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What Activity is the Most Dangerous to Work in? Estimation of the Risk Level of Economic Activities in Ecuador



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ABSTRACT

Background: Classifying economic activities into risk levels is an occupational health and safety practice that several countries worldwide observe. It allows government agencies to formulate public policies with occupational risk prevention requirements tailored to each activity's needs. Further, this level of risk directly influences companies' contributions to occupational risk insurers, whether public or private, according to the dangerousness of their activity. In Ecuador, the classification of economic activities into risk levels was carried out by a Committee of Experts based on administrative data. However, this classification has been questioned for its lack of objectivity and for using administrative records, where underreporting cases limit the accuracy and comprehensiveness of the data.

Methods: This cross-sectional, descriptive, and comparative study uses data from the National Survey of Employment, Unemployment, and Underemployment (ENEMDU). Estimates of the incidence rates of injuries and illnesses by economic activity were grouped into three clusters (high, medium, and low) according to the level of risk.

Results: An alternative risk classification of economic activities was obtained and compared with the existing classification.

Conclusions: Our results help mitigate the uncertainty in the current risk classification of economic activities' lack of methodological rigor and evaluate the relevance of using data from the ENEMDU survey. They also allow a comparison of two risk classifications developed from different methodologies and data sources. From a practical perspective, the results will help decision-makers clarify current regulations in Occupational Safety and Health (OSH) policies.

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1. Introduction

Classifying economic activities into risk levels is an occupational health and safety practice that several countries worldwide observe. It allows government agencies to formulate public policies with occupational risk prevention requirements tailored to each activity's needs. Further, this level of risk directly influences companies'

contributions to occupational risk insurers, whether public or private, according to the dangerousness of their activity [1].

Taking the National Classification of Economic Activities (ISIC) [2] as a reference, several countries have formalized their sectoral occupational risk scales through different legal and regulatory bodies. For example, in the United States of America, the Occupational Safety and Health Act empowers the Occupational Safety and

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Health Administration (OSHA) to issue sectoral regulations [3]. The OSHA establishes differentiated standards according to the occupational risks of sectors such as construction, manufacturing, and agriculture [4]. The European Union's countries maintain regulations at the community level, such as Directive 89/391/CEE, which requires member countries to establish national regulations classifying risk levels by economic sectors [5]. For example, in Spain, Law 31/1995 on the prevention of occupational risks establishes the bases for the highest-risk sectors to have specific regulations, and the Royal Decree 39/1997 classifies the risk levels according to economic activities and defines the obligations of companies in the management of occupational risks [6,7].

In South America, several countries have established specific regulations to classify economic activities by levels of occupational risk. For example, through Law 1562 of 2012 and Decree 1072 of 2015, Colombia classifies economic activities according to five levels of risk and defines the responsibilities of companies in the management of occupational risks according to each risk level [8,9]. Through Law 24,557 of 1995 on occupational risks, Argentina classifies economic activities by risk level. These levels are periodically updated by the Superintendency of Labor Risks, which also determines the contribution rates and preventive obligations [10]. Finally, through Resolution No. 2018-001, Ecuador has classified economic activities according to three levels of occupational risk—low, medium, and high—[11] and has established management requirements in occupational risk prevention for organizations according to their size and level of risk through Executive Decree 255 of 2024 [12].

Although many countries' regulations recommend classifying occupational risk by levels in the different economic sectors, the methodological options for establishing these risk levels can mainly follow three paths, depending on the data source used, which may affect the accuracy of the classification. *One way* is to analyze administrative records of occupational injuries and illnesses, which make it possible to identify economic activities with high morbidity and mortality rates, facilitating the implementation of specific interventions to promote safe and healthy work environments [13]. For example, Spain annually ranks the dangers of economic activities based on administrative records of injuries and illnesses of the population affiliated with the social security system [14]. Similarly, Safe Work Australia uses national statistical information sources to develop the Australian Work Health and Safety Strategy 2023–2033, which establishes a roadmap to reduce the overall incidence of occupational injuries and illnesses to below 3.5% [15]. However, administrative records are often not available or accessible. In addition, these records have various weaknesses that limit understanding of reality, such as the underreporting of injuries and illnesses [16] and the tendency to consider prevalence rather than incidence indicators, which limits comparability between economic activities [13,17].

The second method involves using specialized national surveys on working conditions to assess each sector's occupational risks. National working conditions surveys [13,18–20] based on representative sample designs counteract the limitations of official statistics and provide a complete and more accurate picture of the extent of occupational health problems through self-reports by surveyed workers [21]. For example, France cross-references the information collected through the "Enquête Conditions de Travail – ECT" survey on physical conditions, workloads, schedules, ergonomics, and workers' perceptions with sectoral information to identify the highest risk activities [22]. In Spain, the active population survey (EPA) data are supplemented by statistical analysis methods on the incidence of occupational accidents and illnesses by the economic sector [14]. Through the Health and Safety Executive (HSE), the United Kingdom implements a composite index of occupational risk

that includes rates of occupational accidents and illnesses, stress levels, and mental health by sector. Finally, the Netherlands uses occupational exposure matrices to identify levels of exposure to chemicals by sector and cross-reference them with epidemiological studies and medical records [23]. Examples of studies using such surveys to estimate incidence rates of work-related injuries and illnesses have been conducted in Europe and Asia [24–29], as well as in Latin American and Caribbean countries [30,31].

