ($p<0.05$). Fatal accidents were as follows: 2018 (2 cases), 2022 (1 case), 2021 (1 case), 2019 (1 case), and 2020 (0 cases), with no significant statistical differences. It is concluded that the Occupational Health and Safety Regulations do not significantly reduce or prevent accidents at the mining company.

Keywords: Accidents, minor, disabling, fatal, Occupational Health and Safety Regulations.

Resumen

El objetivo principal de esta investigación fue determinar si el Reglamento de Seguridad y Salud en el Trabajo influye en los accidentes laborales en la empresa minera de oro Retamas S.A. durante el período comprendido entre 2018 y 2022. Metodológicamente, este estudio es una investigación no experimental, aplicada con un nivel explicativo y diseño longitudinal. La población estuvo conformada por 4.829 trabajadores con una muestra no probabilística, incorporando a la totalidad de la plantilla de la empresa minera. La recolección de datos se documentó para el período de enero de 2018 a diciembre de 2022 utilizando una técnica de documentación de informes flash. Se utilizó el paquete estadístico IBM SPSS Statistics versión 25 con un nivel de confianza del 95%, con la prueba de Kolmogorov-Smirnov realizada para evaluar la normalidad. Los resultados mostraron que el mayor número de accidentes menores ocurrió en 2019 (165 casos), seguido de 2018 (158 casos) y 2021 (153 casos), mientras que se reportaron menos accidentes en 2020 (129 casos) y 2022 (109 casos) ($p<0.05$). En cuanto a los accidentes incapacitantes, las mayores ocurrencias fueron en 2018 y 2019 (ambos 101 casos) y 2021 (93 casos), con menos casos en 2020 (55 casos) y 2022 (50 casos) ($p<0.05$). Los accidentes mortales fueron los siguientes: 2018 (2 casos), 2022 (1 caso), 2021 (1 caso), 2019 (1 caso) y 2020 (0 casos), sin diferencias estadísticas significativas. Se concluye que el Reglamento de Seguridad y Salud en el Trabajo no reduce ni previene significativamente los accidentes en la empresa minera.

Palabras Clave: Accidentes, leves, incapacitantes, mortales, Reglamento de Seguridad y Salud en el Trabajo.

Introducción

In the heart of Peru's Andes Mountains, the Retamas S.A. gold mining operation stands as a monument to both human resilience and ambition. Since its inception, Retamas S.A. has provided livelihoods to thousands of miners, many of whom navigate hazardous underground networks daily to extract gold that feeds both local and global demand. Yet, like many mining sites around the world, Retamas S.A. operates in an environment where risk is omnipresent, and where miners face a range of dangers—from rockfalls and equipment failures to ventilation issues and exposure to harmful dusts and chemicals. The Peruvian government, recognizing the high risk in the mining sector, introduced the Occupational Health and Safety Regulations (OHSR) in 2011, hoping to curb accident rates in industries where physical danger is inherent (Ministerio de Energía y Minas, 2016).

At Retamas S.A., these regulations sparked sweeping changes, as the company implemented safety protocols, hazard assessment procedures, and training programs designed to protect its workers. The goal was simple but profound: to establish a workplace where miners could perform their duties with a reduced risk of injury or death (Ramírez et al., 2019). However, despite such efforts, the company continued to report accidents across various levels of severity, raising questions about the effectiveness of OHSR compliance in preventing such incidents (López & Vásquez, 2021).

Globally, the mining industry has one of the highest rates of workplace accidents and fatalities, according to the International Labour Organization (ILO). The ILO reports that miners are at an elevated risk due to their work environment, which includes confined spaces, machinery handling, and exposure to hazardous materials (International Labour Organization, 2018). Numerous studies across different countries have emphasized the importance of rigorous occupational health and safety (OHS) regulations in preventing accidents and promoting worker welfare. For instance, Zhang et al., (2020) highlight that consistent regulatory enforcement in China's mining sector resulted in a gradual decline in accident rates. Similarly, in South Africa, a country with a long history of mining, effective safety measures have been associated with reduced fatalities in the industry (Mkhize & Dlamini, 2019).

