

Article

Safety Workplace: The Prevention of Industrial Security Risk Factors

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Abstract: “To earn a living”. The definition of work and our understanding of the workplace have changed in recent years due to the emergence of occupational health and is now a field of study under continuous improvement. Despite the fact that there is a huge amount of information, studies, and guidance about how to improve occupational security, the factors that must be considered in a workplace as real hazards to avoid in order to achieve a truly healthy workplace are always subject to debate. This research contributes to efforts in two important ways. The first goal assesses the information about security risk factors established and mentioned by official international institutions aimed at safety and security science by using the relationship and categorization between the identified risks during work activities performance. The second goal is to establish the necessary requirements to be fulfilled to ensure that a workplace will be considered “healthy and safe”. As a result, it is defined that the lack of ergonomics represents the most critical risk factor in order to reduce the incidence of work-related illness during the design and continuous improvement of a tailored workplace.

Keywords: industrial design; security factors; biomechanics; hazards; health and security hazards; work risk; discomfort occupational safety; insecurities; discomfort



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1. Introduction

“To earn a living” is perhaps a definition of work that emerged with the use of the first official currency during antiquity [1,2]. Since then, and throughout history until today, with globalization as a unique economic trend, the term “work” has been in constant flux [3]. In 1848, attention to industrial hygiene during the industrial revolution made possible the first steps to achieve what is today known as occupational health [4].

‘Working for a suitable life’, was the next step. The understanding that just earning money without any workers’ healthcare can affect not only the workers but the owners of the industries themselves [5] kick-started the meaning of industrial safety. Work evolved from ‘just make money’, to today, where the concept of decent work has been established as a human right [4,6,7].

The challenge of creating a safe work environment is a recurrent study, as indicated by the ILO (International Labor Organization) in its agenda [8]. Analyses and evaluations of security risks have been carried out, but the concept needs to be defined for all work environments. Issues related to security are continuously studied, and more risk factors in workplaces have appeared [9], from those that are clearly visible (physical factors) to those that are blurred but deeply present and even more hazardous (psychological factors) [10,11].

Both physical and psychological risk factors are directly connected with causing work-related illnesses. Therefore, it is related to whether a workplace is safe or not. Factors related to health and security in work can be understood from different angles, but the research question is: what are the most important risk factors in the workplace?

The conceptualization of a safe climate or workplace is characterized by two groups. The first group is composed of analyses at the individual level and refers to the departments

or units within a company. The second is at the group level and makes considerations for safety at the organizational level, which refers to management attitudes and a company's policies [12].

The psychological safety climate is related to the employee's perception of safety in the organizational structure of the company related to specific policies and practices, including worker education in safety and security practices [13–15].

Today, a wide array of tools and techniques exist for risk identification, including documentation reviews, information-gathering techniques, checklist analysis, assumption analysis, cause-and-effect diagrams and other techniques in order to minimize the effect of an unhealthy workplace [16–18]. In this context, the importance of the identification of risk in the workplace is a main issue in industrial settings and this study aims to contribute to this field of research.

Related Works

A number of studies have delved into developing methods to improve workplace conditions and are directly related with identifying and preventing security factors in the workplace. Risk factors of security in the workplace have been studied for years. The amount of information about occupational safety related to security trends and hazards in the workplace has been identified, as it was mentioned in a study about behaviorally oriented occupational safety in 2009 by Michael Christian, Jill Bradley, James Wallace, and Michael Burk [19,20].

The World Health Organization in 2010 established a general framework about what safety in the workplace is, citing common risk factors to avoid accidents in the workplace [21–23].

A generic testing methodology enhancing an established test process to address risks by trying to develop a procedure on how risk-based testing can be introduced in a test process and derive a stage model for its integration was presented by Michael Felderer and Rudolf Ramler in 2014 [24].

Today, research on Industry 4.0 related to key aspects and the presentation of a design framework to implement risk management focuses on risk identification and prevention as presented by Jiri Tupa, Jan Simota and Frantisek Steiner 2017 [25].

The industrial non-routine operation process is the time sequence where the main hazard source could be the risk originating and the main risk identification described by Weijun Li and Qinggui Cao in 2018 [26].

Hazards such as a lack ergonomics have been discovered and mentioned in several studies related to organizational structure in companies or industrial institutions involving technical aspects [23].

