CC BY NC SA

Espirales
Revista multidisciplinaria de investigación científica

Analysis of the impact of occupational risks in the mining sector in Ecuador

Analisis del impacto de los riesgos laborales del sector minero en Ecuador

José Alberto Bran Cevallos*
Leonardo Álvaro Banguera Arroyo*
Guillermo Ernesto Morales Roman*
Harry Oswaldo Reyes Venegas*
Manuel Israel Samaniego Zamora*

Received: October 30, 2025
Approved: December 12, 2025

Bran, J., Banfuera, L., Morales, G., Reyes, H., Samaniego, M. (2026) Analysis of the impact of occupational risks in the mining sector in Ecuador. *Espirales Revista Multidisciplinaria de investigación científica*, *10* (56), 55-73

Faculty of Industrial Engineering. Master's in Safety, Industrial Hygiene, and Occupational Health alberto.branc@ug.edu.ec
https://orcid.org/0009-0001-6856-2793

Faculty of Industrial Engineering. Doctor of Engineering Sciences with a specialization in Industrial Engineering
leonardo.bangueraa@ug.edu.ec
https://orcid.org/0000-0002-0261-2372

Faculty of Industrial Engineering. Master's in Safety, Industrial Hygiene, and Occupational Health
guillermo.moralesr@ug.edu.ec
https://orcid.org/0009-0000-1389-4910

Faculty of Industrial Engineering. Master's in Safety, Industrial Hygiene, and Occupational Health
harry.reyesv@ug.edu.ec
https://orcid.org/0000-0003-1969-8384

Faculty of Industrial Engineering. Master's in Safety, Industrial Hygiene, and Occupational Health
manuel.samaniegoz@ug.edu.ec
https://orcid.org/0000-0003-1969-8384

Abstract

Mining in Ecuador has become a topic of widespread debate and analysis by various public and private sectors. It is in this context that the present research arises, whose objective is to analyze the impact of occupational hazards in the country's mining sector. The method used corresponds to a documentary-descriptive design, based on various scientific sources. The central criterion for analysis is Occupational Safety and Health, considering the current legal and regulatory framework in Ecuador. To establish a comparative analysis, statistics on occupational accidents and diseases in the mining sector of Andean countries such as Peru and Colombia are presented, given that their extractive processes are similar to those in Ecuador. The results of the Survey on Working Conditions and Health, conducted by the Ministry of Public Health during the period 2021–2022, are also included. The discussion integrates criteria of perception from the economic, social, environmental, political, and occupational safety and health dimensions, which enriched the analysis of the information collected. As a result, a proposal is put forward based on the provisions of the International Labor Organization, specifically Convention 176 on Safety and Health in Mines, adopted on June 22, 1995. It should be noted that, in the Andean region, Peru ratified this convention on June 19, 2008, thereby strengthening its risk prevention policies in the mining sector. In the case of Ecuador, there is still a negative perception of mining, which generates mistrust among the public. Consequently, it is essential that both the State and concessionary companies prioritize the safety and health of workers, while minimizing the impact of mining activity on them. This will help to ensure safer and more sustainable working conditions in the country.

Keywords. Mining, Occupational hazards, Work accidents, Occupational diseases, Legal regulations, Andean Community, Agreement.

Resumen

La minería en el Ecuador se ha convertido en un tema de amplio debate y análisis por parte de diversos sectores públicos y privados. En este contexto surge la presente investigación, cuyo objetivo es analizar el impacto de los riesgos laborales en el sector minero del país. El método empleado corresponde a un diseño documental–descriptivo, fundamentado en diversas fuentes científicas. El criterio central de análisis es la Seguridad y Salud en el Trabajo, considerando el marco legal y normativo vigente en el Ecuador. Para establecer un análisis comparativo, se presentan estadísticas de accidentes de trabajo y enfermedades profesionales en el sector minero de países andinos como Perú y Colombia, dado que sus procesos extractivos guardan similitudes con los del Ecuador. Asimismo, se incluyen los resultados de la Encuesta sobre Condiciones de Trabajo y Salud, elaborada por el Ministerio de Salud Pública durante el periodo 2021–2022. En la discusión se integran criterios de percepción desde las dimensiones económica, social, ambiental, política y de seguridad y salud ocupacional, lo que permitió enriquecer el análisis de la información recopilada. Como resultado, se plantea una propuesta sustentada en las disposiciones de la Organización Internacional del Trabajo, específicamente en el Convenio 176 sobre Seguridad y Salud en las Minas, adoptado el 22 de junio de 1995. Cabe destacar que, en la región andina, el Perú ratificó este convenio el 19 de junio de 2008, logrando con ello fortalecer sus políticas de prevención de riesgos en el sector minero. En el caso del Ecuador, persiste una percepción negativa en torno a la minería, lo que genera desconfianza en la ciudadanía. En consecuencia, se hace indispensable que tanto el Estado como las empresas concesionarias prioricen la seguridad y salud de los trabajadores, al tiempo que se minimice el impacto de la actividad minera sobre ellos. Con ello, se contribuirá a garantizar condiciones de trabajo más seguras y sostenibles en el país.