The third method involves evaluating and classifying occupational risks by multidisciplinary committees of occupational health and safety experts from each economic sector. These committees analyze the working conditions and risks of each activity. This method has been used in some Latin American countries. For example, in Chile, it is through the Institute of Labor Safety (ISL), and in Ecuador, it is through the Interinstitutional Committee on Safety and Hygiene at Work [11]. However, the subjectivity associated with this type of analysis and the lack of clarity regarding the methodological criteria used for selecting the committee experts could reduce the reliability and confidence of these processes.

1.1. The case of Ecuador

In Ecuador, the classification of economic activities into risk levels was carried out by a Committee of Experts based on administrative data, and it materialized in Resolution No. 2018-001 [11]. This Committee of Experts, the Interinstitutional Committee on Safety and Health at Work (CISHT), comprises representatives from the public and private sectors. CISHT analyzed administrative data on accidents and illnesses from the records provided by the Ministry of Labor and the Ecuadorian Social Security Institute. Thus, Resolution No. 2018-001 classifies economic activities into high, medium, and low according to the level of occupational risk based on the probability that the hazards present in the working conditions may cause damage to health (see Table 2). For example, organizations that carry out accommodation and food service activities (H) are classified as low occupational risk, while teaching (O) is considered as medium occupational risk, and construction (E) as high occupational risk. This classification serves to regulate executive actions in the OSH field. For example, the level of risk determines the number of OSH specialist professionals in each organization [12].

However, Resolution No. 2018-001 has two critical concerns. First, it has been questioned because its design lacks a solid scientific basis and objective evidence to support its methodological approach [32]. In this regard, the Resolution is quite confusing and very opaque in its classification criteria. Thus, Article 4 states that "economic activities shall be classified according to their probability and consequence concerning exposure to risk factors, statistics on occupational accidents and occupational diseases, and other variables determined by the Committee" [11, Article 4]. Regarding probability, Article 5 states that high risk "represents those with a high probability that the hazards may cause harm ...," medium risk "represents those with a moderate probability ...," and low risk "represents those with a low probability ... " [11, Article 5]. However, it does not specify what constitutes high, moderate, or low probability, leaving this criterion entirely at the discretion of the Committee of Experts. Regarding the consequences criterion, Article 5 indicates that high risk is defined as having "very serious consequences that affect the entire organization," medium risk is described as having "considerable consequences that impact the results or work of others," and low risk is defined as having "minor consequences that have some impact on results or activities" [11, Article 5]. Again, this criterion is entirely subjective, and it is at the discretion of the Committee of Experts. Consequently, the criteria used by Resolution 2018-001 are lax and subjective, and no

evidence or records have been found by the CISHT that clarify the methodology used in this classification.

Additionally, this standard likely adopted the classification used in other countries without due adaptation or was influenced by political and economic factors of interested parties instead of being based on objective results of reference research [33,34]. Second, the Committee of Experts used administrative records, where under-reporting cases, especially in small and medium-sized enterprises, which often do not report accidents and illnesses to the competent authorities, limit the accuracy, and comprehensiveness of the data [21,35].

Considering the above, the objective of this research is to propose an alternative classification of the risk of economic activities based on data from the National Survey of Employment, Unemployment, and Underemployment (ENEMDU) [36] and compare it with the classification of Resolution No. 2018-001. To this end, the incidence rate of accidents and occupational diseases was first estimated. Then, economic activities were classified into levels of occupational risk (high, medium, and low) through a cluster analysis and, finally, both classifications were compared (the one proposed by this study and that of Resolution No. 2018-001) by analyzing the similarities and differences between them.

This study is part of the Ecuadorian Observatory of Safety and Health at Work initiative and offers several contributions. First, it helps mitigate the uncertainty involved in the lack of methodological rigor of Resolution 2018-001 about the risk classification of economic activities. Second, it evaluates the relevance of using data from the ENEMDU survey for the risk classification of economic activities. Third, it will allow a comparison of two risk classifications developed from different methodologies and data sources. Fourth, from a practical perspective, the results of this research will help decision-makers in OSH policies to clarify current regulations [37,38].

2. Material and methods

2.1. Study design and population

This cross-sectional, descriptive, and comparative study utilizes data from the 2017 National Survey of Employment, Unemployment, and Underemployment (ENEMDU), conducted by the National Institute of Statistics and Census (INEC) in Ecuador. Approval from an ethics committee was not necessary since the data were anonymized from secondary sources and posed no risk to life or human rights.

The ENEMDU is a national survey that, due to its methodological design, represents one of the most important instruments for studying the employment situation, the characterization of the labor market, and the economic activity of companies in the country. Details on the sample design and the applied questionnaire can be found on the INEC website [39]. The ENEMDU is carried out annually from 2010 to the present. However, only the 2017 form included questions about damage to health due to or on the occasion of work. Therefore, the data for this study correspond to 2017.

Of a total of 58,888 people surveyed by ENEMDU, 13,242 (22.5%) were employed in the formal sector of the economy. In Ecuador, employment in the formal sector comprises salaried or self-employed workers affiliated with the Social Security System and who have the Single Taxpayer Registry (RUC) for companies and natural persons. The RUC classifies the main economic activity to which the person, entity, or company is engaged according to the ISIC [40]. Workers in the informal sector were not considered for this paper since occupations in this sector cover multiple tasks, and the working conditions are usually heterogeneous compared to those in formal economic activities.