Considering the risk issues mentioned in the research above, it is reasonable to conclude that the industrial trend is focused on risk prevention and how possible it is to achieve a healthy workplace. In this context, the majority of previous studies do not provide a method to identify the hierarchy of risks related to the workplace. In order to satisfy the absence of this requirement, a methodical framework for industrial risk identification is recommended.

The rest of the document is structured as follows: Section 2 describes the methods. Section 3 includes the results: MSDs (musculoskeletal diseases) is the risk factor more commonly mentioned. Section 4 comprises the discussion. Finally, Section 5 concludes the paper: a lack of ergonomics is the main security risk factor.

2. Materials and Methods

The methodological development of this research, at the first stage, establishes the following keywords: risk factors, security factors, hazards, health and security hazards, insecurities, and threats in workplace in order to compile data from a general framework of research.

To develop a compilation of data, these research keywords were input to the Google Scholar Search engine and official international organization publications (webpages, books, reports, journals, conferences, etc.). The settings search was established to obtain the data and the most important publications considering the following: (i) timeline: publications from 2000 to July 2022, (ii) must be internationals, (iii) Language: English.

After obtaining the publications related to the input keywords, those not relevant to our eligibility criteria were deleted or omitted: the data selected were relevant to health and security in the workplace. In the final stage, the selected studies were those cited most often in the official international occupational health organizations.

The method covers five stages: (i) Establish keywords. (ii) Compilation data entering the keywords. (iii) Fix the search settings. (iv) Establish eligibility criteria. (v) Delete/Omit papers according to criteria. The method stages are shown in Figure 1.

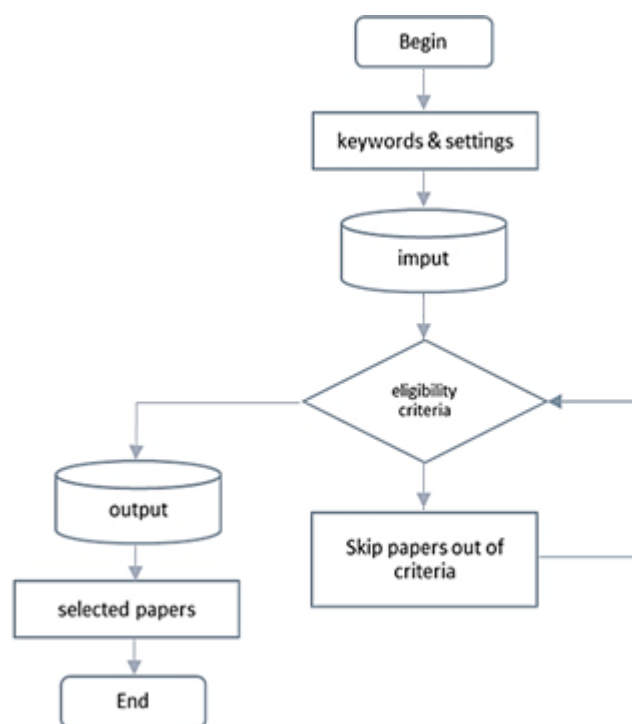


Figure 1. Method stages.

The first step consisted of determining the keywords to identify the studies in this field using the term “safe and healthy workplace”, then more common keywords, identifying “safety risks”, “safety hazards”, “health risks”, “health hazards”, “health issues”, “risk evaluation”, “risk assessment” were collected. In the second step, we evaluated the principal databases for the research papers identified: Web of Science, ScienceDirect, and Scopus, to use the main terms. In the third stage, the data were collected from documents published from 2000 to 2022. In the next filter, the eligibility criteria focused on papers published by official organizations and papers citing official international organizations. Finally, duplicate papers were removed in order to retain focus on the workplace.

Ultimately, the papers most important to consider were papers published by official organizations and papers that cite the official international organizations. Those organizations were chosen according to their member’s number at the time of this research: (i) World Health Organization (WHO), with 197 institutional members. (ii) International Labor Organization (ILO), with 187 institutional member states. (iii) European Agency for Safety and Health at Work (OSHA), with 22 states plans.

In order to obtain a new conceptual model for risk management that can be used in the industry, a thematic analysis was used to overcome the conceptual complications among

the risk identification models and the difficulties at first sight and to simplify the final model. The new conceptual model may be constructed to provide research contributions and help industry practitioners to maintain a “healthy and safe” workplace [27].