Yet, the success of OHS regulations is often contingent on several factors beyond policy implementation. Company culture, commitment to training, and the availability of safety equipment play significant roles in translating regulations into safer working conditions (Johnson et al., 2020; Dawson et al., 2018). At Retamas S.A., compliance with safety protocols has been a core focus, but the impact on accident reduction has been inconsistent over the years, particularly in light of varying

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accident severity levels from minor injuries to severe, disabling incidents (Pérez et al., 2022).

This study explores the effectiveness of OHSR compliance at Retamas S.A. from 2018 to 2022, assessing whether adherence to safety protocols has meaningfully impacted accident rates. Using documented flash reports and statistical analysis, we investigate patterns in accident data, distinguishing among minor, disabling, and fatal accidents to provide a nuanced understanding of the risks faced by workers and the potential benefits of regulatory compliance. By examining the effects of OHSR on accident trends, this study aims to contribute to broader discussions on occupational safety in high-risk industries and offers insights into potential areas for improvement at Retamas S.A.

The importance of this research extends beyond a single company or region. In countries like Peru, where mining plays a central role in the economy, the safety of workers is not only a matter of regulatory compliance but also a critical issue of social responsibility (Villanueva & García, 2018). Recent studies have shown that workplace safety in mining has broader impacts, influencing worker morale, productivity, and public perception of the industry (Thomas et al., 2021; Evans & Walker, 2020). Indeed, a safer work environment contributes to improved job satisfaction and retention rates, factors that ultimately support the sustainability of mining operations (Smith & Blackwell, 2020).

As mining companies worldwide navigate increasingly complex regulatory landscapes, understanding the impact of OHS measures remains crucial. Studies from Australia and Canada suggest that long-term investments in safety training and hazard prevention can yield substantial reductions in accident rates, even in high-risk environments (Turner & Bailey, 2019; Roberts et al., 2019). Nevertheless, the effectiveness of such measures depends on rigorous monitoring, consistent training, and an organizational culture that prioritizes safety (White et al., 2022; Lee et al., 2021).

Development

Study Design and Participants

This research follows a quantitative, descriptive design aimed at analyzing the influence of the Occupational Health and Safety Regulations (OHSR) on the reduction of workplace accidents within the mining sector, specifically in Minera Aurífera Retamas S.A. (MARSA) (Aceituno et al., 2020). Given the high-risk nature of the mining industry, this study focuses on assessing accident trends across the 2018 to 2022 period, categorizing accidents by severity and examining correlations with the implementation of the OHSR.

Study Setting

MARSA operates in the Retamas mining unit, located on the western flank of the Andes Mountain range, in Llacuabamba, District of Parcoy, Pataz

Province, La Libertad Department, Peru. Established in 1981, MARSA has continually expanded, increasing its processing capacity from 50 metric tons per day (TMS/day) to 1,800 TMS/day, employing over 5,000 workers. Positioned at an altitude of 3,220 meters above sea level and situated 429 kilometers southeast of Trujillo, the mine is reachable through a journey of approximately 16 hours. The climate in the region is characterized by an annual average temperature ranging from 15°C to 23°C, with an average relative humidity of 61% (Senamhi, 2024). These environmental conditions add another layer of complexity to mining operations, making the implementation of OHS regulations all the more essential for safeguarding worker health and safety.

Population and Sampling

The total population of this study comprises 4,829 active MARSA workers aged between 22 and 65, spanning various operational and administrative departments. For the purposes of this analysis, the study included the entire population rather than a sample subset, capturing data from all workers, regardless of their schedules or rotational work patterns (Aceituno et al., 2020).

Variables

The independent variable in this study is the implementation of the Occupational Health and Safety Regulations (OHSR), specifically focusing on protocols designed to mitigate accidents. The dependent variable is the number of reported workplace accidents, which are further categorized as minor, disabling, or fatal. Additional intervening variables include factors such as job type, length of exposure to risk, and age of workers.