This study includes workers between 18 and 73 years of age. Workers under 18 were excluded due to the prohibition of working in some economic activities, such as construction, mining, or the chemical and toxic processing industry [41]. Workers up to 73 were included since many older workers remain active in the labor market due to low retirement pensions and increased life expectancy [42]. After reviewing possible null or blank records, the final study sample comprised 12,961 workers (weighted sample of 3,653,668 workers), 59.1% were men, and 40.9% were women.

2.2. Study variables

2.2.1. Economic activity

The ENEMDU 2017 collects information on the main economic activity the respondent worked on during the interview. According to the ISIC in Ecuador, economic activity is classified into twenty-one categories ([Supplementary Table 1](#), see table footnote) [40].

2.2.2. Occupational injuries and illnesses

ENEMDU question 61A6 asks about the occurrence of an injury (“During the last 12 months, have you had an accident while performing your current job?”), and question 61A7 asks about illnesses of possible occupational origin (“Have you suffered from any illness caused by the activities of your current job?”). The response options were “Yes” and “No/Don’t know.” These questions are relevant to understanding how working conditions influence workers’ health and allow for comparative analyses between economic activities at the national level [21].

2.3. Statistical analyses

All statistical analyses were performed using JAMOVI software [43] (version 2.3.21.0). The expansion factor included in the ENEMDU was applied to counteract possible biases in the estimates. Thus, the proportional weights of the population were adjusted according to economic activity, providing nationally representative estimates.

The distribution of affirmative (“yes”) responses to the variables of interest was quantified to estimate the incidence rates of injuries and illnesses. Activities in private households with domestic service (T) and activities in extraterritorial organizations (U) were excluded since they did not present self-reports of work-related injuries and illnesses. Then, the incidence rate was estimated, both crude and specific, by age groups (18–24 ..., and 67–73 years) for each economic activity per 100,000 workers. Subsequently, the age-adjusted rate and its confidence intervals (95% CI) were calculated using the direct method, taking the weighted study population as standard. The result of the rate adjustment allowed for a more precise comparison between economic activities.

To classify economic activities according to the level of occupational risk (high, medium, and low), a K-means cluster analysis was performed with three clusters, including the adjusted incidence rates of occupational injuries and illnesses, using the Hartigan-Wong algorithm [44].

3. Results

3.1. Estimating incidence rates of injuries and illnesses

The characteristics of the sample and the estimated prevalence of occupational accidents and diseases showed significant differences in the distributions by sex, age, and economic activity ($p < 0.001$) (See [Supplementary Material, Table 1](#)).

The crude rates per 100,000 workers were 2200.5 (95% CI: 2185.2–2216.0) for injuries and 5114.5 (95% CI: 5091.1–5138.0) for illnesses. When estimating the rates by age groups (see

Table 1
Cluster analysis result

Cluster	Risk level	Description	Centroids		Economic activities
			Injuries	Illnesses	
1	High	High incidence of injuries and illnesses	1.286	0.908	Five: A, B, D, E, O
2	Medium	Low incidence of injuries and high incidence of illnesses	-0.735	0.654	Five: H, K, L, P, Q
3	Low	Low incidence of injuries and illnesses	-0.306	-0.868	Nine: C, F, G, I, J, M, N, R, S

Table 2
Comparison between the risk classification of economic activities according to Resolution No. 2018–001 and the result of our analysis based on ENEMDU 2017

Economic activities		Occupational risk level	
		Current*	New
Agriculture, livestock hunting, and forestry and fishing	A	Medium	High
Exploitation of mines and quarries	B	High	High
Manufacturing industries	C	Medium	Low
Electricity, gas, air conditioning supplies	D	High	High
Water distribution, sewage	E	Medium	High
Construction	F	High	Low
Trade, vehicle repair	G	Low	Low
Transportation and storage	H	High	Medium
Accommodation activities and food services	I	Low	Low
Information and communication	J	Low	Low
Financial and insurance activities	K	Low	Medium
Real estate activities	L	Low	Medium
Professional, scientific, and technical activities	M	High	Low
Administrative and support activities and services	N	Low	Low
Public administration, defense, and social security	O	Medium	High
Teaching	P	Medium	Medium
Activities, social and health services	Q	Medium	Medium
Arts, entertainment and recreation	R	Medium	Low
Other service activities	S	Low	Low
Activities in private homes with domestic service	T	Low	—
Activities of extraterritorial organizations	U	Low	—

* Resolution No. 2018–001, issued by the Interinstitutional Committee on Occupational Health and Safety (CISHT) [11].

Supplementary Figure 1), higher values were observed in the age range between 25 and 45 years. However, younger workers aged 18 to 24 had notably high values, with a rate of 2184.8 (95% CI: 2143.4–2227.0). Regarding illness rates, an increase in risk was observed from 39 years to 73 years, reaching a rate of 8193.3 (95% CI: 7957.2–8436.5).

