Analyzing the risks of accidents and occupational diseases from the perspective of the work system

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Abstract
The field of occupational safety and health is focused on identifying the risks of occupational injury or illness and applying measures to reduce them until they are eliminated. Occupational risks of occupational injury or illness from the point of view of occupational safety and health are present in all areas of activity. It is true that the magnitude of the risk is directly influenced by the degree of danger of the processes that take place in that field of activity and the probability with which they occur. Over time it has developed several forms of occupational risk analysis as a dimension. In this way, events leading to accidents or occupational diseases or to the environment can be better understood. In order to be able to measure the extent of the occupational risk of occupational injury or illness, assessment methods are used that quantify the occupational risk. The main purpose of the research study is to analyze the risks of accidents and occupational diseases taking into account the four elements of the work system: performer, means of production, production environment and workload. Following the assessment of the risks of occupational injury or improvement, managers receive information on the presence of occupational risks present in the organization, as well as the evolution of these risks when there are changes in production processes. These changes are due to changes in materials, manufacturing processes, legislative changes, upgrades, technological or environmental accidents, conversions or upgrades of production lines. The importance of the research study is represented by the identification and assessment of the risks of occupational injury and illness from the point of view of occupational safety that enter into the economic equation. Thus, we appreciate that the economic interest must not take precedence over considerations related to safety at work.

Keywords
risks of injury, means of production, work environment, work task, performer, work system

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Introduction

The industrial revolution that has been going on in recent decades also includes the field of occupational safety and health management as a component of this development process. The participants and beneficiaries of this revolution must not benefit from a decrease in the level of protection from the beginning of this revolution. Consequently, the field of occupational safety and health management must play a role in this historic stage. Risks (of all kinds) are part of the management of the organization and cannot be ignored in making managerial decisions. Among the risks existing in the activity of the organization, there are also the risks of injury or occupational disease, which can influence the decisions of the managers regarding the development of the activities. The presence of occupational safety and health risks from the point of view of occupational safety and health must be studied in order for the management team to receive the best information on the influence of these risks on the elements of the work system. Understanding risk requires knowledge of its structure and its manifestation. Consequently, it must be penetrated into its complexity and into all areas of knowledge. This risk study requires a comprehensive approach in all aspects of the work process, throughout the work process and taking into account all phases of the existence of work equipment (from design, construction, operation, maintenance and even scrapping of equipment). The evolution of work processes must take into account the fact that there are occupational risks of illness and

injury, and these must be constantly monitored with the evolution of these work processes, because technical progress can not reduce the level of safety on the health of workers. In terms of occupational safety and health, the term *risk* can be defined as the most likely consequence of a hazard, combined with the risk or likelihood of occurrence. The essence of all methods is to identify all the risk factors in the analyzed system (workplace), based on predefined checklists and quantify the size of the risk based on the combination of severity and frequency of the maximum predictable consequence. Thus, the list of identification of risk factors (of possible consequences of the action of risk factors on the human body) is a form that includes, in an easily identifiable and compressed form, the main categories of risk factors for occupational injury and illness, grouped by the criterion of the generating element within the work system (performer, workload, means of production and working environment). Identifying all possible risks involves simulating the operation of the system and deducing those deviations, which can be done by consulting the technologies that control the processes that take place within the organization, computer simulations, filming of processes, consulting sources of information such as: files, technical books, user manuals provided by equipment manufacturers, raw materials, safety data sheets for substances and compounds used, environmental analysis bulletins and many other sources of information. The identification list of risk factors in the analyzed work system is a document that includes the experiences gained and allows to be supplemented with some risks that were not mentioned in this checklist, for a continuous improvement of the process. Today's managers ask to be informed if there is an increase or decrease in the level of risk, so that they can weigh their decisions. For this, the occupational risk of occupational injury or illness must be quantified. The probability of an event occurring is estimated by the frequency of the last similar events. Most often, the risk is measured as an expected value of an undesirable outcome.