The first step of this study was to collect risk identification models, which are performed by library studies and searching various databases. It is summarized in Table 1 and explains the identification risk method used in each piece of research. These risks are categorized into two main categories: the first one is Cumulative Risk related to the combined threats to worker health due to the environment or multiple agents or stressors, which can result in future illnesses. The next category is Latent Risk, related to the combined threats to worker health due to the environment or multiple agents, which can produce immediate consequences such as accidents, injuries, or illness.

Table 1. Risk Identification research.

Risk Identification	Title	Author	Explanation Method
	“Implications of applying cumulative risk assessment to the workplace” [28].	Mary Fox, Kristen Spicer et al.	Cumulative risk assessment (CRA) applied in phases: (i) Hazard identification. (ii) dose-response assessment (iii) exposure assessment. (iv) risk characterization
	“The Future of Risk Identification in a Rapidly Changing Sociotechnical Work Environment” [29].	Joann Kirby et al.	A risk frame created using a mixed methodology of theoretical knowledge and a survey
	“Workplace interventions for common mental disorders: a systematic meta-review” [30].	Joyce Sadhbh, Modini Matthew, Helen Christensen et al.	Evaluate the workplace interventions that may facilitate the prevention, treatment, or rehabilitation of a worker with a diagnosis of depression or anxiety.
Cumulative risk	“Health problems and psychosocial work environment as predictors of long-term sickness absence in employees who visited the occupational physician and/or general practitioner in relation to work: a prospective study” [31].	Helene Andrea, Anna Beurskens et al.	Determine the relationship between the psychosocial work environment, health problems and incident long-term sickness.
	“A systematic review on workplace interventions to manage chronic musculoskeletal conditions” [32].	Glykeria Skamagki, Andrew King et al.	Determine whether there are effective actions inside the workplace that reduce chronic musculoskeletal disorders.
	“How We Prevent Prevention of Musculoskeletal Disorders in the Workplace” [33].	Kim Tae.	Examine the knowledge about the prevention of work-related musculoskeletal pain and musculoskeletal disorders.
	“Long-Term Sickness Absence Due to Mental Disorders Is Associated with Individual Features and Psychosocial Work Conditions” [34]	João Silvestre da Silva-Junior.	Evaluating workers on sick leave for more than 15 days as a result of disabling psychiatric illnesses.

Table 1. Cont.

Risk Identification	Title	Author	Explanation Method
	“Workplace hazard identification and management: The case of an underground mining operation “ [35].	Susanne Bahn.	Uses the findings from two workshops conducted with 77 employees applying research methodology.
	“Workplace Safety: A Strategy for Enterprise Risk Management” [36].	Janet Jule.	Use leadership to increase accountability and reduce injury risks, planning to improve workplace safety by preventing injuries such as overexertion and contact with objects.
	“A Multidimensional Approach to Modelling for Workplace Risk Assessment” [37].	Antonis Targoutzidis et al.	Use tags for accident, human error and risk perception models.
	“Workplace hazard identification: What do people know and how is it done?” [38].	Maciej Serda et al.	Based on two hazard identification and hazard management training workshops to teach workers
	“A comparative outline for quantifying risk ratings in occupational health and safety risk assessment” [39].	Muhammet Gul.	PFAHP is used in weighting the risk parameters of 5 × 5 matrix method.
	“Determination of the risk at workplace, assessment And its rank calculation, in mining activities” [40].	Zeqiri, KemalKortnik, JozeMijalkovski.	Evaluate the risk in the workplace caused by a particular agent through rank through empirical formulas.
	“Hazard Identification, Risk Assessment, and Control Measures as an Effective Tool of Occupational Health Assessment of Hazardous Process in an Iron Ore Pelletizing Industry” [41].	B. Rout and B. Sikdar.	Identify all the possible hazards in workplaces of an iron ore pelletizing industry to make a health risk assessment.
Latent risk	“Investigating Wearable Technology for Fatigue Identification in the Workplace” [42].	Griffiths, ChristopherBowen, JudyHinze, Annika.	Compilation of psychological data collected from wearable systems to determine how the individual performs tasks in the workplace.
	“The Consequences Of Psychosocial Risks In The Workplace In Legal Context” [43].	Seilerová Monika.	Determine the need for the legal regulation of mental workload and the increasing effects of its shortcomings.
	“Musculoskeletal health in the workplace” [44].	Joanne Crawford.	Determine the changes produced by chronic MSK conditions from 2000 and how we can help people with these conditions to recover after suffering the condition.
	“Need for a new workplace safety and health (WSH) strategy for the fourth Industrial Revolution” [45].	Gabriel Chia et al.	To promote a total Worker Health responsive approach in the face of rapid technological advancements
	“Exposure to Environmental and Occupational Particulate Air Pollution as a Potential Contributor to Neurodegeneration and Diabetes: A Systematic Review of Epidemiological Research” [46].	Eirini Dimakakou et al.	Identify the link and mechanisms associated with particulate exposure and disease pathogenesis.
	“Artificial Intelligence-enabled Wearable Medical Devices, Clinical and Diagnostic Decision Support Systems, and Internet of Things-based Healthcare Applications in COVID-19 Prevention, Screening, and Treatment” [47].	Barnes Robin, Zvarikova, Katarina.	Use machine learning algorithms to optimize diagnostic swiftness and precision to identify the most vulnerable individuals