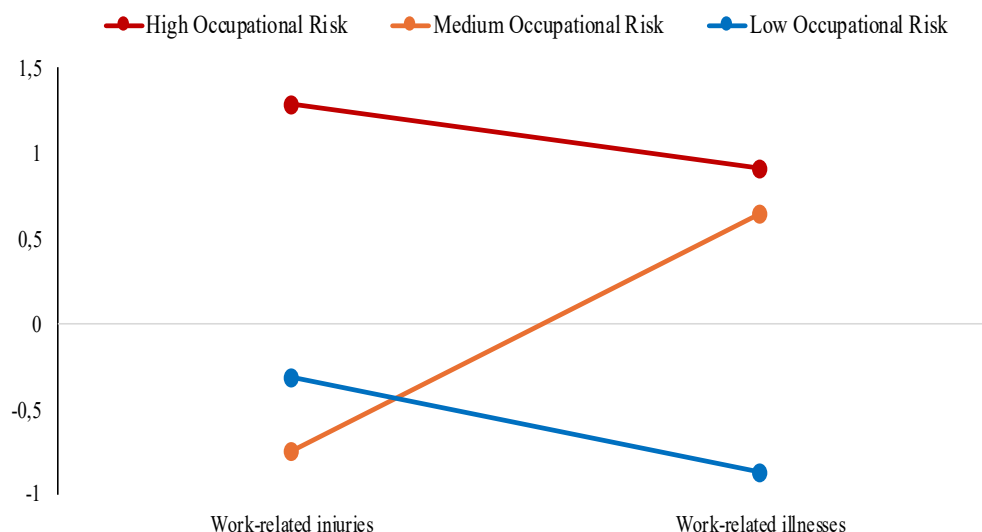
The highest injury rates per 100,000 workers were electricity, gas, and air conditioning supplies (D) with 6113.0, mining and quarrying (B) with 4703.9, water distribution, sewage, waste management, and sanitation activities (E) with 4250.8, and agriculture, livestock, forestry, and fishing (A) with 3789.2. For illnesses, the highest rates correspond to real estate activities (L) with 10738.7 and mining and quarrying (B) with 10353.3 illnesses per 100,000 workers, followed by water distribution, sewage, waste management, and sanitation activities (E) with 7731.4, electricity, gas, and air conditioning supplies (D) with 7223.7, agriculture, livestock, forestry, and fishing (A) with 7128.1 and financial and insurance activities (K) with 7091.7 (See Supplementary Material, Tables 2 and 3).

3.2. Classification of economic activities

Economic activities were classified into three occupational risk groups (high, medium, and low) using a k-means cluster analysis, including the adjusted incidence rates of work-related injuries and illnesses as standardized variables and using the Hartigan-Wong algorithm. Table 1 and Figs. 1 and 2 detail the three resulting clusters.

3.3. Comparison of risk classifications

The risk classification of economic activities carried out by Resolution No. 2018-001 and the classification resulting from our cluster analysis were compared. The result is shown in Table 2. The

**Fig. 1.** Occupational risk level clusters.

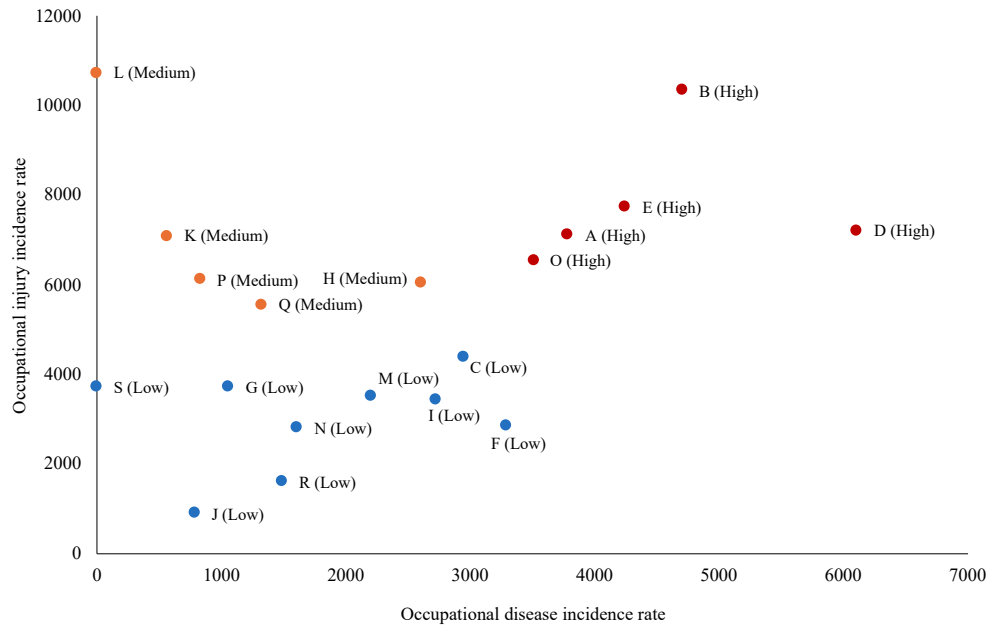


Fig. 2. Distribution of economic activities according to risk level.

percentage of agreement was 47% (Cohen's Kappa = 0.202), indicating a shallow level of similitude (agreement) between these two classifications.

4. Discussion

This study classifies the level of occupational risk by economic activity in Ecuador based on the incidence of accidents and occupational illnesses. The resulting classification differs considerably from the current one, showing only 47% similarity. This difference should be discussed.

The characteristics of the national context may explain the rise in occupational risk levels for certain economic activities. For instance, the most significant differences are found in the agricultural, forestry, and public sewerage services sectors, which are similar to assessments conducted in surveys of working conditions [45] and their rates of disease prevalence [46]. Additionally, a sector with increased risk is identified in public service, defense, and security, shifting from medium to high. This can be attributed to various social conditions in recent years that have heightened exposure to crime in Ecuador [47].

