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Comparative Analysis of Methodologies for Occupational Safety Risk Assessment in an Artisanal Woodworking Industry

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ABSTRACT

The World Health Organisation (WHO) and the International Labour Organisation (ILO) estimate that 81% of deaths are related to occupational accidents. The management of occupational safety risks is substantial in companies, allowing the identification and evaluation of accidents caused by the lack of compliance with protocols and regulations in work activities. The objective of this study is to evaluate occupational safety risks in a woodworking store in the parish of Atahualpa-Ecuador, by comparing three methodologies (William T. Fine, Colombian Technical Guide (GTC-45, an acronym in Spanish) and Hazard Identification, Risk Assessment and Control Measures (IPERC, an acronym in Spanish) for the proposal of guidelines for the prevention of occupational risks. The methodology focuses on three phases: (i) selection and description of the case study, (ii) comparative analysis of occupational risk assessment methodologies, and (iii) proposal of strategic guidelines using Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis. The occupational risk assessment shows that the William T. Fine methodology was 75% effective due to its adaptability to other industries and contribution to a safer working environment. GTC-45 followed this with 65% effectiveness and IPERC with 50%. Finally, this assessment ensures operational stability to minimize occupational risks in the short term.

1. INTRODUCTION

Occupational hazards occur in the work environment on a large scale and are related to the worker's labour [1, 2]. Companies are obliged to manage occupational hazards to reduce occupational accidents and provide optimal working conditions [3].

Globally, manufacturing companies are constantly challenged by occupational hazards or unforeseen actions in the workplace [4]. Preventive measures are essential in occupational health and safety as they allow for controlling potential risk factors at work [5].

In the last 30 years, accidents have occurred frequently in various industries [6]. Globally, the World Health Organisation (WHO) and the International Labour Organization (ILO) report that approximately 2 million people die, and 395 million are victims of occupational accidents each year, generating economic losses in companies and households. However, 361 billion dollars could be saved by applying preventive measures [7, 8]. On the other hand, del Pilar Callizo [9] highlights the document management in the international field concerning occupational risk prevention and control mechanisms such as ILO Convention 187 and the most significant documents about risk prevention, Convention No. 155 on workers' safety and health; Convention No. 187 on the professional framework for safety and health at work.

According to the Andean Community (CAN, an acronym in Spanish) [10]. the current regulatory framework for occupational risk management in Ecuador includes the Andean Instrument for Occupational Safety and Health, CAN Resolution 584.

According to Bejinariu et al. [11], the ISO 45001 standard presents a preventive approach to organizations, which allows them to identify risks in advance and avoid accidents or illnesses. In addition, this international standard is aligned with the Sustainable Development Goals (SDGs) [12], contributing to the Occupational Health and Safety Management System (OHSMS) [13].

In Ecuador, the workers' lives, welfare, and safety are among the company's principles. This action is evidenced in the Constitution of the Republic (2008) with Article 326 [14]. The Ministry of Labour (MT, an acronym in Spanish) and the Ecuadorian Institute of Social (IESS, an acronym in Spanish) are in charge of verifying the correct functioning and compliance of measures, ordinances, and regulations for the benefit of workers [15].

Artisanal or traditional production is related to small and medium-sized enterprises (SMEs). For some, this is an appropriate type of productive unit in modestly developed countries, which generate employment quickly [16]. Since

2022, security has been considered an important right enacted in Micro, Small, and Medium Enterprises (MSMEs. which account for more than 80% of employment in the Andean countries, according to the ILO [17].

In the European Union, 67% of workers are employed by SMEs [18]. However, there is evidence of a higher accident rate for large companies, making it a priority to assess and reduce occupational risks and restore sustainability.

This case study analyses occupational safety risks in the woodworking industry in Atahualpa parish, in Santa Elena province of Ecuador. Woodworking manufacturing is set within a broad segment of primary and secondary industries [19]. Raw material procurement, cutting, design, and assembly generate occupational risks. Therefore, an assessment of the risk factors is urgently needed to take corrective measures to reduce the effect of occupational hazards in the activities carried out in the companies [20].