During the second step, thematic analysis was used for analyzing collected information, offering the most comprehensive map distribution of the main elements of risk identification. This stage is the beginning of typology and model classification. The main risk factors contributing to musculoskeletal disorders are shown in Table 2. It can be classified and set into different types and classified in concordance with the international health and safety organization [48]. Based on related studies where ergonomic risks are considered [28], these groups are classified in: Mechanical risk (RM), Physical risk (RP), Chemical risk (RC), Ergonomic risk (RE), Psychosocial risk (RPY) and ordered according to the position for making a relation to determine the classification.

Table 2. Main factors contributing to musculoskeletal disorders.

LEADING RISK FACTORS RELATED TO MUSCULOSKELETAL DISORDERS			
Classification/Code	Cause	Effect	Example
RP1	Application of big efforts	Critical overloading	Carrying, pushing or pulling, lifting heavy objects
RP2 and RE1	Moving weighty loads during long periods of time.	Degenerative diseases particularly in the lumbar spine	Manual materials manipulation
RM1 and RP3	Repeated movements during handling of objects	Fatigue and Overload in specific muscles	Assembly work, check-out work, a long time typing
RE3	Working in unergonomic posture	Overload of skeletal and muscular system	Working with the trunk, or hands or arms heavily bent or twisted
RE4	Load by static muscular	Long-lasting muscular activity [keeping the static position] and possible overload in specific muscles	Working in a limited space
RE5	Muscular inactivity	Decrease in functional capacity of tendons, muscles and bones	Long-term sitting work with short muscular demands
RM1 RE6	Monotonous repetitive movement	Unspecific complaints in the extremities	Repeated activity the same muscles with pauses without relaxation
RM2	Constant vibration	Dysfunction of nerves, reduced blood flow, degenerative disorders, and psychological disorders caused by stress	Manipulating a machine with annoying vibration or using vibrating hand tools.
RE7	Physical environmental aspects: light, sounds, temperature, etc.	Damage to the sensory organs of the worker, diseases in the sensory nervous system, and psychological disorders caused by stress.	Work with improperly light, noisy environment, uncomfortable temperature, etc.
RCH1	Exposure to chemicals products or factors in the workplace.	Burn, injury or permanent illness.	Direct contact with a specific chemical product can produce injury or illness.
RPS1	Physical and social outcomes such as work-related stress, burnout or depression.	Stress, Depression.	Poor communication between manager and workers

3. Results

There are several risks in the workplace. These risks are defined as chemical hazards, ergonomic hazards, physical hazards, and psychological hazards, to mention a few [49–51]. Carrying out in-depth research into existing documents, including those defined by health and safety organizations presented in the standards, it was found that many published documents point out that musculoskeletal disorders (MSDs) caused by biopsychosocial

and biomechanical influences have a significant impact on the individual. Furthermore, since the beginning of the 18th century, MSDs have been defined as an occupational etiologic hazard [52]. Due to the continuous efforts taken by industrial safety managers to improve the workplace to prevent risks, today, the possible syndromes or diseases are very familiar and recognized by people. For example, diseases related to the hand such as carpal tunnel syndrome or tendonitis, and in another cases, diseases related to the back such as example thoracic outlet syndrome, and tension neck syndrome [53,54]. Table 3 exposes the compendium of time that appears for each risk category obtained from the literature processed in Table 1.

