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Analysis of the labor accident rate in the Manufacturing Sector

Análisis de la siniestralidad laboral en el Sector Manufacturero

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ABSTRACT

The purpose of this research is to provide an updated analysis of the occupational accident rate in the manufacturing sector in Zone 8 of Ecuador. In Ecuador, there are annual statistical records of occupational accidents (occupational accidents and diseases) published by the Ecuadorian Institute of Social Security (I.E.S.S. - Division of Labor Risks) in its annual Statistical Bulletin. Under this statistical data presentation format, the I.E.S.S. publishes global

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accident figures for productive sectors such as Manufacturing, Mining, Agriculture, Services, etc. The occupational accident rate is considered a critical indicator of occupational safety and health, and its study makes it possible to identify existing risks and develop effective strategies to prevent occupational accidents and illnesses.

RESUMEN

El objetivo de esta investigación es proporcionar un análisis actualizado de la siniestralidad laboral en el sector manufacturero de la Zona 8 de Ecuador. En Ecuador existen registros estadísticos anuales de siniestralidad laboral (accidentes de trabajo y enfermedades profesionales) publicados por el Instituto Ecuatoriano de Seguridad Social (I.E.S.S. - División de Riesgos del Trabajo) en su Boletín Estadístico anual. Bajo este formato de presentación de datos estadísticos, el I.E.S.S. publica cifras globales de accidentalidad para sectores productivos como Manufactura, Minería, Agricultura, Servicios, etc. La siniestralidad laboral se considera un indicador crítico de la seguridad y salud en el trabajo, y su estudio permite identificar los riesgos existentes y desarrollar estrategias eficaces para prevenir los accidentes y enfermedades profesionales.

Keywords / Palabras clave

Accident rate; Production sectors; Accident statistics; Occupational disease statistics.

Siniestralidad; Sectores de producción; Estadísticas de accidentes; Estadísticas de enfermedades profesionales.

Introduction

The manufacturing industry is an integral part of the economy of Zone 8 as of Ecuador as a whole, and provides numerous jobs to local workers (Blay-Palmer et al., 2021; Knapp, 2018, 2018; Martinez Valle, 2017; Valverde Lucio et al., 2021; Vela-Almeida et al., 2018).. However, authors such as, Badri et al., (2018); Jilcha & Kitaw, (2017); Kim et al., (2019); Lette et al., (2018) describe that activity in these manufacturing industries also entails various occupational hazards, which can result in accidents and illnesses that affect both workers and companies. The Statistical Bulletin of the IESS - Division of Labor Risks, presented by. (Vega Suárez, 2022)states that 11,502

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occupational accidents occurred in Ecuador during the year 2021. This figure includes all productive activities such as industry, commerce, mining, commercial activity, agriculture, etc. Different authors such as, (Contreras Ovejero et al., 2018; Gómez García et al., 2018; Hacay-Chang Leon & Gómez García, 2021; Rodas & Sanchez, 2019) establish that occupational accidents, can be understood as occupational accidents and diseases, this accident rate represents a growing concern in terms of safety and health in the workplace. The manufacturing sector plays a significant role in the economy of Zone 8 of Ecuador, and it is essential to understand and address the challenges related to occupational accidents in this sector to ensure safe and healthy working conditions.

For Mohammadfam et al. (2017); Payá Castiblanque & Beneyto Calatayud, (2018); Petitta et al.in their analysis of occupational accidents, this can have devastating consequences for both workers and companies. Occupational accidents and illnesses can result in serious injuries, permanent disabilities and even loss of life. In addition to the human impact, occupational accidents generate considerable costs for companies, including medical expenses, workers' compensation and lost productivity.

Despite efforts to improve working conditions and promote occupational safety, occupational accidents in the manufacturing sector in Ecuador's Zone 8 remain a major concern (Hacay-Chang Leon & Gómez García, 2021).. To develop effective prevention and improvement strategies, it is crucial to understand the underlying causes and trends associated with occupational accidents and diseases in this specific sector.