Among the most commonly used techniques for occupational risk assessment in the woodworking industry are the William T. Fine method, the Colombian Technical Guide (GTC-45, an acronym in Spanish), and the Hazard Identification, Risk Assessment and Control Measures (IPERC, acronym in Spanish). The William T. Fine method assesses risks by linking likelihood, exposure, and consequences to implement control actions effectively [21]. On the other hand, the GTC-45 method determines the deficit according to the probability and consequence of risks to the safety and health of workers [22]. Finally, the IPERC method assesses the likelihood and risk severity [23].

The case study focuses on the need for occupational risk analysis in the woodworking industry to ensure better occupational health of workers. It is verified by the statistics of artisans qualified by the Ecuadorian Professional Training Service (SECAP, an acronym in Spanish, which indicates that only 30 of the 300 artisans in the Parroquia Atahualpa are qualified by SECAP [24]. Additionally, this study will provide strategic guidelines for woodworking industries adapted to their realities by considering artisans' experiences through interviews. In this context, the following research question is established: Does the comparative analysis of methodologies affect the assessment of safety risks in occupational accidents in the furniture industry?

The objective of this research is to evaluate occupational risks in the furniture industry located in a coastal province of Ecuador through the comparative analysis of three methodologies (William T. Fine, GTC-45, and IPERC) and the Strengths, Weaknesses, Opportunities, Threats (SWOT) matrix for the proposal of strategic guidelines for occupational safety-oriented to the training of artisans and process optimization in the sector under study. The SWOT analysis considers the results of personalized interviews with the artisans of the wood industry in the case study.

2. MATERIALS AND METHODS

The method used for this study was a quantitative approach in the non-experimental category with a descriptive research framework [25]. For that reason, this study focuses on finding methodologies that minimize the safety risks of the local woodworking industry. In addition, the research used a non-participant direct observation technique for data collection, as it is a small woodworking industry, and thus, information was obtained from the source. Figure 1 complements the methodology used in this study, detailing the phases and tools specifying each process.

Phase (I): Identifying and describing the case study.

Phase (II): Matrix and comparative analysis of the methodologies for the occupational security risk using the methods William T. Fine, GTC-45, and IPERC.

Phase (III): Proposal of guidelines for the artisanal industry of the case study using the Strengths, Weaknesses, Opportunities, Weaknesses, and Threats (SWOT) analysis to proceed to the strategies proposal.

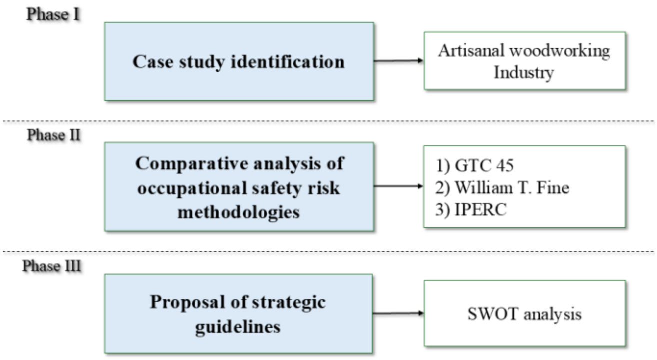

Figure 1. Methodological approach

2.1 Case study

In this phase, we described the woodworking industry of the case study, located in Atahualpa parish, Santa Elena province-Ecuador (see Figure 2). The Atahualpa parish is well-known as the capital of woodworking as it is an emblematic reference point for artisanal activity [26]. We considered four criteria for the selection of the woodworking industry as other studies [27].

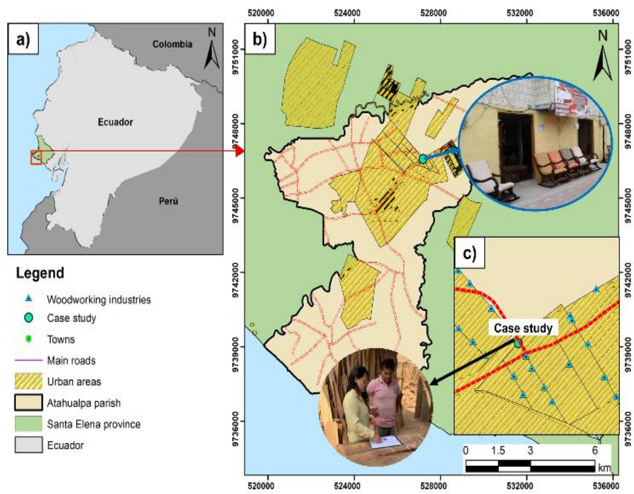

Figure 2. Location of the woodworking industry in the case study

-Representativeness: An estimated 120 operators are distributed in 30 workshops (see Figure 2).