Palabras Clave. Mineria, Riesgos laborales, Accidentes de trabajo, Enfermedades profesionales, Normativa legal, Comunidad Andina, Convenio.

Introduction

The Ecuadorian government has shown interest in the social developments currently affecting the mining industry. Meanwhile, international organizations such as the International Labor Organization (ILO) seek to obtain information on occupational accidents and illnesses that this economic sector should report to its governing bodies. Society's high demand for materials from the mining sector has been increasing considerably. Despite this, the sector has contributed exponentially to the increase in carbon dioxide (CO2) levels (Burga et al., 2024) . Over time, mining has come to play an important role in the economic growth and sustainable development of countries in the Latin American region (Massa-Sánchez et al., 2018) . Ecuador, for its part, has experienced three historical periods: the Pre-Columbian, Colonial, and Republican eras. (. Ecuador makes its mining policy clear in Article 408 of the Constitution of the Republic of Ecuador (2008) , which states that non-renewable natural resources are the inalienable property of the State. (analyze the current 2020-2030 mining policy agenda, which consists of six pillars and seeks to encourage domestic and foreign investment, eliminate illegal mining, and consequently control the safety risks associated with

mining work (Estupiñan et al., 2021) . In Ecuador, the continued presence of transnational mining companies has brought the issue of natural resources under scrutiny in both academic and social circles (Massa-Sánchez et al., 2018).

Sustainable mining considers economic, social, and environmental aspects, with a democratic approach that involves the participation of those affected by artisanal, small-scale, medium-scale, and large-scale mining processes (Vásconez Carrasco & Torres León, 2018) . In Ecuador, the total area concessioned to mines and mining projects in the first quarter of 2025 covers 92,759 hectares, distributed across seven provinces. Most of this area is located in the province of Morona Santiago and corresponds to the mining projects of San Carlos Panantza with 38,548 hectares and Warintza with 16,796 hectares, according to the Mining Sector Bulletin of the . Figures from the Ministry of Production, Foreign Trade, Investment, and Fisheries for December 2024 indicate that the economically active population (EAP) is 8.6 million, of which 5 million are men and 3.6 million are women. the working-age population is 13.3 million, of which 34 out of every 100 have adequate employment, 62 out of every 100 have inadequate employment, and 4 out of every 100 are unemployed. On the website of the Ecuadorian Social Security Institute (IESS, General Occupational Risk Insurance, 2024) (IESS) reported a total of 21,250.00 reports of occupational accidents (AT), and the General Insurance for Occupational Risks (SGRT) classified a total of 18,205.00, of which 1.33% (243) correspond to the mining and quarrying economic sector. Some authors agree that the main social problems facing the sector are crime and illegal mining, which generate a high security risk for mining workers and nearby populations due to armed confrontations and money laundering (Estupiñan et al., 2021) . This paper seeks to provide answers about the impacts that occupational risks are having on the mining sector in Ecuador. Andean countries such as Colombia, Ecuador, and Peru have similar activities associated with illegal mining, with certain distinct contrasts.

The study concludes that the governance of illegal mining coexists with corruption and complicity among public officials at all levels of the illicit activity, supporting the thesis that organized crime requires the state for its profitability and survival, generating a neo-extractivist system in the region (Rivera-Rhon & Bravo-Grijalva, 2023) . Within the Mining Policy Framework (MPM) of the Intergovernmental Forum on Mining, Minerals, Metals, and Sustainable Development (IGF). As a result of the evaluation carried out in Ecuador, it was concluded that there is a significant difference between the processes developed by large-scale mining companies and artisanal, small-scale, and medium-scale mining companies (ASM), with the latter carrying out simultaneous operations such as exploration and exploitation. On the other hand, there is a notable lack of technical standards and practical guidelines to facilitate the implementation and control of health and safety measures in the mining sector (IGF, 2019) . It is also necessary to consider the social diagnosis presented in the National Development Plan for the Mining Sector 2020-2030, which highlights the lack of qualified personnel in the mining business, which is why empirical and anti-technical methods persist in mining operations.

Similarly, the theory presented by Robert Castel and Michel Crozier, who analyze the vulnerability to which the country's mining workers are exposed, cannot be ruled out

(Cárdenas Valencia, 2023) . As a research reference, there are the conclusions of some authors who, after applying classical models such as Heinrich, Bird & Germain, found that at the national level there is underreporting of more than 70%, unlike the Takala and Collaborators model, which estimates underreporting of 67% for fatal work accidents and 96% for non-fatal accidents (Valenzuela Mendieta et al., 2023). Potential underreporting of fatal workplace accidents of 67% and non-fatal accidents of 96% (Valenzuela Mendieta et al., 2020) . According to the Ministry of Labor's (Ministerial Agreement No. 196, 2024) , Annex 2 allows the risk level of companies to be identified by economic sector, placing mines and quarries as companies with a high risk level. With this background, the aim of this research paper is to respond to the impact of occupational risks to which workers in Ecuador's mining sector are exposed. To this end, all available information from various scientific sources will be collected and a viable and sustainable proposal will be presented to the country that will enable the state to control and mitigate the impact of occupational risks that affect labor productivity in the sector.