The objective of this research is to conduct an updated analysis of the occupational accident rate in the manufacturing sector in Zone 8 of Ecuador. It will seek to examine the trends, causes and consequences of occupational accidents in order to identify areas for improvement and provide practical recommendations to reduce occupational risks and promote a safe and healthy work environment. It is therefore crucial to conduct a detailed analysis of occupational accidents in this sector in order to identify problem areas and propose effective solutions.

The C.I.I.U. (International Standard Industrial Classification), as an instrument for the classification of productive activities in Ecuador, covers 21 sectors such as Agriculture, Livestock, Forestry and Fishing,

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Mining and Quarrying, Manufacturing, etc.; in turn, within the Manufacturing sector there are 24 classifications or subsectors of economic activities that start with coding C10 to C33, which generate a total of 24 subsectors within the Manufacturing sector, such as:

SUBSECTORNAME

- C-10 Processing of food products
- C-11 Beverage processing
- C-12 Manufacture of tobacco products
- C-13 Manufacture of textile products
- C-14 Manufacture of garments
- C-15 Manufacture of leather and related products
- C-16 Manufacture of wood products
- C-17 Manufacture of paper and paper products
- C-18 Printing and playback of recordings
- C-19 Manufacture of coke and refined petroleum products
- C-20 Manufacture of chemicals and chemical products
- C-21 Manufacture of pharmaceutical products
- C-22 Manufacture of rubber and plastic products
- C-23 Manufacture of other non-metallic mineral products
- C-24 Base metal manufacturing
- C-25 Manufacture of fabricated metal products
- C-26 Manufacture of computer, electronic and optical products
- C-27 Manufacture of electrical equipment
- C-28 Manufacture of machinery and equipment
- C-29 Manufacture of motor vehicles, trailers and semi-trailers
- C-30 Manufacture of other types of transport equipment
- C-31 Furniture manufacturing
- C-32 Other manufacturing
- C-33 Repair and installation of machinery and equipment

Specifically in the industrial activity, according to the IESS Bulletin, 206 occupational accidents occurred in 2021, including all provinces of the country.(Vega Suárez, 2022).

In the undergraduate thesis works that are part of the present research, the segregation of the figures of work accidents among the subsectors that make up the Manufacturing area was carried out by means of mathematical artifices; this information also served as the basis for the preparation of this document.

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Through an approach based on the review of existing literature, as well as the analysis of data collected from reliable sources, it is expected to obtain a comprehensive view of the current situation of occupational accidents in the manufacturing sector in Zone 8 of Ecuador. The results of this research could be used by labor authorities, companies and other relevant actors to develop effective policies and programs that contribute to the prevention and reduction of occupational accidents and diseases in this sector.

This document has a structure consisting of an Introduction, Methodology, Results, Discussion and conclusions detailing the research data presented.

When looking at the official figures of occupational accidents in Ecuador and the current International Standard Industrial Classification (S.I.I.C.), the question arises: What would be the scenario if the figures of occupational accidents and diseases were segregated by productive sector and even by productive subsectors, such as the 24 manufacturing subsectors mentioned above? In addition, is there any benefit for companies and their workers to have this information, especially if the objective of this information processing is to reduce occupational accidents and diseases in the workplace?

To answer the first question, five Manufacturing subsectors have been chosen for analysis; then a selection exercise is carried out from among the five subsectors, based on the following criteria:

- Number of companies in the sector.
- Number of employees.
- Number of accidents.
- Accident severity (average number of days of disability).
- Number of cases of occupational diseases.
- Severity of occupational disease cases.
- Number of provinces where the companies of the analyzed sector are located.
- Production volume (for domestic and export markets) in dollars for each sector.
- Volume of exports of each sector in dollars.