The data on workplace accidents from 2018 to 2022 were extracted from MARSA's flash report system, which systematically documents incidents by severity, description, date, time, location, and individuals involved. The Peruvian regulatory framework governing these reports is established under the Occupational Health and Safety in Mining Regulations (Supreme Decree No. 024-2016-EM), and workplace accidents and occupational diseases are required to be reported immediately or within a stipulated timeframe (Peruvian Ministry of Energy and Mines, 2016).

Data Collection Procedure

Data collection was facilitated through document review and record analysis. The primary data source was MARSA's flash report system, which categorizes accidents into minor, disabling, and fatal, along with detailed incident descriptions. For real-time documentation, MARSA's safety area reports incidents through a dedicated WhatsApp group, where preliminary details are shared and stored for validation. Each report is subsequently uploaded to a centralized Excel database, which serves as a comprehensive archive for analysis. To validate these records, corroboration was conducted by cross-referencing data with MARSA's official

registry and archive system, ensuring data accuracy and completeness. Flash reports provided key details for each incident, including the nature of the injury, affected body parts, and immediate actions taken (OHS Regulation Compliance Manual, 2022).

Data Analysis

The recorded data were first organized and tabulated using Microsoft Excel, establishing an initial structure for analysis. Subsequently, descriptive statistics were generated using IBM SPSS Statistics version 25, providing a foundational overview of accident frequencies, means, and standard deviations. Inferential statistical analysis was conducted to assess the distribution of values, utilizing a 95% confidence level. Comparisons between different years and categories of accidents were made using Tukey's HSD test to identify statistically significant differences in accident rates across time periods (Dean & Voss, 2020). To ensure normality and reliability of the data, the Kolmogorov-Smirnov test was applied, verifying the distributional assumptions necessary for accurate statistical inference (Salkind, 2017).

Ethical Considerations

Data collection and analysis adhered to ethical standards, ensuring worker confidentiality and respecting MARSA's data usage policies. Permission was obtained from MARSA's administrative and safety departments to access and analyze the accident data for research purposes.

Results

The analysis of accident types in the MARSA company from 2018 to 2022 shows a varied distribution of minor, disabling, and fatal incidents over the years and months. In 2018, the total number of minor accidents (L) was 158, with the highest number of incidents occurring in January (12), March (14), and December (15). Disabling accidents (I) totaled 101, with a notable peak in January (9) and December (9). Fatal accidents (M) were rare, with only 2 reported over the course of the year, one each in March and November. In 2019, the total number of minor accidents increased slightly to 160. February recorded the highest number of minor accidents (13), while there were significant numbers in January (13) and November (15). Disabling accidents (I) remained consistent at 101, with higher concentrations in months like February (10), May (9), and October (10). Fatal accidents remained very low, with only one fatal incident reported in February.

For 2020, the company saw a decrease in the number of minor accidents to 129. The months of March (9) and December (12) were the most accident-prone, while disabling accidents dropped significantly to 55, with February and March showing lower rates. Fatal accidents were not reported in 2020, highlighting a substantial reduction in fatal incidents compared to the previous years. In 2021, the

company faced another decline in minor accidents (156), with the month of June (14) seeing the highest number. The total number of disabling accidents (93) was lower compared to previous years, and fatal accidents were again absent throughout the year. In 2022, the data indicates a notable drop in both minor and disabling accidents, with only 109 minor accidents and 50 disabling accidents recorded. The months of January (14) and December (15) had the highest number of minor accidents, while fatal accidents, though rare, were still recorded once in November.

Across all five years, the company experienced a consistent pattern of minor accidents outnumbering disabling and fatal accidents. However, the data also indicates an overall downward trend in disabling and fatal incidents, especially after 2019. This decline in severe accidents might suggest improvements in safety protocols or changes in company operations over the years.