Materials and methods

This study will be conducted using a documentary-descriptive method, which will allow the researcher to analyze the results obtained by other authors, as well as the statistics available from public and private organizations related to the mining sector in Ecuador.

First, it is considered necessary to review the legal history of concessions granted to artisanal, small, medium, and large-scale mining companies. Likewise, the socioeconomic situation of the sector, its geographical and operational distribution in the country, will be analyzed, and the current legal framework for occupational risk management and prevention will be described.

Secondly, the characteristic processes of mining activity will be presented, exposing the main hazards and risks associated with work in the sector, as well as the most frequent types of accidents and occupational diseases. Similarly, the levels of risk that this economic activity represents will be identified, in accordance with current national regulations.

The results obtained will be compared with official statistics issued by public institutions and with information reported by non-governmental organizations (NGOs) linked to occupational safety in mining. Subsequently, the information collected will be analyzed and interpreted, complementing it with data from structured surveys conducted by competent bodies, in order to deepen the understanding of the most relevant problems in the sector.

This analysis will reveal the main causes of fatal and non-fatal occupational accidents, as well as occupational diseases resulting from this economic activity in Ecuador.

Finally, the study raises the need to put forward not only a proposal but also an urgent recommendation to the current government to consider acceding to the International Labour Organization (ILO) Convention on Safety and Health in Mining. This measure

would make it possible to redirect the national policy on occupational risk prevention, strengthening the protection and well-being of the working population in the mining sector.

Results

The Constitution of the Republic of Ecuador,(2008) , in Article 408, regarding natural resources, states: "Non-renewable natural resources and, in general, subsoil products are the inalienable, imprescriptible, and unseizable property of the State (...) The State shall participate in the benefits of the exploitation of these resources (...) The State shall ensure that the mechanisms of production, consumption, and use of natural resources and energy preserve and restore natural cycles and allow for dignified living conditions."

With regard to nature and the environment, Article 395, paragraph 1, establishes: "The State shall guarantee a sustainable model of development that is environmentally balanced and respectful of cultural diversity, conserves biodiversity and the natural regeneration capacity of ecosystems, and ensures the satisfaction of present and future needs."

Following the regulatory order, there is the Mining Law (, Article 1 (Purpose of the Law) of which provides: "This Mining Law regulates the exercise of the sovereign rights of the Ecuadorian State to administer, regulate, control, and manage the strategic mining sector, in accordance with the principles of sustainability, precaution, prevention, and efficiency. Oil and other hydrocarbons are exempt from this Law."

For its part, Article 8 of the same Law establishes: "Mining Regulation and Control Agency. The Mining Regulation and Control Agency is the technical-administrative body responsible for exercising the State's power of supervision, audit, intervention, and control of the phases of mining activity carried out by the National Mining Company, joint mining companies, private initiative, small-scale mining, and artisanal and subsistence mining, in accordance with the provisions of this Law and its regulations."

Within this framework, the technical team of Sectoral and Fiscal Statistics Management publishes the Mining Sector Bulletin on a quarterly basis through the Central Bank of Ecuador. These documents present a detailed analysis of the sector, highlighting, among other aspects, the total area concessioned to mines and mining projects, which during the 2024 period reached the following magnitude, as presented in Table 1:

Table 1. *Area Concessioned to Mines*

QUARTER	AREA - HECTARES
First	124,093
Second	101,822
Third	101,822
Fourth	101,822

Source: (Central Bank of Ecuador, 2024)

The same source indicates that, for the first quarter of 2025, the total area concessioned to mines and mining projects in the country covers 92,759 hectares, distributed across seven provinces: Imbabura, Cotopaxi, Bolívar, Azuay, El Oro, Zamora Chinchipe, and Morona Santiago. It also reports on the total employment generated during the 2024 period, information that is presented quarterly in the corresponding reports (see Table 2).

Table 2. *Employment Generated by the Mining Sector*

Quarter	Employment generated	Employment Direct	Employment Indirect
First	40,556	10,139	30,417
Second	44580	11145	33,435
Third	48,072	12018	36054
Fourth	49064	12266	36,798

Source: (Central Bank of Ecuador, 2024)

In the first quarter of 2025, mines and mining projects generated a total of 46,096 jobs, of which 11,524 were direct jobs and 34,572 were indirect jobs.

With regard to the legal and regulatory framework that regulates and controls occupational risk prevention in this economic sector, the following instruments are considered:

Constitution of the Republic of Ecuador (2008).

Andean Instrument on Occupational Safety and Health (Decision 584).

Regulations of the Andean Instrument on Occupational Safety and Health (Resolution 957).

- Labor Code.
- Organic Law on Disabilities.
- Social Security Law.
- Fire Protection Law.
- Mining Law (Articles 68 and 69).
- Occupational Health and Safety Regulations (Executive Decree 255).
- General Rules for Compliance with Occupational Health and Safety Obligations (Ministerial Agreement No. MDT-2024-196 and Annexes 1, 2, and 3).
- Regulations on Occupational Safety and Health in the Mining Sector (Resolution No. ARCERNNR-013/2020 – Legal Bulletin).