For the purposes of this research, only the first four parameters are considered; however, for subsequent studies, the application of the nine criteria is recommended in order to better identify the sectors

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whose occupational accident rate should be prioritized. In response to the second question posed, the benefits that would be obtained, in the event of this advance in the processing of accident figures, are: (i) being able to determine productive sectors prone to occupational accidents; (ii) categorizing productive sectors by typology, frequency and severity of their accidents and occupational diseases; (iii) identifying the root cause of recurrent accidents in each sector to prevent their repetition; (iv) comparing the effectiveness of preventive strategies implemented by productive sectors to reduce accidents; (v) reproducing within the same sector the most effective prevention strategies; (vi) incentivizing sectors with better results in the management of preventing occupational accidents, etc. Furthermore, the possibility of using segregated accident figures as a tool for comparison between countries in the region should not be ruled out, especially in relation to the costs of medical care for occupational accidents.

Possible scenarios if the current status quo continues:

- Lack of information on the behavior of the occupational accident rate of a given productive activity.
- Lack of information on the corrective measures needed to reduce the accident rate in certain productive sectors.
- Sanctions by the Ministry of Labor for non-compliance with SSO regulations.
- Lack of campaigns to reduce occupational accidents and diseases in companies.
- Limitations for the calculation of the medical costs required for the care of patients injured or affected by any occupational pathology.
- Impossibility of carrying out comparative studies on accident rates between productive sectors of the country / or region.
- Lack of comparative studies between countries in the region on the amount of investment in medical care for occupational accidents.

Materials and Methods

The present study was based on an exhaustive review of the scientific and technical literature on occupational accidents in the manufacturing sector in Zone 8 of Ecuador. Updated data were collected from reliable sources, such as government reports,

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occupational safety statistics, previous studies and undergraduate thesis work that were developed with the research structure that was established and applied. The data obtained were analyzed and used to calculate accident rates and determine the main causes of occupational accidents and diseases in the manufacturing sector. Also by mathematical artifices the segregation of the figures of work accidents among the subsectors that compose the manufacturing area was performed.

PROBLEM-SOLVING HEURISTICS:

The heuristics used include the following steps:

- Identification of the companies belonging to the subsector.
- Segregation of the companies located in zone 8 (Guayaquil, Durán and Samborondón), determination of the number of occupational accidents and illnesses corresponding to zone 8.
- Stratification in large companies, SMEs and microenterprises.
- Accident rate projection for a 5-year period.
- Identification of the causes of the accident rate in the subsector.
- Determination of the average level of development of the Occupational Risk Prevention Management System in the companies involved in the study.
- Calculation of the Pearson correlation between the accident rate and the Effectiveness Index of the Occupational Risk Prevention Management System.
- Intervention proposal to the sectors depending on the results of the correlation calculation (point 7).
- Determination of medical care costs per accident in the subsectors.

For the present article, the first four stages of the heuristics mentioned above were taken as a reference.

1. This research is based on five productive subsectors that were analyzed, as follows:
2. C.I.I.U.-C.10: Processing of foodstuffs
3. C.I.I.U.-C-11: Beverage processing
4. C.I.I.U.-C-13: Manufacture of textile products
5. C.I.I.U.-C-17: Manufacture of paper and paper products
6. C.I.I.U.-C-22: Manufacture of rubber and plastic products

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In these five subsectors, the following data have been taken into consideration in order to select one of them and apply the proposed methodology:

- Number of companies comprising each subsector.
- Number of employees.
- Characteristics of the pilot company belonging to the subsector: severity of accidents, Accident Incidence Rate per ten thousand workers and Occupational Health and Safety Management Effectiveness Index.