-Type of industry: Woodworking manufacturing workshops are considered cottage industries in the study area.

-Number of workers: An average of six artisans works in each woodworking industry in Atahualpa parish.

-Accessibility: The industry is located in the urban center of the parish.

The target population (N) represents the 30 operators in the wood craft industry organized in the so-called Interprofessional Association of Artisans of Atahualpa. Subsequently, the representative sample (n) was calculated with the finite population sampling equation (Eq. (1)) [28]:

$$n = (z^2 \times p \times q \times N)/[\varepsilon^2(N-1) + z^2 \times p \times q] \quad (1)$$

where,
p: probability of success
q: probability of failure
z: confidence level
ε: sampling error

The representative sample considered the following statistical parameters: p=0.5, q=0.5, and a confidence level of 80% (z = 1.28. and a ε=0.0691. The resulting representative sample (n) is 6, representing the number of artisans working in the selected woodworking industry.

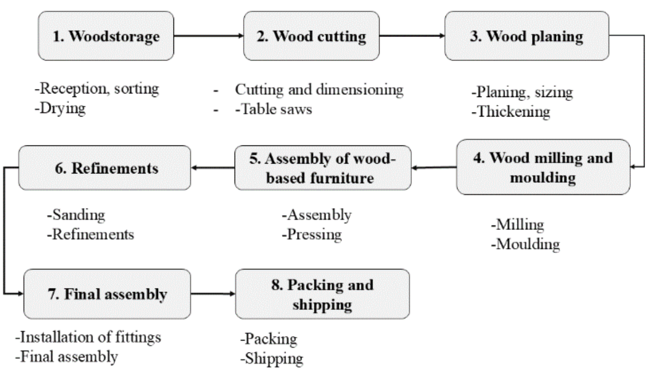

Figure 3. Work areas and processes of the case study industry

The literature review was also conducted on occupational safety in the woodworking industry. It is important to consider preventive factors to achieve healthy areas and workers [29, 30]. Therefore, the work areas of the case study industry were identified with the associated activities for their respective process as shown in Figure 3.

2.2 Methodologies for the occupational risk assessment

The assessment of occupational risks in woodworking industries is essential to ensure an efficient environment and the occupational safety of workers [31]. This practice allows for identifying and adopting best practices by analyzing occupational risk methodologies to establish management strategies [32]. Occupational risk management aims to protect workers and minimize the incidence of accidents [33]. In this phase, we applied three methodologies: William T. Fine, GTC-45, and the IPERC.

The William T. Fine method was created in 1971, which assesses the degree of hazard by considering criteria such as consequence, exposure, and probability, considering three objective evaluation parameters that guarantee quality services. This technique differs from the GTC-45 and IPERC methodologies, focusing on quality and production processes [34]. This method focuses on safety, ergonomics, physical risks, and being flexible and efficient in industries. For example, in the metal-mechanic sector of the coastal region, risks in the turning and milling area are assessed, and preventive actions such as personal protective equipment (PPE. safety controls and improvements in procedures are prioritized [35].

Eq. (2) relates the control factors and assesses the risk by assigning a numerical value indicating the importance of the corrective measure to prevent the hazard.

$$DD = C \times E \times P \quad (2)$$

where,
C = Consequence
P = Probability
E = Exposition
DD = Degree of Danger

Table 1. Parameters for calculating risk using the William T. Fine method

Consequence (C)		Exposure (E)		Probability (P)	
Value	**Definition**	**Value**	**Definition**	**Value**	**Definition**
100	Catastrophe	10	Continuously	10	Highly likely
50	Multiple deaths	6	Frequently	6	Very likely
25	Fatality	3	Occasionally	3	Unusual
15	Extremely serious injury	2	Extraordinarily	1	Remotely possible
5	Disabling injuries	1	Almost never	0.5	Extremely emotional
1	Small cuts	0.5	Very rarely	0.1	Practically impossible

Source: Adapted from: [21].

Table 2. Action about the degree of danger

Magnitude of Risk	Degree of Danger	Action Against Risk
More than 400	Very high risk	Immediate cessation of the hazardous activity
200 to 400	High risk	Immediate correction
70 to 200	Significant risk	Urgent correction need
20 to 70	Possible risk	It is not an emergency, but the risk must be corrected
Less than 20	Acceptable risk	No correction required

Source: Adapted from [36].