Risk measurement is often done by using the frequency of recent similar events, using statistical methods. These methods can also be costly for the loss of human life, which is particularly difficult to achieve, although this approach puts people in a position to decide to insure against death. The use of statistical methods is difficult to achieve in areas that have very rare negative or catastrophic events (nuclear power industry, pandemics that have not occurred in recent centuries) have occurred in new industries that have not accumulated a history of illness or occupational injury. In practice, occupational risk assessment studies are developed by a group of professionals, accompanied by senior technical staff, qualified in the field of activity of the organization and job leaders, because they know the particularities of the processes carried out in the organization. These teams decide on the methods used to identify and assess the occupational risks of occupational disease or injury. The methods used to evaluate these processes must take into account the four elements of the work system, the performer, the workload, the means of work / work equipment and the work environment. These methods should give managers as clear information as possible about the range of risks encountered from minimum to medium to maximum possible (Parnell, 2014). The risk is a value resulting from the product between the probability of occurrence of the event and the maximum possible severity of the analyzed process.

Accidents at work, occupational diseases and deaths at work involve high economic costs for individuals, employers, governments and society. The negative effects of poor management of occupational safety and health management include high-cost early retirement, loss of qualified staff and absenteeism (Băbuț and Moraru, 2016). Accidents, illness, and death are associated with different types of costs. First, there are direct costs, such as healthcare costs. There are also costs resulting from lost productivity and declining production. Then there are the costs associated with the impact on human well-being - namely the impact on human life and health - which can be quantified and included in a pregnancy estimate. These elements are involved in each case of an accident at work or occupational disease, and the sum of the costs of all cases would provide an estimate of the total cost of accidents at work and occupational diseases (Moraru and Băbuț, 2018).

Countries with poor occupational safety and health systems use valuable resources to treat preventable accidents and diseases. A sound national strategy brings many benefits, such as (Oarga and Rațiu, 2018):

- increase productivity by reducing absenteeism due to illness;
- reduction of healthcare costs;
- maintenance of older workers;
- stimulating more efficient working methods and technologies;
- reducing the number of people who have to cut back on their work schedule to care for a family member.

Current methods use mathematical formulas, evaluation scales, statistical elements, graphs, matrices or diagrams and define the minimum, average and maximum risk value. All methods of assessing the occupational risk of occupational disease or injury quantify the risk. This occupational risk is compared to the risk area (minimum to maximum) and provides information on the presence, importance, and likelihood of occurrence in the organization's processes.

1. Review of the scientific literature

Etymologically, the origin of the term risk is not very clearly defined. From the time of Homer (Charter Picena-1193) appears the term *risk* which describes the threats faced by the characters, but it is not a commercial or legal term (Griffiths, 2018). The term commercial risk appears in Italy in the 13th-14th century, and the term maritime risk appears in seventeenth-century France. In the same century, the term risk appears in the context of life and fire insurance (Parnell, 2014).

The risk can be seen as referring to the probability of uncertain future events, for example, a factor defined by the frequency with which a negative event may occur and the probable magnitude of a future loss. Currently, the concept of risk has definitions given by dictionaries or scientific papers, with negative connotations and refers to the possibility of unwanted events and negative impact of examples: chemical, seismic, volcanic, economic, financial, computer or injury risks or occupational disease (Amason, 2020).

There is a requirement in practice to quantitatively analyze the risk. To meet this requirement, several methods have been developed to measure it. This is necessary in order to be able to decide on the importance of risk, of the costs arising from avoiding or reducing risks (Koufopoulos, 2012).

It should be noted that there are important authors who do not accept the quantification of risks and make references to methods of accepting unpredictable occurrences, and only that. We just have to accept the inevitable and rejoice if we gain from it (Kaplan and Norton, 2020).

In statistics, the risk function is defined as the expected value of a certain loss based on uncertainty. This value of risk takes into account all the possibilities, all the possible acts that can lead to losses. In terms of occupational health and safety, the term *risk* can be defined as the most likely consequence of a hazard, combined with the risk or likelihood of occurrence (Rothaermel, 2020). As such, risk is a function of hazard and exposure.

From the point of view of occupational health and safety, *risk* is present in all organizations, regardless of the field of activity (Petreanu et al, 2013). This *risk* can be quantified by several methods, with the aim of measuring it according to the probability of its occurrence and the maximum possible severity (Darabonț and Dăscălescu, 2011). It is true that the magnitude of the risk is directly influenced by the degree of danger of the processes that take place in the organization and the probability with which they can occur (Fred, 2017). The purpose is to reduce the risk of illness and occupational injury of workers present in the processes carried out by the organization. This risk reduction is followed at all stages of the organization's operation: at the time of designing the technological processes, at the time of purchasing the equipment, at the time of modernization of some production lines, when there are conversions of manufacturing flows, their modernization or even during the operation of this equipment. (Fayol, 2015).