The most notable decreases are observed for certain economic activities traditionally considered among the most dangerous due to the risks associated with their tasks and processes [48]. The construction industry significantly reduces occupational risk, going from high to low. Implementing more rigid regulations, adopting a safety culture, and providing continuous training have likely contributed to improving safety conditions on construction sites. Also, the manufacturing industry reduces occupational risk from medium to low. The mechanization of processes and the implementation of occupational health and safety management systems have probably facilitated the identification and mitigation of risks more efficiently [49].

Likewise, the results allow us to uncover the most vulnerable economic activities and age groups that require special attention and additional intervention to improve working and health conditions. For example, considering age in agriculture and mining activities, it is observed that older workers face a more critical situation in occupational illnesses. However, the injury figures due

to accidents are similar to those of other age groups. This could be because the calculated rates are aggravated for the smaller population, unlike the larger populations. Nevertheless, as literature reports [50,51], workers aged 55 and over are more susceptible to developing chronic and long-term occupational diseases due to prolonged exposure to occupational risks and physiological changes inherent to aging, compared to younger workers.

The change in the level of risk in Ecuadorian companies generates new requirements in terms of quantity and specialization of occupational health and safety experts. This implies the need to incorporate more technicians and physicians trained in occupational risk prevention, especially in sectors with greater risk exposure. In addition, organizations, according to their size and risk level, must adapt their internal structures to comply with regulations. This scenario requires investment in training and hiring and close coordination between the public and private sectors to ensure that occupational health and safety policies are effective and sustainable in the long term.

Our results are reliable because we use ENEMDU data instead of other sources. Previous studies [52] have developed similar initiatives to classify occupational risks in Latin American and Middle Eastern companies. The results obtained from ENEMDU reflect specific differences in the risk classification of productive activities compared to those outlined in Resolution 2018-001. This alternative classification, based on ENEMDU data and developed using a methodology that seeks to address the methodological limitations of Resolution 2018-001, has parallels in the risk classifications of activities conducted in France [22], Spain [14], and the United Kingdom [23]. Furthermore, comparing the ENEMDU classification with Resolution 2018-001 will give researchers and policymakers a broader perspective for analyzing this issue.

In this sense, the methodology utilized in this study aimed to address these disadvantages by integrating methodological tools from some of the countries mentioned in the previous paragraph. Utilizing ENEMDU as a survey of working conditions draws an intriguing parallel with the methodology employed in France. Furthermore, enhancing the survey with work-related accidents and occupational illness rates mirrors those developed in Spain and the United Kingdom.

4.1. Strengths and limitations

The main strength of our study is the data source used. The ENEMDU is a large-scale survey with a large sample size, which represents the employment situation and characterization of the labor market of all employed people in the country, including dependent workers and self-employed workers. In addition, ENEMDU is assessed for continuous quality control at the time of the survey application and before the data publication on the Internet to guarantee accuracy.

Another strength of our study is that it counteracts the underreporting in administrative records and provides broader coverage. Standardizing the incidence of work-related injuries and illnesses allows the occupational risk level to be clustered for each economic activity, thereby validating the results.

Despite these strengths, some limitations should be considered. The responses reported by the surveyed workers are based on perceptions that could be subject to recall bias for injuries and the impossibility of establishing a relationship between illnesses and work [20]. Unfortunately, the ENEMDU does not contain information on the severity of the injury or diagnosis of the illness. These variables would have made the classification of the level of occupational risk more accurate. In addition, the estimates made in this study correspond to the year 2017. Occupational health and safety conditions have likely changed (improved or worsened), considering factors such as the effects of the COVID-19 pandemic.

It is important to note that ENEMDU collects data from formal workers; therefore, our analyses focus on the working population in the formal sector. Some sectors, such as construction (F) and agriculture (A), have a significant number of informal workers (approximately 77%) [53,54], for which no accurate or official data on occupational accidents and illnesses exists, limiting the sector's risk classification. To accurately categorize risk levels, future research should involve focus groups with key stakeholders in the sector to identify perceptions, experiences, and factors that influence working conditions and occupational safety.

The underreporting of injuries and illnesses in official statistics poses a significant challenge in Ecuador, as it hampers the effective design of occupational risk prevention and control strategies. The reasons for underreporting may vary by country and the level of formality in the economic sector. The most underreported economic activities within the formal sector include construction, transportation, and manufacturing [55,56]. In this context, the ENEMDU serves as a valuable source of information for estimating the true magnitude of occupational health and safety issues. Its approach offers a broader and more representative perspective on workplace reality, addressing the shortcomings of administrative records, which often suffer from deficiencies in data coverage and accuracy. Unlike Resolution 2018-001, the ENEMDU takes into account statistical representativeness and methodological standardization that enhance the transparency and replicability of its data. Nonetheless, it would be beneficial for future research to conduct a Delphi analysis focused on ergonomics and risk assessment to facilitate data validation, particularly in the construction, transportation, and manufacturing sectors.

For future studies, it may be proposed to develop a theoretical model to support this classification and see how well the proposed model fits the data (through fit indices). For example, the theoretical model may include the type of risks to which each occupation is exposed (see job descriptions for the different occupations and activities) and how the presence of these risks can explain (through regression analysis) the occurrence of injuries or illnesses.

Furthermore, it is suggested that OSH experts discuss our results to ratify this new classification, especially when the national OSH policy for 2025-2030 is due to happen.