C is the damage considered due to the risk of an expected injury. Variable E measures the time an operator needs to execute a task, which implies risk exposure. Finally, the parameter P estimates the probability that an injury may occur and be considered acceptable before the risk becomes intolerable [21]. Table 1 quantifies the C, E, and P parameters for assessing occupational safety risks using the William T. Fine matrix. Table 2 shows the classification of risks according to their magnitude with a range of values to determine the hazard level of the risk [36].

The GTC-45 method establishes guidelines and assesses occupational risks, focusing on workplace occupational health and safety management [37]. This method analyses risks in sectors such as construction and manufacturing, improving organizational quality [38].

For example, in the manufacturing sector in Pasto Colombia, the risk from ultraviolet solar radiation of the UVA and UVB type was analyzed, where 31% of the offices analyzed are at risk in critical unacceptable conditions exposed to the sun [39].

To assess the Risk Level (RL. the process-oriented parameters and formulas of Eq. (3) are used.

$$RL = PL \times CL \tag{3}$$

where,

PL = Probability Level

CL = Consequence Level

Consequence Level (CL) assesses the seriousness of the results [40]. To determine the Probability Level (PL. Eq. (4) is used as follows:

$$PL = DL \times EL \tag{4}$$

where,

DL = Deficiency Level

EL = Exposure Level

Table 3. Assessed occupational hazards

Deficiency Level	Value	Exposure Level	V	Consequence Level	Value	Consequence Level	Value
Very High (VH)	10	Continue (EC)	4	Very High (VH)	24-40	Mortal (M)	100
High (H)	6	Frequent (EF)	3	High (H)	10-20	Very Serious (VS)	60
Medium (M)	2	Occasional (EO)	2	Medium (M)	8-10	Serious (G)	25
Low (L)	0	Sporadic (EE)	1	Bajo (L)	2-4	Minor (M)	10

Source: Adapted from [22].

Eq. (4) considers three variables. Firstly, the Deficiency Level (DL) refers to the relationship between the identified hazards and the likelihood of the events. Secondly, the Exposure Level (EL) is when the worker is exposed to a risk during the working day. Thirdly, the Probability Level (PL) results from the multiplication between the DL and EL, helping to prioritize the risks. Table 3 evaluates the level of preventive measures of the DL. A very high level of the DL is assigned when the detected hazards cause accidents. The EL to the hazard is classified according to their frequency from continuous, frequent, occasional, and sporadic, with a scale of 4 to 1. The PL is classified from low risk to maximum risk, which helps to prioritize actions. Finally, the four-level risk classification determines that if the CL decreases, so does the severity of the damage.

Table 4 determines the level of risk for considering preventive measures. The more likely the event is to occur, the stronger the consequences.

Table 4. Determination of the risk level

Probability Level Consequence Level	40-24	20-10	8-6	4-2
100	4000-2400	2000-1000	800-600	400-200
60	2400-1440	1200-600	480-360	240-120
25	1000-600	500-250	200-150	100-50
10	400-240	200-100	200-150	100-50

Source: Adapted from [22].

Table 5 includes the Risk Level (RL) from acceptable to the lowest, specifying the possibility of improvement and evidence of the risk's acceptability according to the level shown in Levels I and II as not acceptable and Levels III and IV as acceptable.

The IPERC method focuses on identifying accidents early and preventing occupational diseases [41]. This technique is widely used in occupational safety. For example, there are physical hazards in the public cleaning services sector (e.g., handling sharp objects and static electricity) [42]. Table 6 shows the relationship between the probability of the occurrence of the risks and the severity of the damage they cause, expressing the classification of probability between low, medium, and high with a rating of 3, 5, and 9, respectively. The severity varies from slightly harmful, harmful, and highly harmful, ranging from 4 to 8.

Table 5. Meaning of risk level according to GTC-45

Risk Level	Value of Risk Level	Significance
I	4000-600	Not Acceptable
II	500-150	Not Acceptable
III	120-40	Acceptable
IV	20	Acceptable

Source: Adapted from [23].