STEP 1: SELECTION OF THE SUBSECTOR TO BE ANALYZED

The information corresponding to the five subsectors is shown below:

- Sub-sector (C.I.I.U.)
- A: Projected number of accidents in 2023 (based on the projection of accidents taking the figures of the last 10 years as a reference).
- G.I.: Accident Severity Index.
- I.I.: Incidence rate of accidents per thousand workers.
- T: Working population of the subsector
- L: Occupational Health and Safety (OHS) legal compliance indicator.
- C: Correlation index between the variables number of accidents versus OHS legal compliance.

Table 1 shows the data for each subsector.

Table 1. *Data of the selected subsectors.*

C.I.I.U.	A (2023)	I.G.	I.I c/10,000t year 2018	T (year 2018)	L (%)	C
C-10	**1687**	**ND**	**87.62**	**145.511**	86.35	**0,407(+)**
C-11	6	58,0	85.99	11.047	86,35	0.85 (-)
C-13	45	**85,0**	84.92	12.128	64.7	0.95 (-)
C-17	96	27.3	53.60	14.177	75.52	0.26 (-)
C-22	23	84.90	79.18	18.058	**62.30**	0.97 (-)

NA: Data not available.

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Based on the figures presented in Table 1, subsector C-10 Food products manufacturing is selected. The selection criteria are: greater number of workers, higher incidence rate and Pearson correlation of positive sign, i.e., despite having the subsector a greater legal compliance, however, the accident rate increased during the period analyzed. (Ana Bajaña, 2022; Calderón Tenorio, 2022; Quintero Becerra, 2022; Veintimilla Franco, 2022)..

This sector is analyzed to observe how the figures of occupational accidents and diseases behave in a given time range; also how these figures are contrasted with the interest of the companies in preventing risks and, based on their behavior, to show the advantages of this proposal.

STEP 2: CALCULATION OF THE PEARSON CORRELATION INDEX.

Based on the information gathered, a correlation index is calculated between the behavior of the Effectiveness Index (OHS legal compliance) and the historical behavior of accidents, for a period of 5 years.

In order to interpret the relationship between the efficiency index and the accident rate, we will find the correlation coefficient between the two variables. For our study we will use Pearson's correlation coefficient, which defines this level as between - 1 and 1, and we will analyze whether it is negative or positive with the following formula:

$$\boldsymbol{r} = \frac{n\sum_{i=1}^{n} X_i Y_i - \sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i}{\sqrt{[n\sum_{i=1}^{R} X_i^2 - (\sum_{i=1}^{n} X_i)^2][n\sum_{i=1}^{R} Y_i^2 - (\sum_{i=1}^{R} Y_i)^2]}}$$

Applying Pearson's correlation formula, we obtained the correlation coefficient between the OHS system effectiveness index and the accident rate, obtaining that:

r = - 0,95

This result indicates a negative correlation, i.e. an inverse correlation between

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the data used for its calculation, the lower the number of accidents, the higher the efficiency index, or the higher the number of accidents, the lower the efficiency index, or the higher the number of accidents, the lower the efficiency index.

effectiveness.

STEP 3: RANKING OF COMPANIES BASED ON THE CORRELATION OF ACCIDENTS vs EFFECTIVENESS RATE TO INTERVENE OR INCENTIVATE

The presentation of this ranking is intended to encourage the Ministry of Labor, as the entity in charge of controlling occupational risk prevention, to intervene in sectors with low performance or to stimulate companies and workers that stand out by reducing accidents and occupational pathologies in the workplace.

In the future, the automation of the ranking and the creation of the respective computer platform for the entry of the respective information should be sought.

Results

The results obtained revealed that the occupational accident rate in subsector C-10 Food processing of the manufacturing sector in Zone 8 of Ecuador has experienced an upward trend in recent years. Several factors were identified as contributing to this situation, such as lack of adequate worker training, precarious working conditions, obsolete equipment and machinery, and a poor safety culture in some companies. Also, a higher incidence of injuries was observed in certain subsectors, such as the textile industry and chemical manufacturing.