With regard to the processes carried out in the sector, the Mining Law (,(2009)), in Article 27, describes the phases that make up mining activity in Ecuador

Table 3. *Phases of mining activity in Ecuador*

PHASES	MINING ACTIVITIES
Prospecting	Consists of indications of mineralized areas.
Exploration	This involves determining the size and shape of the deposit, as well as the content and quality of the mineral present. Exploration may be initial or advanced and also includes the economic evaluation of the deposit, its feasibility, and the design of its exploitation.
Exploitation	This comprises all mining operations, work, and tasks aimed at preparing and developing the deposit and extracting and transporting the minerals.
Beneficiation	This consists of a set of physical, chemical, and/or metallurgical processes to which the minerals produced by exploitation are subjected in order to increase their useful content or grade.
Smelting	This consists of the process of melting minerals, concentrates, or precipitates in order to separate the desired metal product from other accompanying minerals.
Refining	"It consists of the process of converting metal products into high-purity metals."
Marketing	"This consists of the purchase and sale of minerals or the conclusion of other contracts for the purpose of trading any product resulting from mining activity."
Mine closure	This consists of the termination of mining activities and the subsequent dismantling of the facilities used in any of the phases referred to above, if they are not in the public interest, including environmental restoration in accordance with the closure plan duly approved by the competent environmental authority.

Source: Mining Law, (2009)

With regard to occupational risk prevention policy, the mining sector is based on the country's current regulatory framework. The Mining Law (, , in Article 68, establishes that "mining rights holders have the obligation to preserve the mental and physical health and lives of their technical staff and workers, applying the mining and industrial safety and hygiene standards set forth in the relevant legal and regulatory provisions. In addition, they must provide permanent health and care services, as well as guarantee hygienic and adequate living conditions in stable work camps, in accordance with plans and specifications approved by the Mining Regulation and Control Agency and the Ministry of Labor" (Castillo-Guamán & Quiñonez-Lara, 2024) .

Similarly, the regulations stipulate that "mining concessionaires are required to have Internal Occupational Health and Mining Safety Regulations in place, approved and in

force, in accordance with the provisions of the Mining Safety Regulations and other relevant regulations issued by the competent institutions." (Mining Law, 2009) .

Similarly, the Agency for the Regulation and Control of Energy and Non-Renewable Natural Resources (ARCERNNR) issued Resolution No. ARCERNNR-013/2020, establishing the Occupational Health and Safety Regulations for the Mining Sector, in accordance with national and international legal instruments on risk prevention.

This regulatory framework contributes to consolidating prevention policies in the mining sector, considering that this economic activity is characterized by a high level of risk in all its operational phases Ministerial Agreement No. 196, (2024) , Annex 2. These risks include physical, chemical, ergonomic, mechanical, and psychosocial factors derived from the extreme conditions in which mining operations are carried out in Ecuador. Table 4 presents the risk factors associated with mining activities

Table 4. *Hazards and risks associated with mining activities*

RISK	RISK FACTOR	HAZARDS
PHYSICAL	NOISE, VIBRATIONS, TEMPERATURE, HUMIDITY, RADIATION, LIGHTING . ("174 Health and Safety Regulations for Construction and Works	-FAILURES IN GEOLOGICAL STRUCTURES: ROCKFALLS AND LANDSLIDES. -FAILURES IN THE HANDLING OF DYNAMITE AND DETONATORS: EXPLOSIONS AND USE OF EXPLOSIVES. -MACHINERY GENERATES HIGH DECIBEL NOISE AND VIBRATIONS.
MECHANICAL	MACHINERY, TOOLS, LIFTING DEVICES, FACILITIES, WORK SURFACES, ORDER AND CLEANLINESS. ("174 Safety and Health Regulations for Construction and Public Works")	-UNPROTECTED MACHINERY AND MOTORIZED VEHICLES IN RESTRICTED AREAS. -PRESENCE OF HIGH-VOLTAGE CABLES. -LACK OF ORGANIZATION IN WORK AREAS
CHEMICAL	MINERAL AND VEGETABLE DUST, METAL DUST AND FUMES, AEROSOLS, MIST, GASES, VAPORS, AND LIQUIDS USED IN WORK PROCESSES. ("174 Safety and Health Regulations for Construction and Public Works")	. EXPOSURE TO TOXIC SUBSTANCES. -INHALATION OF DUST AND SILICA. -TOXIC GASES AND OXYGEN DEFICIENCY IN UNDERGROUND WORK AREAS. -CONTACT WITH ACIDS AND CYANIDES.
ERGONOMIC	INCORRECT POSTURES, PHYSICAL OVEREXERTION, UNSAFE LIFTING, USE OF TOOLS, MACHINERY, AND EQUIPMENT THAT ARE NOT SUITABLE FOR THE USER. (174 Safety and Health	CONSTRAINED WORKING SPACES IN UNDERGROUND MINING. EXCESSIVE MOVEMENT OF LOADS