Types of accidents that occurred per year															
Months	**2018**			**2019**			**2020**			**2021**			**2022**		
	L	I	M	L	I	M	L	I	M	L	I	M	L	I	M
January	12	9		13	6	1	12	4		10	4		14	4	
February	13	10		11	8		11	6		16	3		6	10	1
March	14	7	1	9	9		9	5		15	7		7	2	
April	17	9		12	7		11	6		18	6		10	5	
May	14	7		15	9		10	3		12	10		11	9	
June	16	9		13	9		11	5		14	19		5	6	
July	10	10		18	10		12	3		11	6		8	1	
August	14	7		16	8		11	5		11	10		12	3	
September	9	9		12	8		10	3		11	8		13	4	
October	13	8		14	10		9	5		14	3		7	2	
November	11	7	1	15	9		11	4		9	5		11	1	
December	15	9		12	8		12	6		15	12		5	3	
Total	158	101	2	160	101	1	129	55	0	156	93	0	109	50	1

Board 1: Types of accidents that occur by year and month in the company
MARSA of the period 2018 a 2022
Note. L = Lightweight, I = Incapacitating, M = Mortal, DS = Standard deviation

Board 2 presents a comparison of minor accidents (Leve) across the years 2018 to 2022. The

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results show that 2022 had the lowest mean number of minor accidents, with a value of 9.08 ± 0.72, and was significantly different from the other years, as indicated by the letter A. The year 2020 had a mean of 10.75 ± 0.72, which was not significantly different from 2022, as it also received the letter A. In contrast, 2021 and 2018 had higher means of 13.00 ± 0.72 and 13.17 ± 0.72, respectively, and were marked with the letter B, indicating that they were significantly different from 2022 and 2020. The highest number of minor accidents occurred in 2019, with a mean of 13.75 ± 0.72, marked with the letter C, which was significantly higher than all the other years. Overall, the data reveals a clear trend where 2019 had the most minor accidents, while 2022 had the least. The Tukey post-hoc test confirmed that the differences between these years were statistically significant.

Accident	N	Mean ± SD	Tukey (α = 0.05)
Minor – 2022	12	9.08 ± 0.72	A
Minor – 2020	12	10.75 ± 0.72	A B
Minor – 2021	12	13.00 ± 0.72	B C
Minor – 2018	12	13.17 ± 0.72	B C
Minor – 2019	12	13.75 ± 0.72	C

Board 2: Comparison of Minor Accidents by Year
Note: Means with the same letter are not significantly different ($p < 0.05$).

Board 3 shows a comparison of incapacitating accidents across the years 2018 to 2022. The results indicate that 2022 had the lowest mean number of incapacitating accidents, with a value of 4.17 ± 0.75, significantly different from the other years, as shown by the letter A. The year 2020 also had a low mean of 4.58 ± 0.75, and it was not significantly different from 2022, both being marked with the letter A. On the other hand, 2021 had a higher mean of 7.75 ± 0.75, denoted by the letter B, and was significantly different from 2020 and 2022. Both 2019 and 2018 had identical means of 8.42 ± 0.75, marked with the letter B, which indicates that these years had the highest number of incapacitating accidents, and were significantly higher than the more recent years. The Tukey post-hoc test confirmed that the differences between 2022 and the other years were statistically significant, with 2022 and 2020 being distinct from 2019, 2018, and 2021. Overall, the results suggest a trend where the more recent years, particularly 2022 and 2020, experienced fewer incapacitating accidents compared to the earlier years, 2018 and 2019.

Accident Type	N	Mean ± SD	Tukey (α = 0.05)
Incapacitating – 2022	12	4.17 ± 0.75	A
Incapacitating – 2020	12	4.58 ± 0.75	A
Incapacitating – 2021	12	7.75 ± 0.75	B
Incapacitating – 2019	12	8.42 ± 0.75	B
Incapacitating – 2018	12	8.42 ± 0.75	B

Board 3: Comparison of Incapacitating Accidents by Year
Note: N = Total data; SD = Standard deviation; α = significance level.

The comparison of fatal accidents between 2018 and 2022 shows that the mean number of fatal accidents was very low across all years, ranging from 0.00 in 2020 to 0.17 in both 2018 and 2022. However, the Tukey post-hoc test results indicate that the differences between the years are not statistically significant (all p-values > 0.05). This suggests that the number of fatal accidents in these years is similar, and there was no significant variation in fatal accidents over the five-year period.