Table 6. Scoring and ranking of the probability and severity of occupational hazards

Probability		Severity	
Ranking	**Score**	**Ranking**	**Score**
Low	3	Slightly harmful	4
Medium	5	Harmful	6
High	9	Extremely harmful	8

Source: Adapted from [23].

Table 7. Classification of risk levels

Severity Probability	Slightly Harmful (4)	Harmful (6)	Extremely Harmful (8)
Low (3)	12-20 Low Risk	12-20 Low Risk	24-36 Moderate Risk
Medium (5)	12-20 Low Risk	24-36 Moderate Risk	40-54 Significant Risk
High (9)	24-36 Moderate Risk	40-54 Significant Risk	60-72 Critical Risk

Source: Adapted from [23].

Table 7 sets out the combination of probability (P) and severity (S), specifying each at three levels to enable a risk assessment. This indicates which situation merits immediate attention or control to reduce work-related incidents.

Table 8 includes the Saaty scale [43], which assessed the importance levels of the occupational hazards identified in the case study woodworking store.

Table 8. Saaty scale

Meaning	Saaty Scale
Equal importance	1
Weak or slight	2
Moderate importance	3
Moderate plus	4
Strong importance	5
Strong plus	6
Very strong	7
Very, very strong	8
Extremely strong	9

Source: Adapted from [43].

2.3 Proposed guidelines

One-to-one interviews were conducted with the six operators in the case study industry representing the representative sample calculated in Section 2.1. It allowed information to be gathered from the artisan's experience of needs and challenges. The interview included 14 semi-open-ended multiple-choice questions. Then, the SWOT analysis was conducted, considering the results of the artisans' experiences. This approach includes two external factors (opportunities and threats) and two internal factors (strengths and weaknesses) [44, 45]. According to Serrano & Salvador [46]. SWOT analysis makes it possible to generate strategies that contribute to decision-making [47], benefiting companies. Finally, strategic guidelines are established in the artisanal woodworking industry for improvement in the framework of occupational safety.

3. RESULTS

3.1 Analysis of the case study

In the woodworking industry analyzed in this study, artisans are exposed to physical, chemical, and ergonomic safety risks. For example, chemical risk arises when using varnishes and paints or when handling wood waste when sanding without eye protection. On the other hand, ergonomic risk occurs because operators are confronted with awkward postures when loading raw materials or sanding them. These activities can be repetitive or prolonged in the work environment, causing damage to the back, spine, or joints. This is consistent with research in Indonesia on upper limb function, physical activity, and neck pain in woodcarvers [48].

This section identified work areas prone to occupational hazards in the woodworking industry (see Figure 4). The William T Fine, GTC-45, and IPERC methodologies were applied. In the storage area, the risks are related to blows, impacts, injuries, and crushing that can occur when handling raw materials. There are risks in the cutting and milling areas when obtaining the dimensions of the wood and handling machinery. The inadequate use of tools can cause cuts or amputations, as the proper processes are not followed when carrying out their activities. On the other hand, in the finishing and final assembly area, the risks are caused by handling the final product. The hazards identified with the three methodologies occur monthly, mainly in the cutting and milling areas.

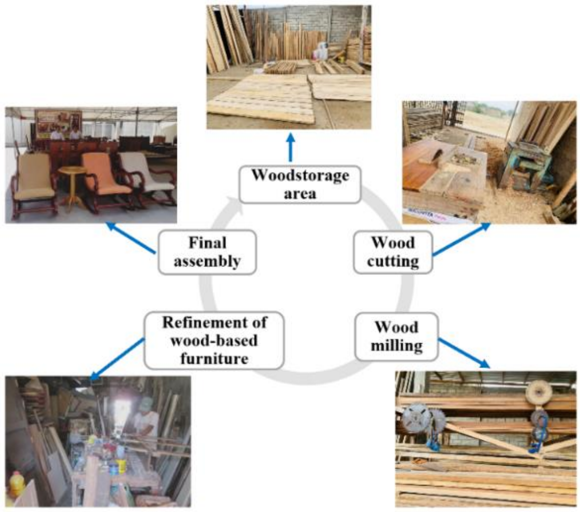

Figure 4. Work areas in the artisanal woodworking industry with an incidence of occupational risks

3.2 Comparative analysis of occupational safety risk methodologies

Table 9 includes the Williams T. Fine methodology criteria, showing a very high Grade of Danger (GD) in the cutting and finishing area. This is due to handling sharp tools and heavy loads, which could cause serious accidents. According to Salguero and Padilla [19]. the analysis of risk factors influences decision-making, preventing occupational accidents and safeguarding the operators' integrity.