	Regulations for Construction and Public Works).	
PSYCHOSOCIAL	CONTROL OF THE WORK PROCESS, AUTOMATION, MONOTONY, REPETITIVENESS, PARCELING OF WORK, JOB INSTABILITY, EXTENDED WORKING HOURS, ROTATING SHIFTS AND NIGHT WORK, REMUNERATION, AND INTERPERSONAL RELATIONSHIPS. ("174 Health and Safety Regulations for Construction and Public Works").	LONG WORKING DAYS AND NIGHT SHIFTS

Source: Ministerial Agreement No. 174 MDT – OSH Regulations – Mining

With regard to the recording of occupational accidents in the mining sector, the Ecuadorian Social Security Institute (IESS), although no longer considered the governing body for Occupational Safety and Health in the country, continues to compile and maintain statistics on occupational accidents in all economic sectors. In this context, Table 5 presents the reported and classified figures for the mining sector.

Table 5. *Workplace accidents – IESS-SGRT*

PERIOD	REPORTED TO TO THE IESS	ACCIDENTS CLASSIFIED BY THE IESS	MINING SECTOR	% MINING SECTOR MINING
2020	17715	11629	168	1.44
2021	19567	13,043	196	1.5
2022	18320	15730	259	1.65
2023	20598	15,985	219	1.37
2024	21,250	18205	243	1.33
TOTAL	97,450	74,592	1085	1.45

Source: IESS, General Occupational Risk Insurance, (2024)

It is necessary to raise awareness of the occurrence of occupational accidents in the sector. First, most of these incidents occur in the workplace, accounting for more than 50% of the total. Second, occupational traffic accidents are recorded, accounting for less than 20% of the total reported.

The IESS-SGRT has been responsible for keeping statistics on occupational diseases in Ecuador. However, according to the information available on its website, the records only cover the period from 2012 to 2017, as shown in Table 6.

Table 6. *Occupational diseases*

Year	OCCUPATIONAL DISEASES-EP - TOTALS	EP- MINING AND QUARRYING SECTOR	% OF ODD – MINING AND QUARRYING SECTOR
2012	19	2	10.53
2013	87	2	2.29
2014	327	12	3.67
2015	534	18	3.37
2016	500	30	6.00
2017	244	22	9.01
TOTAL	1,711	86	5.03

Source: IESS, General Occupational Risk Insurance, (2024)

A recent study of the mining sector reveals that, according to the IESS (, during the period 2017–2023, a total of 254 occupational diseases were classified, with the following diagnoses: carpal tunnel syndrome, rotator cuff syndrome, Quervain's tenosynovitis, epicondylitis, lumbar disc herniation, bilateral sensorineural hearing loss, asthma, pneumoconiosis, pulmonary silicosis, pulmonary tuberculosis, brucellosis, neuroborreliosis, and dysphonia with mixed anxiety and depression disorder (Villacrés-López et al., 2024) . This research is also based on studies conducted in countries in the Andean region, where the extraction process is similar to that in Ecuador. For example, during the period 2011–2020, 37,899 occupational diseases were classified in Peru in the mining sector alone. The detailed data can be found in Table 7 (Aquino-Canchari et al., 2022).

Table 7. *Occupational Diseases in Mining. Peru 2011-202*

OCCUPATIONAL DISEASE	PATIENTS	% OF REGISTERED OCCUPATIONAL DISEASES
HEARING LOSS	35,891	94.71
PNEUMOCONIOSIS	1875	4.95
MERCURY POISONING	12	0.03
TOXIC EFFECTS OF MAGNESIUM AND ITS COMPOUNDS	11	0.03
DERMATITIS	9	0.02
OTHER	101	0.26
TOTAL	37,899	100.00

IESS, General Occupational Risk Insurance, (2024)

In addition, another study conducted in Peru during the period 2010–2019 reported 422 fatal work accidents in the mining sector (Ospina Salinas, 2022) . On the other hand, a study conducted in Colombia between 2010 and 2019 was considered, whose purpose was to describe the environmental and socioeconomic impact on health

generated by artisanal mining. This systematic review analyzed 21 national studies and 27 studies of specific locations. The results indicated a high rate of health effects on artisanal miners due to exposure to mercury, with the lack of protection against occupational hazards being a major concern (López Jiménez et al., 2022).

Given this scenario, the International Labor Organization (ILO), for the Andean countries and as a result of the meeting held with experts in mine safety and health in 2017, concluded that the origin of deaths from mining activity in the region corresponds to: underground operations 45%, open-pit operations 25%, and other processes 30%.

Finally, the survey developed by the Ecuadorian Ministry of Public Health during the period 2021–2022 on working conditions and health was included. This document was prepared with technical support from the Pan American Health Organization (PAHO) and the World Health Organization (WHO) through its regional office in Ecuador. The study population used an observational, descriptive, cross-sectional methodology applied at the national level. A stratified random sample of 4,290 workers from various economic activities was obtained, distributed as follows: 534 (12.45%) workers from the agricultural sector, 411 (9.58%) from the construction sector, 411 (9.58%) from the mining sector, 413 (9.63%) from the fishing sector, 452 (10.51%) from the informal sector, and 2,070 (48.25%) from the health sector.