The analysis of the results shows the need to implement effective prevention measures in subsector C-10 Food Product Processing of the manufacturing sector in Zone 8 of Ecuador. These measures should include occupational safety training programs, regular inspections of working conditions, improvement of infrastructure and equipment, and promotion of a safety culture in all companies in the sector. In addition, it is suggested that incentives and sanctions be implemented to encourage compliance with labor safety standards.

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Conclusions

The occupational accident rate in subsector C-10 Food processing of the manufacturing sector in Zone 8 of Ecuador is a significant problem that requires immediate attention. The results of the present investigation have provided an updated analysis of the situation, highlighting the main causes of occupational accidents and illnesses in the sector and proposing practical recommendations for improving occupational safety and health. It is essential that both government authorities and companies in the sector collaborate in implementing the proposed measures to achieve a safer and healthier work environment in Ecuador's Zone 8. In addition, it is established for future research to continue with the analysis of the behavior of the other subsectors of the manufacturing sector in Ecuador's Zone 8, so that comparative statistical tables can be generated on the behavior of the country's labor accident rate.

References

Bajaña, N. B. (2022). Statistics, preventive and corrective measures and trends by accidentability and occupational morbidity of the productive subsector of paper and paper products manufacturing according to the C.I.I.U. code [Thesis, Universidad de Guayaquil. Faculty of Industrial Engineering. Career of Industrial Engineering]. http://repositorio.ug.edu.ec/handle/redug/60765

Badri, A., Boudreau-Trudel, B., & Souissi, A. S. (2018). Occupational health and safety in the industry 4.0 era: A cause for major concern? Safety Science, 109, 403-411. https://doi.org/10.1016/j.ssci.2018.06.012.

Blay-Palmer, A., Santini, G., Halliday, J., Malec, R., Carey, J., Keller, L., Ni, J., Taguchi, M., & van Veenhuizen, R. (2021). City Region Food Systems: Building Resilience to COVID-19 and Other Shocks. Sustainability, 13(3), Article 3. https://doi.org/10.3390/su13031325

Calderón Tenorio, C. A. (2022). Statistics, preventive and corrective measures and trends for occupational accidents and morbidity in the productive subsector of beverage production according to ISIC code C-11. [Thesis, Universidad de Guayaquil. Faculty of

Received July 11, 2022 / Approved October 30, 2021 Pages: 114-130
eISSN: 2600-5743

Industrial Engineering. Career of Industrial Engineering]. http://repositorio.ug.edu.ec/handle/redug/64344

Contreras Ovejero, S., Manzanedo del Campo, M. Á., & Herrero Cosío, Á. (2018). Economic crises and their influence on occupational accidents. Dirección y Organización, 65, Article 65. https://doi.org/10.37610/dyo.v0i65.525. https://doi.org/10.37610/dyo.v0i65.525

Gómez García, A. R., Salazar, P. M., Espinoza Samaniego, C. E., & Cajías Vasco, P. E. (2018). I Survey on Occupational Safety and Health in Quito: Occupational accidents. Podium, 33, 25-34. https://doi.org/10.31095/podium.2018.33.3.

Hacay-Chang Leon, A. I., & Gómez García, A. R. (2021). Effect 2020 on the occupational accident rate in the Republic of Ecuador: An atypical year for COVID-19. Revista Colombiana de Salud Ocupacional, 11(1), Article 1. https://doi.org/10.18041/2322-634X/rcso.1.2021.7381. https://doi.org/10.18041/2322-634X/rcso.1.2021.7381

Jilcha, K., & Kitaw, D. (2017). Industrial occupational safety and health innovation for sustainable development. Engineering Science and Technology, an International Journal, 20(1), 372-380. https://doi.org/10.1016/j.jestch.2016.10.011

Kim, N. K., Rahim, N. F. A., Iranmanesh, M., & Foroughi, B. (2019). The role of the safety climate in the successful implementation of safety management systems. Safety Science, 118, 48-56. https://doi.org/10.1016/j.ssci.2019.05.008.