Table 10 includes the evaluation of occupational risks applying the GTC-45 matrix. A very high level of risk probability was identified in the drying area, showing that there is no efficient knowledge of handling raw materials. Also, there is no proper classification for the execution of the processes. Additionally, this analysis shows a very high probability and impact on the thickness and finishing area application. In contrast, the other processes are set as tolerable as they are not exposed to cutting or cumbersome tools.

Table 11 represents the activities that persist in assessing the IPERC methodology, specifying finishing as a critical risk level and sanding as a low risk. Unlike the other areas, no urgent measures are being taken. However, essential risks are specified.

Table 12 shows the comparative matrix between the William T. Fine, GTC-45, and IPERC methodologies, considering eight criteria: the purpose of the method, evaluation formulas, components, rating scale, simplicity and ease, associated standards or guidelines, assessment, and reliability. Subsequently, the Saaty scale [49] was used to assess the methodologies. It is indicated that the William T. Fine methodology has a rating of 54 on some criteria, followed by GTC-45 with 47 and IPERC with a value of 36. This shows that the William T. Fine methodology is more adaptable and flexible in the woodworking industry.

Table 9. Risk assessment with the William T. Fine criterion in the woodworking industry

Danger Action	Consequence	Exposure	Danger	Grade of Danger	Grade of Danger Level
Crushing due to poor wood storage management	5	6	6	180	Remarkable
Entrapment due to mishandling of raw material	15	3	6	270	High
Severe amputation due to machine mishandling	25	3	6	450	Very high
Severe cutting injuries from mower mishandling	5	6	6	180	Notable
Hand entrapment in machinery	15	3	6	270	High
Hand cutting injury	15	3	6	270	High
Injury due to incorrect handling of the polishing machine	5	2	6	60	Possible
Cutting injury by the sawing tool	5	6	10	300	High
Penetrating injury due to mishandling of sharp tool	1	6	10	60	Possible
Fracture due to mishandling of heavy tool	5	3	6	90	Remarkable
Particle projection injuries to hands	1	3	6	18	Acceptable
Impact by contact with the paint and varnish product	25	6	10	1500	Very high
Shocks from hand tools	1	6	10	60	Possible
Bruising and laceration of the hands	5	3	6	90	Remarkable
Impact of improper handling of tools	1	3	6	18	Acceptable
Collision due to poor shipment preparation	15	3	6	270	High

Table 10. Risk assessment with the GTC-45 methodology in the woodworking industry

Hazard	Risk Assessment						
Action Description	Level of Deficiency	Exposure Level	Probability Level	Probability Level	Consequence Level	Risk Level	Value
Crushing due to poor wood storage management	6	3	18	Very High	60	1080	Not Acceptable
Entrapment due to mishandling of raw material	10	4	40	Very High	60	2400	Not Acceptable
Severe amputation due to machine mishandling	6	4	24	Very High	60	1440	Not Acceptable
Severe cutting injuries from mower mishandling	6	4	24	Very High	60	1440	Not Acceptable
Hand entrapment in machinery	6	3	18	Very High	25	450	Not Acceptable
Hand cutting injury	10	3	30	Very High	60	1800	Not Acceptable
Injury due to incorrect handling of the polishing machine	6	3	18	Very High	25	450	Not Acceptable
Cutting injury by the sawing tool	6	4	24	Very High	60	1440	Not Acceptable
Penetrating injury due to mishandling of sharp tool	2	4	8	Medium	25	200	Not Acceptable
Fracture due to mishandling of heavy tool	6	3	18	Very High	60	1080	Not Acceptable
Particle projection injuries to hands	2	4	8	Medium	10	80	Acceptable
Impact by contact with the paint and varnish product	10	3	30	Very High	25	750	Not Acceptable
Shocks from hand tools	6	3	18	Very High	25	450	Not Acceptable
Bruising and laceration of the hands	6	4	24	Very High	60	1440	Not Acceptable
Impact of improper handling of tools	2	3	6	Medium	10	60	Acceptable
Collision due to poor shipment preparation	6	4	24	Medium	25	600	Not Acceptable