Several surveys were consolidated for data collection: Survey on Working Conditions and Health in Latin America, Job Precariousness Scale (EPRES), Nordic Questionnaire on Musculoskeletal Symptoms, Goldberg Mental Health Questionnaire (GHQ-12), and European Community Respiratory Health Survey (ECRHS). For data analysis, the MSP used Epi Info version 7 (CDC) statistical software, performing descriptive analyses with absolute and relative frequencies, grouping workers according to their economic activity. The survey results for the mining sector were as follows:

A total of 411 workers participated in the mining sector, most of whom were men, 70.80% of whom were between 30 and 49 years old, and more than half of whom had a secondary education (57.66%). Fifty-six point forty-five percent worked more than 40 hours per week, and almost all had been working for more than 60 months (98.54%). In addition, 82.00% reported having no contract or a temporary contract, almost half of the workers (47.69%) said they had little certainty about the continuity of their contract, and 59.69% worked during the day.

With regard to working conditions, 18.73% were exposed to high or very high levels of noise; 34.79% to hand or arm vibrations; and 9.73% to whole-body vibrations. 7.79% handled toxic substances, and 32.38% stated that these substances were labeled as hazardous, although more than half (53.13%) considered that the information on the label was sometimes difficult to understand. In addition, 50.61% were exposed to chemicals; of these, 52.61% were aware of the health effects and 50.71% received information on how to prevent these effects. Only 2.19% came into contact with infectious materials. In terms of workplace violence, 1.46% reported having been physically assaulted by people in the workplace, 1.95% by outsiders, and 1.22% reported having been victims of sexual harassment or abuse.

In terms of health, more than 90% considered themselves to be in good or very good health; 23.11% reported having had COVID-19 confirmed by RT-PCR testing. 5.84% reported having had a work-related accident in the last 12 months, and more than 90% of workers were exposed to moderate job insecurity.

In terms of work activity, mining sector workers often or always worked standing up (88.56%), frequently used hand tools (45.74%), and performed repetitive tasks in less than a minute (46.96%). In addition, 61.80% worked while walking sometimes, and 68.86% adopted awkward postures. However, most reported that their workplace often or always allowed them to work comfortably (71.31%), perform the necessary movements (71.05%), and change posture (68.59%); likewise, the lighting in the workplace made it easier to maintain proper posture (73.88%) and not strain their eyes (55.99%).

The most prevalent musculoskeletal symptoms in the last 12 months were recorded in: neck (35.77%), sh r shoulders (26.28%), hands/wrists (22.14%), lumbar spine (21.41%), thoracic spine (18.49%), knees (14.11%), hips/legs (12.41%), and ankles/feet (7.54%).

The prevalence of distress among mining sector workers was high, affecting more than half of the participants (57.18%). Logistic regression analyses confirmed that the risk of distress increased among workers with medium or low job security, shift work, inability to adapt working hours to family commitments, and those who considered their health to be poor or fair.

The most common respiratory symptom was chronic phlegm (13.63%). Logistic regression indicated that mining sector workers were 1.45 times more likely to have chronic phlegm than workers in other sectors. The variables associated with this increased risk were: age over 50, length of service between 60 and 120 months, day-night shift work, exposure to whole-body vibration, and perception of fair health.

The results of this survey show the presence of occupational diseases among mining workers, many of which could be prevented through appropriate measures and the correct use of personal and collective protective equipment. The country's occupational safety and health regulatory bodies recommend: monitoring occupational health through pre-employment, occupational, and periodic examinations; monitoring environmental contaminants; assessing occupational risks; using appropriate tools for data analysis; and reflecting management indicators. The comprehensive health of workers must be a priority, as it is a right enshrined in the Constitution of Ecuador A recent study on the most prevalent risks concludes that organizational and productive changes in economic sectors have led to the incorporation of new technologies and, therefore, an increase in occupational risks, especially those related to work-related stress derived from new forms of work organization, which demands better records of accidents and occupational diseases and the implementation of more effective prevention strategies (Calderon Landivar et al., 2025) . Another relevant aspect to consider in this research is the economic impact of occupational accidents and illnesses, for which we have used information provided by the IESS General Occupational Risk Insurance, available on its website and shown in Table 8.

Table 8. *IESS-SGRT Monetary Subsidy Report*

YEAR	# Beneficiaries	Subsidized Value	Accidents Work	%	Occupational illness	%	Mining sector	%
2020	9010	2,600,692.66	8992	99.8	18	0.2	195	2.16
2021	12,149	3,417,066.78	12131	99.85	18	0.15	249	2.05
2022	15,951	5,026,237.28	15,913	99.76	38	0.24	369	2.31
2023	16,292	5,566,065.10	16,250	99.74	42	0.26	264	1.62
2024	18,314	5,835,605.74	18,250	99.65	64	0.35	295	1.61

Talking about mining in Ecuador is a very sensitive issue, as it involves economic, social, environmental, and political aspects. This study analyzes the impact of occupational risks in extractive activities in the region or concession areas. At the same time, it is necessary to refer to opinions or perceptions on each of these aspects, given that they have a significant impact on the current reality.