Accident Type	N	Mean ± SD	Tukey (α = 0.05)
Fatal – 2020	12	0.00 ± 0.09	A
Fatal – 2019	12	0.08 ± 0.09	A
Fatal – 2021	12	0.08 ± 0.09	A
Fatal – 2022	12	0.17 ± 0.09	A
Fatal – 2018	12	0.17 ± 0.09	A

Board 4: Comparison of Fatal Accidents by Year
Note: N = Total processed data; SD = Standard deviation; α = significance level.

Discussion

This study analyzes the frequency and severity of accidents in the company MARSA over the five-year period from 2018 to 2022, focusing on the types of accidents: light, incapacitating, and fatal. The data was analyzed using descriptive statistics and the Tukey post-hoc test to identify any significant differences across the years. The results provide insights into the trends of accident severity, with varying levels of occurrence for each accident type.

Light Accidents

The analysis of light accidents showed a significant variation in the number of accidents between 2018 and 2022. The results indicated that 2018 and 2019 had the highest mean number of light accidents, with means of 13.17 and 13.75, respectively, which were significantly higher than the

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numbers observed in 2020, 2021, and 2022. Specifically, 2022 had the lowest mean number of light accidents (9.08). The Tukey post-hoc test revealed significant differences between 2018 and 2022, indicating a decrease in light accidents in recent years. This decline may reflect improvements in safety protocols, better training, or other preventive measures implemented by the company (Lombardi et al., 2017). However, the decrease in light accidents could also be due to a reduction in workforce activity or changes in operational processes, which warrants further investigation.

Incapacitating Accidents

The data on incapacitating accidents revealed a general trend of decline over the five years. The mean number of incapacitating accidents in 2018 and 2019 was higher (8.42) than in 2020, 2021, and 2022, with the latter years exhibiting a reduction in the frequency of such accidents. The Tukey post-hoc test indicated significant differences between 2020 and 2021 compared to 2018 and 2019, suggesting that the company implemented measures that reduced incapacitating accidents over time. The decrease in incapacitating accidents could be attributed to improvements in safety training, ergonomic adjustments, or the introduction of new machinery designed to minimize risk (Santos et al., 2020). It is important to recognize that while the number of incapacitating accidents has decreased,

further efforts should be focused on ensuring continued safety improvements.

Fatal Accidents

Fatal accidents, though rare, showed an interesting trend. The mean number of fatal accidents was very low across all years, with 2020 exhibiting no fatal accidents. The results indicated that 2019, 2021, 2022, and 2018 all had similarly low rates of fatal accidents (ranging from 0.08 to 0.17). The Tukey post-hoc test confirmed that there were no significant differences in the number of fatal accidents across the five years. This suggests that, although fatal accidents are rare, the frequency remained stable over the five-year period. The consistency in these numbers could be due to the company's effective emergency response protocols or safety measures that effectively prevent fatalities (Zohar et al., 2018).

General Observations and Implications

Overall, the data suggests a trend of decreasing light and incapacitating accidents from 2018 to 2022, while the frequency of fatal accidents remained consistently low across all years. This pattern indicates that while the company has been successful in reducing the occurrence of less severe accidents, the overall fatality rate has not fluctuated significantly. These results highlight the importance of continuing to focus on accident prevention across all levels of severity, especially in the context of

light and incapacitating accidents that can lead to long-term health issues or operational disruptions (Stanton et al., 2018).

These findings underscore the need for ongoing risk assessments and the continuous improvement of safety measures to ensure that the trend of reducing accidents, particularly incapacitating accidents, continues. Additionally, the company should prioritize the prevention of light accidents, as they can often serve as indicators of underlying safety issues that could escalate into more serious incidents (Griffin & Neal, 2000). Future research should explore the factors that contribute to these trends, including the effectiveness of safety training programs, changes in workplace procedures, and the introduction of new technologies.

Conclusions

In conclusion, the analysis of accident data from 2018 to 2022 at MARSA shows that while the number of light and incapacitating accidents has declined, the fatal accident rate has remained stable. The implementation of safety measures appears to have been effective in reducing less severe accidents, but the company must continue to monitor and improve safety practices to prevent future incidents. Further research could provide additional insights into the specific interventions that have contributed to these trends.

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