Table 11. Risk assessment with the IPERC method in the woodworking industry

Hazard	Risk	Assessment Probability			
		Probability	Severity	Risk Level	Importance
Crushing due to poor wood storage management	Severe injury	5	6	30	Moderate
Entrapment due to mishandling of raw material	Loading of heavy material	5	6	30	Moderate
Severe amputation due to machine mishandling	Limb entrapment	5	8	40	Importance
Severe cutting injuries from mower mishandling	Deep cutting	5	8	40	Importance

Hand entrapment in machinery	Retention of hands or fingers	5	6	30	Moderate
Hand cutting injury	Severe cuts	5	6	30	Moderate
Injury due to incorrect handling of the polishing machine	Severe cuts	9	6	54	Importance
Cutting injury by the sawing tool	Accidental contact incision	9	6	54	Importance
Penetrating injury due to mishandling of sharp tool	Cisura punctures	9	6	54	Importance
Fracture due to mishandling of heavy tool	Impact by tools	5	6	30	Moderate
Particle projection injuries to hands	Severe cuts	5	4	20	Low
Impact by contact with the paint and varnish product	Impact of the product	9	8	72	Critical
Shocks from hand tools	Severe shock	5	6	30	Moderate
Bruising and laceration of the hands	Accidental blows	5	6	30	Moderate
Impact of improper handling of tools	Impact of mishandling	9	6	54	Importance
Collision due to poor shipment preparation	Impact of the product	5	6	30	Moderate

Table 12. Comparative matrix of occupational safety risk methodologies

Criteria	Methodologies					
	William T. Fine	**Precent**	**GTC-45**	**Percent**	**IPERC**	**Percent**
Purpose of the method	6	11	5	11	4	11
Evaluation formulas	7	13	6	13	3	8
Components	7	13	5	11	4	11
Rating scales	7	13	5	11	3	8
Simplicity and ease	8	15	6	13	5	14
Associated standards or guidelines	6	11	8	17	7	19
Validation	6	11	6	13	5	14
Reliability	7	13	6	13	5	14
Total	54	100	47	100	36	100
Effectiveness (100%=75)	**75**		**65**		**50**	

3.3 Strategic guidelines in the artisanal woodworking industry

The interviews with the artisans identified that the working conditions are unreliable, training in occupational hazards, and the application of safety protocols are required. A SWOT analysis was carried out with these results and the analysis of the problems (see Table 13). Strengths and weaknesses were identified based on the experiences and opinions of the operators, while opportunities and threats were analyzed based on the competitive context and national standards [50].

The combination of these variables—strengths, opportunities, weaknesses, and threats—establishes strategies [51], which are adapted to the needs of the case study.

Encourage the identification and implementation of safety management protocols for staff improvement.

Staff training campaigns in technologies and software (e.g. 3D furniture design and modeling (AutoCAD digital marketing).

Promote strategic alliances for market expansion of a woodworking manufacturing company.

Evaluation of performance and compliance with international standards for productivity and effectiveness of quality management in the company.

Table 13. SWOT matrix in the artisanal woodworking industry

Internal Factors (IF)	
Strengths (S)	**Weaknesses (W)**
S1 Established woodworking quality S2 Qualified operators S3 Links with suppliers	W1 Lack of safety protocols W2 Evidence of contaminants W3 High physical load
External Factors (EF)	
Opportunities (O)	**Threats (T)**
O1 Knowledge acquired in tools O2 Sustainable products O3 Leverage technology to simulate risks	T1 Competition from large workshops with innovation T2 Increasing raw material costs T3 Strict occupational safety regulations
IF + EF	
S + O	**W + O**
(S2 + O3) Implement simulation training to reduce accidents at work (S1 + O2) Use qualified materials with environmentally friendly design (S3 + O1) Leverage suppliers to incorporate safety technologies	(W1 + O3) Integrate body movement sensors to mitigate risk control (W3 + O1) Apply ergonomic standards in processes using efficient tools (W2 + O2) Optimization of cutting design with software to reduce wood dust contamination
S + T	**W + T**
(S2 + T3) Compliance with safety standards through operator training (S3 + T2) Strengthen alliances with suppliers for cost stability with competitive raw material prices	(W1 + T3) Establish a safety management system that complies with current statutes for operators and processes (W2 + T2) Decrease the use of materials and reduce pollutants present with resource planning

4. DISCUSSION

Applying the results matrix covers essential issues for perception so that the William T. Fine methodology takes a more comprehensive view towards correcting risks by prioritizing the most feasible risks. The application, which focuses more on assessing occupational safety and health, is centered on GTC-45, whereby IPERC is oriented towards active prevention by identifying, evaluating, and controlling occupational risks.