From an economic point of view, according to mining sector reports presented by the Central Bank of Ecuador, mining is an important source of tax revenue and foreign exchange generated by the export of natural resources. It also generates direct and indirect employment, which is beneficial for the country, and attracts both domestic and foreign investment. However, the benefits of the sector are not distributed equitably, favoring only small groups, and there is suspicion of tax evasion due to the lack of control and the presence of organized groups involved in acts of corruption, as various authors have pointed out. This highlights the need to implement sustainable long-term mining policies.

On the social side, many Ecuadorians see mining as an opportunity for progress, especially in areas neglected by the state, associating it with job creation and development. However, social conflicts between communities, companies, and the state are recurrent and represent a significant challenge.

From an environmental perspective, it is important to recognize that many companies and the state promote responsible mining, and the current legal framework establishes obligations for environmental remediation and corporate social responsibility. However, the results of this study and the "Health and Work" survey conducted by the Ministry of Public Health and other agencies show evidence of water source contamination and adverse effects on human health and the ecosystem.

In the political sphere, reports from public agencies show that the State promotes mining as a strategic development policy, although it does not yet have firm mechanisms for action. There are suspicions of corruption and limited independence of control agencies.

With regard to the impact of occupational hazards, from a legal standpoint, there has been a discrepancy between the provisions of Executive Decree 255-2024 and

Resolution No. ARCERNNR-013/2020. According to Article 425 of the Constitution, respecting the hierarchical order of application of regulations, it is necessary to update the technical and legal requirements of the resolution issued by the board of directors of the Agency for the Regulation and Control of Energy and Non-Renewable Natural Resources, to ensure consistency with other legal bodies and allow for proper regulation and control.

Taking Executive Decree 255 as a reference, the governing bodies for Occupational Safety and Health (MDT and MSP) have not yet complied with the transitional provisions, which has required consulting other sources to obtain information on occupational accident and disease rates. According to the IESS-SGRT, during the period 2020–2024, a total of 74,592 workplace accidents were classified, of which 1,085 (1.45%) corresponded to mines and quarries. As for occupational diseases, the available information covers the period 2012–2017, during which 1,711 patients were classified (Villacrés-López et al., 2024) . report that during 2017–2024, 254 occupational diseases were classified; However, the same source indicates that 244 were registered in 2017, leaving a record of only 10 occupational diseases between 2018 and 2023.

Among the member countries of the Andean Group, Peru has maintained ILO Agreement 176 in force since June 19, 2008, although its initial acceptance was complex. According t , during 2011–2020, 37,899 occupational diseases were recorded in the Peruvian mining sector, of which 94.7% corresponded to hearing loss. In addition, between 2010 and 2019, 422 fatal workplace accidents were reported in mining (Ospina Salinas, 2022) . These data show significant progress in Peru in occupational safety and health in mining, whose achievements can serve as a benchmark for Ecuador.

Conclusions

Mining in Ecuador is a high-impact economic activity; however, it shows significant limitations in the economic, social, and environmental spheres and, particularly, in occupational safety and health management. The results show that, during the period 2020–2024, 74,592 work accidents were reported, of which 1,085 (1.45%) corresponded to the mining sector, most of which occurred in the workplace itself. With regard to occupational diseases, official records report 1,711 cases in the period 2012–2017, of which 86 (5.03%) were associated with mining activities, with recurring diagnoses such as hearing loss, pneumoconiosis, pulmonary silicosis, pulmonary tuberculosis, and herniated discs, among others.

According to the International Labor Organization (ILO), deaths linked to mining activity in the region are distributed as follows: 45% in underground operations, 25% in open-pit operations, and 30% in other processes. Adding to this problem is the persistence of high rates of underreporting of accidents, both fatal and non-fatal, which is causing concern in various sectors, including non-governmental organizations.

In contrast, Peru is a relevant benchmark in the Andean region. The ratification of ILO Convention 176 in 2008 made it possible to redesign national health and safety policies in the mining sector, focusing them on reducing environmental impact, protecting workers' health, and building a sustainable and equitable mining model over time.

Based on this evidence, it is concluded that Ecuador needs to strengthen its public policies on occupational safety and health in mining. The adoption and ratification of ILO Convention 176 would represent a substantial step forward, ensuring that all mining operations in the country are covered by this international instrument. This would allow not only for the establishment of legal provisions in line with international standards, but also for the designation of competent authorities with the power t rrest or restrict mining activities in cases of risk to the safety and health of workers, thus contributing to the reduction of negative impacts and the promotion of responsible and sustainable mining.

References

Ministerial Agreement No. 196, Pub. L. No. AM 196, 196 196 23 (2024). https://www.bcseguridadysalud.com/single-post/acuerdo-ministerial-2024-196-anexo-1-y-anexo-2

Aquino-Canchari, C. R., Huamán-Castillón, K. M., & Jiménez-Mozo, F. (2022). Occupational diseases in mining in Peru, 2011-2020. *Journal of the Spanish Association of Occupational Medicine Specialists*, *31*(3), 275–282.