Table 3. Risk identification results.

Identified Risk	Number of Appearances	Cited Research
Mechanical risk	7	[30–32,34,37,39,40]
Physical risk	13	[27,28,31,32,34–36,38,40,41,43,45,46]
Chemical risk	3	[34,38,40]
Ergonomic risk	18	[27–33,35,36,38–46]
Psychosocial risk	3	[30,33,42]

Succeeding in identification and categorization, the next step involved the relationship between risk and the main theme in order to identify the main risk presented during work activities. This result is presented in Figure 2.

On the other hand, in in-depth studies on workplace health, MSDs include some work-related illnesses such as tendon tenderness and associated illnesses such as bursitis, tenosynovitis, or epicondylitis. In addition to disorders producing carpal tunnel syndrome or sciatica, these diseases could include other body affections, for example back pain, and other regional pain syndromes that are not related to any pathology [53,55–57]. Causes were found to be directly related to the uncomfortable layout of the workplace, which results in trauma to the musculoskeletal system; this discomfort is included as the main cause of MSDs. Hence, the evaluation of WMSDs takes into account the possible risks present in the workplace including the requirements for keeping the healthy/safe workplace itself [56,58,59].

In this context, the typology stage in this study is composed of analyzing the risk identification and developing a theoretical structure from Table 3 and its associations shown in Figure 2. By recognizing their different combinations, all the possible types are created and named. Then, the workplace evaluation steps are created in order to reduce the risk and upgrade the work environment. This method is illustrated in Figure 3.

In order to avoid ergonomic hazards, the factor risks analysis in the workplace or workstation shall be classified as more relevant, as shown in Figure 4: (i) Analysis for manual materials handling, (ii) Analysis for seated work, (iii) Analysis for extended arm reach, and (iv) Analysis for avoiding cumulative trauma disorders of the wrist [57,60].