Knapp, G. (2018). Mountain Agriculture for Global Markets: The Case of Greenhouse Floriculture in Ecuador. In Mountains: Physical, Human-Environmental, and Sociocultural Dynamics (1st ed.). Routledge.

Lette, A., Ambelu, A., Getahun, T., & Mekonen, S. (2018). A survey of work-related injuries among building construction workers in southwestern Ethiopia. International Journal of Industrial Ergonomics, 68, 57-64. https://doi.org/10.1016/j.ergon.2018.06.010.

Martínez Valle, L. (2017). Agribusiness, Peasant Agriculture and Labour Markets: Ecuador in Comparative Perspective. Journal of

Received July 11, 2022 / Approved October 30, 2021 Pages: 114-130
eISSN: 2600-5743

Agrarian Change, 17(4), 680-693. https://doi.org/10.1111/joac.12188

Mohammadfam, I., Kamalinia, M., Momeni, M., Golmohammadi, R., Hamidi, Y., & Soltanian, A. (2017). Evaluation of the Quality of Occupational Health and Safety Management Systems Based on Key Performance Indicators.

in Certified Organizations. Safety and Health at Work, 8(2), 156-161. https://doi.org/10.1016/j.shaw.2016.09.001. https://doi.org/10.1016/j.shaw.2016.09.001

Payá Castiblanque, R., & Beneyto Calatayud, P. J. (2018). Union participation and occupational health: A positive relationship. Barataria: Castilian-La Mancha journal of social sciences, 24, 61-81.

Petitta, L., Probst, T. M., & Barbaranelli, C. (2017). Safety Culture, Moral Disengagement, and Accident Underreporting. Journal of Business Ethics, 141(3), 489-504. https://doi.org/10.1007/s10551-015-2694-1

Quintero Becerra, N. E. (2022). Statistics, preventive and corrective measures and trends by accident rate and occupational morbidity of manufacturing industries of the productive subsector of food product processing according to the International Standard Industrial Classification Code C.I.I.U. C10. [Thesis, University of Guayaquil. Faculty of Industrial Engineering. Career of Industrial Engineering]. http://repositorio.ug.edu.ec/handle/redug/60818

Rodas, L., & Sanchez, R. (2019). Design of indicators to measure occupational accidents: The Spanish case. Revista ESPACIOS, 40(32). https://www.revistaespacios.com/a19v40n32/19403208.html. https://www.revistaespacios.com/a19v40n32/19403208.html

Valverde Lucio, A., Gonzalez-Martínez, A., Alcívar Cobeña, J. L., & Rodero Serrano, E. (2021). Characterization and Typology of Backyard Small Pig Farms in Jipijapa, Ecuador. Animals, 11(6), Article 6. https://doi.org/10.3390/ani11061728

Vega Suárez, R. (2022). Boletín Estadistico, IESS (N.º 26; p. 136). IESS, Dirección Actuarial, de Investigación y Estadística.

Received July 11, 2022 / Approved October 30, 2021 Pages: 114-130
eISSN: 2600-5743

https://www.iess.gob.ec/documents/10162/8421754/09_BOLETIN_ESTADISTICO_26_2021

Veintimilla Franco, V. S. (2022). Statistics, preventive and corrective measures and trends for occupational accidents and morbidity in the productive subsector of textile product manufacturing according to C.I.I.U. code C-13. [Thesis, University of Guayaquil. Faculty of Industrial Engineering. Career of Industrial Engineering]. http://repositorio.ug.edu.ec/handle/redug/64520

Vela-Almeida, D., Kolinjivadi, V., & Kosoy, N. (2018). The building of mining discourses and the politics of scale in Ecuador. World Development, 103, 188-198. https://doi.org/10.1016/j.worlddev.2017.10.025.

Received July 11, 2022 / Approved October 30, 2021 Pages: 114-130
eISSN: 2600-5743