4.2. Conclusions

The joint estimates of the incidence of work-related injuries and illnesses have allowed economic activities to be grouped into a new occupational risk level classification that differs from Resolution No. 2018-001 issued by the CISHT. Although a definitive classification is not provided, these findings underline the importance of implementing specific preventive measures adapted to the dangerousness of each economic activity. In addition, it suggests the need for more up-to-date future studies and periodic monitoring of the impact of working conditions on workers' health. In the meantime, this study provides valuable information that can guide the development of public policies and intervention strategies, thus contributing to the improvement of safe and healthy work environments in the country.

CRediT authorship contribution statement

Antonio R. Gómez-García: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Raúl Gutierrez-Álvarez:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation. **Alywin H. Chang-León:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **José A. García-Arroyo:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Authorship statement

All authors contributed substantially to the conception and design of the paper, the acquisition, analysis, and interpretation of data, and the critical review and approval of the final manuscript.

Ethical statement

Not applicable.

Data availability statement

Not applicable.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) did NOT use any generative AI and AI-assisted technologies to develop any phase of the manuscript.

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Conflicts of interest

1st. All authors have participated in the design and execution of this document.

2nd. All authors have read and approved the manuscript version we sent you.

3rd. The manuscript's content is original and is not subject to review by any other journal. Likewise, its content is not subject to copyright by any publication or published elsewhere.

4th. The authors have no conflicts of interest related to the manuscript to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.shaw.2025.03.004>.