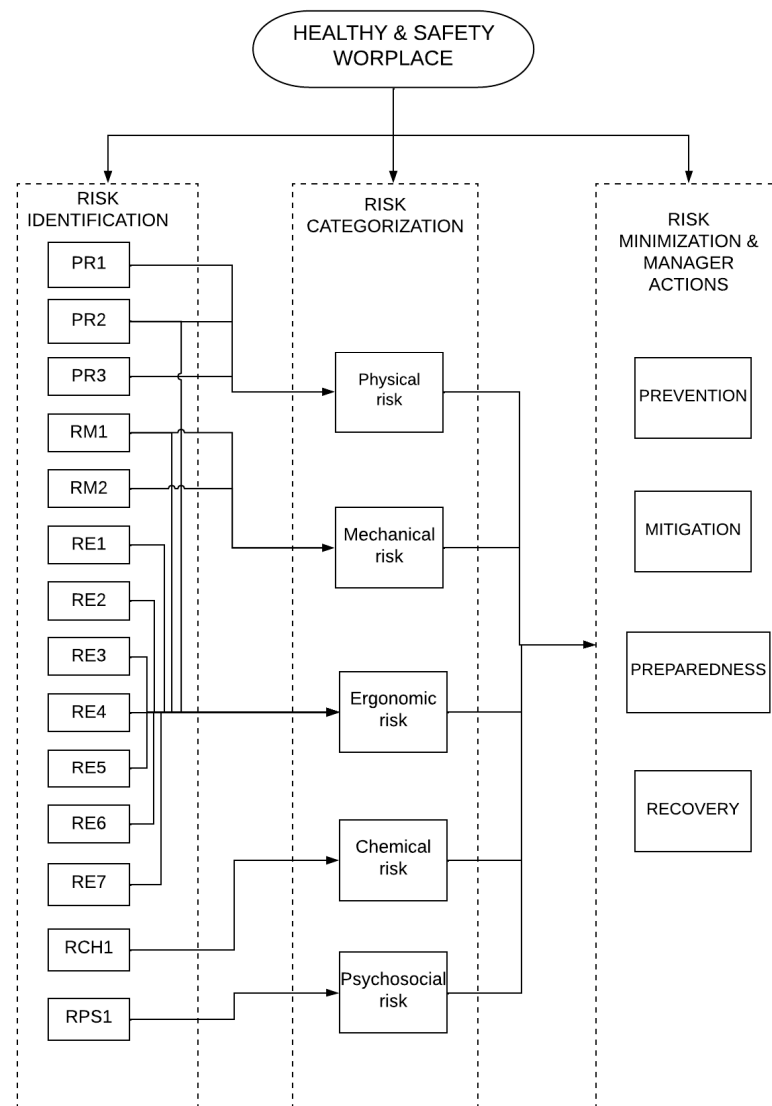


Figure 2. Risk relation and definition.

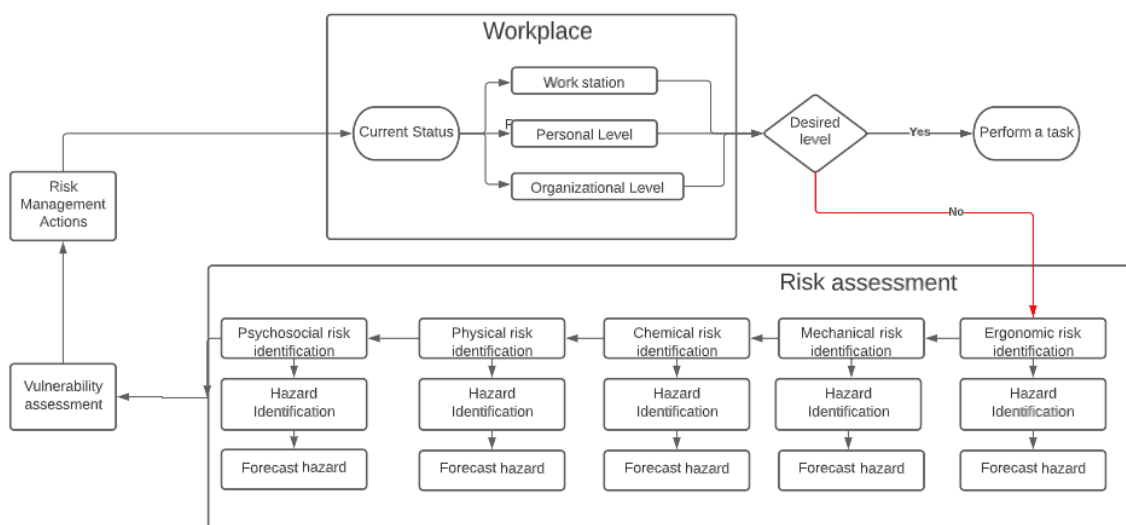


Figure 3. Workplace evaluation method.

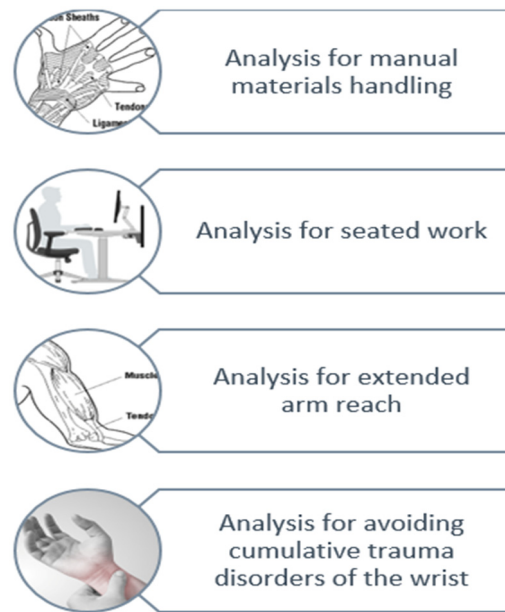


Figure 4. Main risk factors to analyze in order to avoid ergonomic hazards into workplace.

Work injuries can be caused by different factors and can be called accidents, but work-related illness can be classified and set into different types. The injuries are illustrated in Table 4 [61].

Table 4. Injury and Possible Causes [61].