Central Bank of Ecuador. (2024). *Mining Sector Bulletin* (No. Second Quarter; p. 24). Central Bank of Ecuador. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://contenido.bce.fin.ec/documentos/Estadisticas/Hidrocarburos/ReporteMinero112024.pdf

Burga, P., Catañeda, J., Sotomayor, G., & Bustamante, Y. (2024).

Environmental impact in relation to the use of solid waste in the construction and mining sectors in the years 2019-2024. 10. https://dx.doi.org/10.18687/LEIRD2024.1.1.793

Calderon Landivar, R., Loja Llano, D. E., Tena Garcia, T. J., & Quiñonez Castillo, Karla A. (2025). (PDF) Risks of greater incidence in the occurrence of work accidents and occupational diseases: A bibliographic review. *ResearchGate*. https://doi.org/10.56294/hl202574

Cárdenas Valencia, P. H. (2023). *Social security system in the face of occupational risks for workers in the mining sector in Ecuador, 2008–2019* [master's thesis, Flacso Ecuador]. http://repositorio.flacsoandes.edu.ec/handle/10469/19346

Castillo-Guamán, J. P., & Quiñonez-Lara, A. P. (2024). FIGEMPA: Research and Development. *FIGEMPA: Research and Development*, *17* (1), 59–66. https://doi.org/10.29166/revfig.v17i1.4442

Constitution of the Republic of Ecuador, Pub. L. No. 449, 449 Official Register 136 (2008). https://www.oas.org/juridico/pdfs/mesicic4_ecu_const.pdf

Estudian, R., Romero Crespo, P. L., García, M., Garcés, D., & Valverde, P. (2021). Mining in Ecuador: Past, present, and future. *Geological and Mining Bulletin*, *132*(4), 533–549.

IESS, General Occupational Risk Insurance. (2024). *IESS, Ecuadorian Social Security Institute 2024*. https://www.iess.gob.ec/es/web/guest/visor-riesgos

IGF. (2019). *EVALUATION OF THE IGF MINING POLICY FRAMEWORK* (EVALUATION OF THE IGF MINING POLICY FRAMEWORK, pp. ii–iv). International Institute for Sustainable Development (IISD). https://www.jstor.org/stable/resrep21924.1

Mining Law, Pub. L. No. N° 517, N° 517 36 (2009). https://www.ambiente.gob.ec/wp-content/uploads/downloads/2015/06/Ley-de-Mineria.pdf

López Jiménez, C. L., Velásquez Bonilla, N. J., Mejía Restrepo, J. C., & Mesa Giraldo, C. F. M. (2022). Environmental and socioeconomic impact on health generated by artisanal gold mining in Colombia. *Revista Salud Uninorte*, *38* (2), 608–627. https://doi.org/10.14482/sun.38.2.331.76

Massa-Sánchez, P., Del Cisne Arcos, R., & Maldonado, D. (2018). Large-scale mining and social conflicts: An analysis for southern Ecuador. *Development Problems. Latin American Journal of Economics*, *49* (194), 119–141. https://doi.org/10.22201/iiec.20078951e.2018.194.63175

Ospina Salinas, E. (2022). Fatal work accidents and occupational diseases in mining (General Regime). Peru: 2010–2019. *Workers' Health.*, *30*(2), 109–128.

Oviedo-Anchundia, R., Moina-Quimi, E., & Naramjo-Moran, J. (2017). Heavy metal pollution in southern Ecuador associated with mining activity. *ResearchGate*, *2* (4), 5. https://doi.org/10.21931/RB/2017.02.04.5

Rivera-Rhon, R. A., & Bravo-Grijalva, C. E. (2023). Criminal governance and productive enclaves of illegal mining in Ecuador. *Logos Science & Technology Magazine*, *15*(2), 49–69.

Valenzuela Mendieta, R., Bravo Cuenca, M. E., & Gómez García, A. R. (2020). Underreporting of Work Accidents in Ecuador: New Evidence, Limitations, and Priorities | PDF | Ecuador | Statistics. *Scribd*, *24* (101), 8. https://doi.org/file:///C:/Users/Leonardo%252520Banguera/Downl

oads/332-article-989-1-10-20200621.pdf

Vásconez Carrasco, M., & Torres León, L. (2018). Mining in Ecuador: Sustainability and Legality. *Journal of Social Development Studies: Cuba and Latin America*, *6*(2), 83–103.

Velóz, J., & Lopez, J. (2020). National Development Plan for the Mining Sector 2020-2030. *FARO*. https://grupofaro.org/analisis/plan-nacional-de-desarrollo-del-sector-minero-2020-2030/

Villacrés-López, M. A., Noroña-Salcedo, D. R., & Leiton-Urresta, A. E. (2024). Prevalence of occupational diseases in Ecuador during the period 2017-2023. *Journal of the Spanish Association of Occupational Medicine Specialists*, *33*(3), 328–337.