References

- Ji Z, Pons D, Pearce J. A methodology for harmonizing safety and health scales in occupational risk assessment. *Intern J Environ Res Public Health* 2021;18(9). <https://doi.org/10.3390/ijerph18094849>.
- ILOSTAT. International standard industrial classification of all economic activities (ISIC) [Internet]. 2024. <https://ilostat.ilo.org/methods/concepts-and-definitions/classification-economic-activities/>.
- Perna JB, Library of Congress. Occupational safety and health Act, 1970: a bibliography. Washington (DC): Law Library, Library of Congress. 1974. <https://www.loc.gov/resource/llgrdppub.2019668696/>.
- Occupational Safety and Health Administration. 29 CFR parts 1910 and 1926 standards improvement (miscellaneous changes) for general industry and construction standards; paperwork collection for coke oven emissions and inorganic arsenic; final rule. 1998. Available from: <https://www.osha.gov/laws-regs/federalregister/1998-06-18>.
- Council of the European Union. Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work. *Official Journal of the European Communities*. 1989. <https://eur-lex.europa.eu/CT-RPS>.
- Jefatura del Estado. Ley 31/1995, de 8 de noviembre, de prevención de Riesgos Laborales. *Boletín Oficial del Estado* 1995;269:10–1. <https://www.boe.es/eli/es/lo/1995/12/27/16>.
- Jefatura del Estado. Royal decree 39/1997, January 17, adopting regulations on prevention services. (BOE. No. 27, 31.01.1997). 1997. <https://www.boe.es/buscar/act.php?id=BOE-A-1997-1853>.
- Gobierno Nacional de Colombia. Ley No. 1562 del 11 jul 2012 por la cual se modifica el sistema de riesgos laborales y se dictan otras disposiciones en materia de salud ocupacional [Internet]. 2012. <http://wsp.presidencia.gov.co/Normativa/Leyes/Documents/ley156211072012.pdf>.
- Gobierno Nacional de Colombia. Decreto 1072, Por medio del cual se expide el Decreto Único Reglamentario del Sector Trabajo [Internet]. Bogotá; 2015.
- República de Argentina. Ley 24557 de Riesgos del Trabajo. [Internet]. <https://www.argentina.gob.ar/normativa/nacional/27971/actualizacion> 1995; 1995.
- CISHT. Resolución 2018-001. Clasificación, categorización y niveles de riesgo laboral en materia de seguridad y prevención de riesgos laborales. [Internet]. 2018. <https://www.salud.gob.ec/resoluciones-del-comite-interinstitucional-de-seguridad-e-higiene-del-trabajo/>.
- Ministry of Labor. Decreto Ejecutivo 255 Reglamento de Seguridad y Salud en el trabajo, Registro Oficial 554 del 9 de Mayo del 2024 [Internet]. 2024.
- ILO. Introductory report: 23rd world congress on safety and health at work 27–30 November 2023. International Labour Organization. 2023. https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@ed_protect/@protrav/@safework/documents/publication/wcms_906187.pdf.
- INSST. Accidentes laborales y variables relacionadas con el trabajo. Análisis a partir del módulo especial de la EPA. Instituto Nacional de Seguridad y Salud En El Trabajo. 2022. <http://cpage.mpr.gob.es>.
- SWA. About the data. Safe Work Australia. 2024. https://www.safe-workaustralia.gov.au/sites/default/files/2024-07/awhs23-33-baseline-report-about-the-data_jul2024.pdf.
- Takala J, Hämäläinen P, Saarela KL, Yun LY, Manickam K, Jin TW, Heng P, Tjong C, Kheng LG, Lim S, Lin GS. Global estimates of the burden of injury and illness at work in 2012. *J Occup Environ Hyg* 2014;11(5):326–37. <https://doi.org/10.1080/15459624.2013.863131>.
- PAHO. Health Indicators. Conceptual and operational considerations. Pan American Health Organization. 2018. https://iris.paho.org/bitstream/handle/10665.2/49056/09789275120057_eng.pdf?sequence=6&isAllowed=y.
- EUROGIP. Estimaciones actualizadas du phénomène de sous-déclaration des accidents du travail en Europe. [Internet]. 2023. Available from: <https://eurogip.fr/wp-content/uploads/2023/12/EUROGIP-2023-Sous-declaration-des-AT-en-Europe.pdf>.
- Leigh JP, Du J, McCurdy SA. An estimate of the U.S. government's undercount of nonfatal occupational injuries and illnesses in agriculture. *Ann Epidemiol* 2014;24(4):254–9. <https://doi.org/10.1016/j.annepidem.2014.01.006>.
- Stock S, Nicolakakis N, Raiq H, Messing K, Lippel K, Turcot A. Underreporting work absences for nontraumatic work-related musculoskeletal disorders to workers' compensation: results of a 2007–2008. *Surv Québec Working Popul (world)* [Research-Article] 2014. <https://doi.org/10.2105/AJPH.2013.301562>; *American Public Health Association*.
- ILO. Collecting data on occupational safety and health: a mapping of different types of household and establishment surveys. International Labour Organization. 2022. https://vzf.ilo.org/wp-content/uploads/2022/06/Collecting_data_on_occupational_SH-4.pdf.
- Enquête. « Conditions de travail – risques psychosociaux » (2024X061TV)—CNIS. [n.d.]. Retrieved October 11, 2024, from <https://www.cnis.fr/enquetes/condition-de-travail-risques-psychosociaux-edition-2024-ct-rps-2024x061tv/>.
- National Institute for public health and the environment. RIVM. 2024. <https://www.rivm.nl/en>.
- Ajslev JZ, Sundstrup E, Jakobsen MD, Kines P, Dyreborg J, Andersen LL. Is perception of safety climate a relevant predictor for occupational accidents? Prospective cohort study among blue-collar workers. *Scand J Work Environ Health* 2018;44(4):370–6. <https://doi.org/10.5271/sjweh.3723>.
- Cho Y. Data resource profile: the Korean working conditions survey (KWCS). *Ann Occup Environ Med* 2023;35:e49. <https://doi.org/10.35371/aoem.2023.35.e49>.
- Fort E, Haddak MM, Pelissier C, Charbotel B. Evolution of work conditions for employees driving for work in France based on data from the 2003, 2010 and 2017 SUMER surveys (Surveillance Médicale des expositions aux risques Professionnels). *J Saf Res* 2024;89:288–98. <https://doi.org/10.1016/j.jsr.2024.04.002>.
- Hyeseon C, Sooin P, Insoo K, Myungsun K. Differences in the effects of work environment on health problems and satisfaction of working condition by gender: the 6th Korean working conditions survey. *Int J Environ Res Public Health* 2023;20(19). <https://doi.org/10.3390/ijerph20196824>. Article 19.
- Nappo N. Is there an association between working conditions and health? An analysis of the Sixth European Working Conditions Survey data. *PLoS ONE* 2019;14(2):e0211294. <https://doi.org/10.1371/journal.pone.0211294>.
- Park SJ, Jung M, Sung JH. Influence of physical and musculoskeletal factors on occupational injuries and accidents in Korean workers based on gender and company size. *Int J Environ Res Public Health* 2019;16(3). <https://doi.org/10.3390/ijerph16030345>. Article 3.
- Benavides F, Wesseling C, Delcos G, Felknor S, Pinilla J, Rodrigo F. Working conditions and health in Central America: a survey of 12,024 workers in six countries. *Occup Environ Med* 2014;71(7). <https://doi.org/10.1136/oemed-2013-101908>.
- Merino-Salazar P, Artazcoz L, Cornelio C, Iñiguez MJL, Rojas M, Martínez-Iñigo D, Vives A, Funcasta L, Benavides FG. Work and health in Latin America: results from the working conditions surveys of Colombia, Argentina, Chile, Central America and Uruguay. *Occup Environ Med* 2017;74(6):432–9. <https://doi.org/10.1136/oemed-2016-103899>.
- Gómez-García AR, Hacay Chang A, Valenzuela-Mendieta RO, García-Arroyo JA. Leaving no-one behind in the workplace health promotion: towards regulatory equity in the Ecuadorian micro-enterprises. *J Public Health Policy* 2024;45(1):152–63. <https://doi.org/10.1057/s41271-023-00466-x>.
- Leka S, Jain A, Zwetsloot G, Andreou N, Hollis D. Future challenges of occupational safety and health policy-making in the UK. *Policy Pract Health Saf* 2016;14:65–80. <https://www.tandfonline.com/doi/abs/10.1080/14773996.2016.1231871>.
- MacEachen E, Kosny A, Ståhl C, O'Hagan F, Redgrift L, Sanford S, Carrasco C, Tompa E, Mahood Q. Systematic review of qualitative literature on occupational health and safety legislation and regulatory enforcement planning and implementation. *Scand J Work Environ Health* 2016;42(1):3–16. <https://doi.org/10.5271/sjweh.3529>.
- Nowrouzi-Kia B, Nadesar N, Casole J. Systematic review: factors related to injuries in small- and medium-sized enterprises. *Int J Crit Illness Inj Sci* 2019;9(2):57–63. https://doi.org/10.4103/IJCIIS.IJCIIS_78_18.
- INEC. Encuesta Nacional Empleo, Desempleo y subempleo (ENEMDU). Instituto Nacional de Estadística y Censos. 2017b. <https://www.ecuadorencifras.gob.ec/enemdu-2017/>.
- ILO. Quick Guide on sources and uses of statistics on occupational safety and health. International Labour Organization. 2020. <https://www.ilo.org/media/392361/download>.
- Sienkiewicz M, van Nes P, Deleglise MA. Chapter 5—achieving policy impact. In: Sucha V, Sienkiewicz M, editors. *Science for policy handbook*. Elsevier; 2020. p. 44–51. <https://doi.org/10.1016/B978-0-12-822596-7.00005-X>.
- INEC. Diseño muestral ENEMDU. Instituto Nacional de Estadística y Censos. 2017a. <https://www.ecuadorencifras.gob.ec/disenio-muestral-2/>.
- INEC. Clasificación Nacional de Actividades Económicas (CIIU Rev. 4.0). Instituto Nacional de Estadística y Censos. 2012. <https://aplicaciones2.ecuadorencifras.gob.ec/SIN/metodologias/CIIU204.0.pdf>.
- INEC. Trabajo infantil en Ecuador: Hacia un entendimiento integral de la problemática. Instituto Nacional de Estadística y Censos. 2015. https://www.ecuadorencifras.gob.ec/documentos/web-inec/Bibliotecas/Libros/Trabajo_Infantil_en_Ecuador.pdf.
- Rosero-Bixby L. Socioeconomic inequalities in national transfers accounts in Ecuador 2006 and 2011: did a new socialist government make a difference? *J Econom Ageing* 2024;27:100483. <https://doi.org/10.1016/j.jeoa.2023.100483>.
- The jamovi project. Jamovi (Version 2.3) [Computer Software] 2024. Retrieved from <https://www.jamovi.org>; 2024.
- Fujimoto K, Angelone LM, Rajan SS, Iacono MI. Simplifying the numerical human model with k-means clustering method. In: Makarov SN, Noetscher GM, Nummenmaa A, editors. *Brain and human body modeling 2020: computational human models presented at EMBC 2019 and the BRAIN Initiative® 2019 meeting*. Springer International Publishing; 2021. p. 261–70. https://doi.org/10.1007/978-3-030-45623-8_15.
- OPS & MSP. Panorama Nacional de Salud de los Trabajadores. Encuesta de Condiciones de Trabajo y Salud 2021–2022 [Internet]. 2023. Available from:

- <https://www.salud.gob.ec/wp-content/uploads/2022/05/Panorama-Nacional-de-Salud-de-los-Trabajadores-Encuesta-de-Condiciones-de-Trabajo-y-Salud-2021-2022.pdf>; 2021-2022.
- [46] Barneo-Alcántara M, Díaz-Pérez M, Gómez-Galán M, Carreño-Ortega Á, Callejón-Ferre AJ. Musculoskeletal disorders in agriculture: a review from web of science core collection. *Agronomy* 2021;11(10):10. <https://doi.org/10.3390/agronomy11102017>.
- [47] Mantilla J, Andrade C, Vallejo MF. Why cities fail: the urban security crisis in Ecuador. *J Strategic Security* 2023;16(3). <https://doi.org/10.5038/1944-0472.16.3.2147>.
- [48] Paguay M, Febres JD, Valarezo E. Occupational accidents in Ecuador: an approach from the construction and manufacturing industries. *Sustainability* 2023;15(16):16. <https://doi.org/10.3390/su151612661>.
- [49] Hulshof CTJ, Pega F, Neupane S, van der Molen HF, Colosio C, Daams JG, Descatha A, Kc P, Kuijjer PPFM, Mandic-Rajcevic S, Masci F, Morgan RL, Nygård CH, Oakman J, Proper KI, Solovieva S, Frings-Dresen MHW. The prevalence of occupational exposure to ergonomic risk factors: a systematic review and meta-analysis from the WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury. *Environ Int* 2021;146:106157. <https://doi.org/10.1016/j.envint.2020.106157>.
- [50] Peng L, Chan AHS. A meta-analysis of the relationship between aging and occupational safety and health. *Saf Sci* 2019;112:162–72. <https://doi.org/10.1016/j.ssci.2018.10.030>.
- [51] Vives A, Gray N, González F, Molina A. Gender and ageing at work in Chile: employment, working conditions, work-life balance and health of men and women in an ageing workforce. *Ann Work Exposures Health* 2018;62(4): 475–89. <https://doi.org/10.1093/annweh/wxy021>.
- [52] Garavito D, Kocsis I. Classification of economic activities in Colombia according to workplace accident and disease rates using a data clustering algorithm. *Int J Eng Manag Sci* 2017;2(3). <https://doi.org/10.21791/IJEMS.2017.3.5.3>.
- [53] Bustamante VC, Mendoza C, Muñoz RM, Bravo S. Job quality in the shadow of Informality: a regional analysis in Ecuador. *Investigaciones Regionales - J Reg Res*; 2024. <https://doi.org/10.38191/iirr-jorr.24.062>.
- [54] Mejía Chávez M, Mejía Chávez L, Mejía Morales M, Lara Haro D. La informalidad en el Ecuador: Una medición del tamaño del sector informal desde la perspectiva de la desigualdad. *Cuestiones Económicas* 2023;33(2). <https://doi.org/10.47550/RCE/33.2.6>.
- [55] Fagan KM, Hodgson MJ. Under-recording of work-related injuries and illnesses: an OSHA priority. *J Saf Res* 2017;60:79–83. <https://doi.org/10.1016/j.jsr.2016.12.002>.
- [56] Wuellner S, Phipps P. (2018). Employer knowledge of federal requirements for recording work-related injuries and illnesses: implications for occupational injury surveillance data. *Am J Ind Med* 2018;61(5):422–35. <https://doi.org/10.1002/ajim.22824>.