INJURY/ILLNESS POSSIBLE CAUSES				
Injury or illness	Cuts, abrasions, amputations, and punctures on human body	Stress on muscles and ligaments. Numbness, or poor circulation in hands and arms.	Eye injuries	Broken bones and bruises
Probable cause	When hand tools are designed to cut or move metal and wood it can cut easily the body parts	Repetitive activity, in the same posture, using the same tool during the labor period.	Material waste flying as chips of wood or metal cause often momentarily or permanent blindness	Strokes or slips during the worker is holding a tool

4. Discussion

This study identified the main cause for work-related problems as the lack of ergonomics in the workplace; taking into account an analysis of effect-cause as shown in Figure 5, an MSDs is an undesired effect in a healthy workplace as a primary intention. Many studies have been carried out focusing on safety and security science to find a solution to this problem. This finding is in harmony with work by other authors in this field such as the studies “Preventing Musculoskeletal Disorders” [62], or the “Relationship between human resource development system and job satisfaction” [63].

In concordance with studies where the “healthy workplace” is defined [64], a “safety and Healthy workplace” is considered only if it has the following four mandatory points: (i) identify and prevent the sources of possible illness. (ii) Services of “personal health care resources”. (iii) Positive feedback assuring a work environment that does not cause re-injury. (iv) Comfortability inclusive for people suffering from any disability.

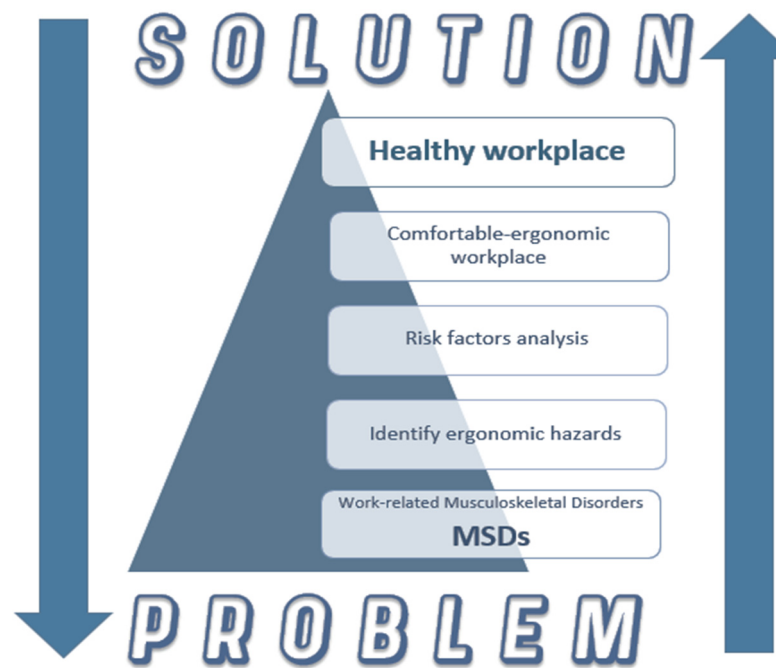


Figure 5. Overview of effect-cause relation of Healthy workplace and biomechanics.

As another contribution, this study presents the steps for ergonomic evaluation to achieve the final solution for a healthy workplace, shown in the problem-solution diagram in Figure 5, starting with the MSDs identification, and then focusing on ergonomic hazard identification and minimization and continuing with the risk factors analysis to meet the ergonomic healthy solution.

5. Conclusions

In a logical small analysis, it is possible to determine that most of life is spent in working years. In this sense, the workplace is a good place to share initiatives that promote the mental and behavioral health of workers to reduce the possibility of future illness related to workplace comfort.

In order to achieve a healthy workplace, industrial organizations have specific concerns [65]. The specific parameters to explain the needs are categorized into two sets: (i) Physical work Environment and (ii) Psychosocial Work Environment, as shown in Figure 6, where Physical Work Environment is directly related to biomechanical ergonomic risk factors in the workplace [21,66].

This risk analysis methodology strives toward an easily applicable method with a hierarchy phase, which is applicable to workstation design and healthy organization. It could be established as a requirement for the improvement of companies to be included in the digitalization of the new industrial tendency.

The investigation was conducted using a qualitative methodology. In this sense, the results are presented in a general form. Subsequent studies may apply quantitative analysis methodologies to risk identification by carrying out tailored industrial risk management.



Figure 6. Identified needs concern to achieve a healthy workplace [64].

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