Applying new methodologies to assess risks and deterioration is considered efficient for wood structures [52]. They impact the performance and productivity of industries [53]. The identification and assessment of occupational safety risks ensure a more efficient environment. This study demonstrates that risk assessment helps to prevent occupational incidents and ensure efficient control of risk actions in the woodworking company in the case study. The critical aspect of this study is the importance of safety and health in workers in the handicraft woodworking industry and the need to strengthen knowledge by integrating preventive measures. It is associated with a study that indicates the integrity of implementing safety and health at work to address these gaps, seeking efficiency [54].

This study conducted a comparative analysis of occupational risk assessment methodologies (William T. Fine, GTC-45, and IPERC), showing an association between the criteria assessed and improving the working environment by reducing risks. This is consistent with Cappelletti et al. [20], who analyzed risk minimization through improvement strategies in the woodworking industry.

With the William T Fine methodology, the relationship between occupational hazards and workers' daily exposure was defined, leading to consequences for their health. In the analysis by Carpio et al. [21]. parameters were determined in a construction site environment in Spain, proposed preventive actions, and exhaustive controls in work environments were performed. The GTC-45 methodology establishes the risks immersed in the processes for assessing the work situation. According to Bucheli et al. [22]. with the application of this methodology, a deficit was found in some establishments of the repaving project of General Rumiñahui Avenue in Quito, Ecuador. This leads to the proposal of corrective measures regarding occupational accidents. It was determined that the IPERC methodology has a flexible and adaptable scope of application to other industries. This influences decision-making. Likewise, Acevedo et al. [55] analyzed the IPERC matrix in industrial companies, highlighting that risk assessment contributes significantly to the work environment.

The identified limitations of the occupational risk assessment methods include the fact that the William T. Fine method uses a subjective assessment and does not consider all of the psychosocial risks involved [21]. The GTC-45 method is complex to adapt to organizations with rigid structures [56]. La metodología IPERC carece de precisión cuantitativa, y no considera todos los riesgos psicosociales asociados [55].

This study recognized the following topics for future studies: continuous personnel training in new protocols and technologies, the establishment of public policies for woodworking industries, and the use of plastic wood from recycled Polyethylene Terephthalate (PET) to replace wood in the artisanal woodworking industry or the manufacture of enclosures or other products. It will contribute to reducing the use of natural resources and mitigate occupational risks by avoiding handling chemical products or materials prone to deterioration, thus promoting safer working conditions.

5. CONCLUSIONS

This study assessed occupational safety risks in an artisanal woodworking industry in the coastal sector of Ecuador. Three methodologies were compared (Williams T. Fine, GTC-45, IPERC, which allowed the establishment of management strategies for thorough and efficient control in the established areas, contributing to the worker's safety.

The diagnosis of the case study provides a clear perspective on the occupational risks in the woodworking factory work area in the province of Santa Elena, analyzing methodologies that contribute to decision-making. For example, innovative technologies could be used to improve processes continuously. This, in turn, represents strategies to mitigate occupational accidents related to exposed workers.

In the comparative analysis, the evaluation criteria of the three methodologies were determined to contribute to decision-making and minimize occupational safety risks for operators in the artisanal woodworking industry. William T. Fine's methodology proved to be more adaptable and flexible for assessing safety risks in the case study. This result generates an efficient estimation of hazard actions with reliable results. Of the criteria justifying the selection of this methodology, simplicity and ease accounted for 15%, and evaluation formulas, components, rating scales, and reliability indicated 13%. The purpose of the methodology, associated standards or guidelines, and validation scored 11%.

The combination of the occupational risk assessment results and the SWOT analysis was considered to understand the situation of the woodworking industry in the case study. The SWOT analysis established strategic guidelines to ensure that occupational risk management practices are more effective. This includes regular inspection of risks and planned adaptation to reduce work-related accidents. In this study, the non-existence of an occupational risk action plan for small enterprises with up to 10 workers per the provisions of Ministerial Agreement No. MDT-2017-0135 is recognized as a limitation.

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