There have also been identified times when radical changes in production processes have taken place, as specific legislation has become very strict in terms of occupational safety and health, which required the reduction of occupational risks. There were situations in which industries were abandoned because the measures required to reduce occupational risks were so costly that, from a financial point of view, industrial activity could no longer continue. A very good example is the asbestos industry and the materials that make up this mineral (Moraru and Popescu-Stelea, 2015).

2. Research methodology

The main purpose of the research is to analyze the risks of accidents and occupational diseases from the perspective of the components of the work system:

C1. Means of production: (hand tools, power tools, motorcycles, manufacturing, transport, verification and control lines);

C2. Work task: this is described by the following documents: individual employment contract, job description, regulations and collective bargaining agreements, administrative decisions, work tasks received verbally from the employer, those received on the organization's communication channels (email, telephone, intranet), delegations, travel orders;

C3. Work environment: At the time of the occupational risk assessment, the work environment will be described in detail. The following will be taken into account: room size, substances, chemical or biological compounds, lighting, drafts, vibrations, radiation at work, crowding;

C4. Performer: the name of the position will be mentioned, according to the individual employment / collaboration / volunteering contract. It also analyzes whether the worker has medical examinations for the job, professional qualification, correctly applies the procedures, if he has been trained in terms of safety and health at work and uses the correct personal protective equipment, respects the knowledge of safety signs at work.

The research plan includes the following steps:

1. Training - gather the necessary information, identify the situations to be analyzed, work tasks, operations, select and train all participants in the analysis.

2. Structuring - drawing up the list of work tasks and operations to be performed in order to fulfill them. The information is gathered from the workers' job descriptions, their own work instructions, machine technical books, maintenance instructions, accident reports, occupational diseases and dangerous incidents, the history of technical defects or breakdowns of the analyzed machinery or equipment. It analyzes all operations performed during the preparation-completion period, how the work is carried out under normal conditions, in the conditions of production flow disruptions, transfers within and between work tasks, how the production process, maintenance and repairs are completed, order and cleanliness, how it ends.

3. Identifying the sources of risk - is done by questioning workers, job leaders, using lists of possible risks and looking for problematic situations, technical defects or working methods. Possible deviations from the normal course of work are identified.

4. Risk estimation - this method does not estimate the risk of illness or occupational injury depending on the severity or probability of occurrence, but only makes a practical estimate of the risks, on a scale from 0 to 4 in importance.

The research team included Romanian managers in the field of occupational safety and health. The survey unit was represented by company managers from four fields of activity: automotive, IT, energy, food - who perceive occupational safety and health activities.

The data collection was carried out between December 2021 and March 2022, with the help of the questionnaire, a quantitatively structured research tool. A number of 612 valid questionnaires were obtained, thus allowing the use a large number of statistical techniques to analyze the data collected. As both the time and the interview materials and operators traditionally adopted in the surveys are quite expensive, a modern method of applying the questionnaire was used, namely its design and application online based on the Google Forms application. The obtained results were recorded, stored and structured, obtaining the database necessary for the analysis. The recorded data were subjected to adjustment, grouping, aggregation and coding operations for easier processing, analysis and interpretation. Therefore, a database was created that could be used electronically.

In the modeled socio-economic universe, the problems of assisting the economic decision are generated by the multicriteria decision-making processes that we used in the study of the research of the *maximum utility method.*

Modeling seeks to make the most of the information base scientifically, and the procedures for imitating the rational mode of decision-making are, in more or less elaborate forms, the conceptual essence of models.

The steps of the global utility method are as follows (Johnsonbaugh, 2010):

Step 1. Build the utility matrix with the elements, i = 1..., r and j = 1..., n.

Each element of the matrix is calculated for the maximum criterion with the expression:

$$x_{ij} = u_{ij} = \frac{x_{ij} - x_{i\min}}{x_{i\max} - x_{i\min}} \quad (1)$$

and for each minimum criterion with the expression:

$$x_{ij} = u_{ij} = \frac{x_{i\max} - x_{ij}}{x_{i\max} - x_{i\min}} \quad (2)$$

where:

x_{ij} = the value of indicator *i* associated with indicator *j*;

$x_{i\max}$ = the minimum value of indicator *i*;

$x_{i\min}$ = the maximum value of the indicator *i*.

Step 2. Calculate the global utility for each project as the sum of the products in the element of the utility matrix (the column vector corresponding to the project) and the important coefficient given for each indicator.

$$UG_j = \sum_{i=1}^{r} \alpha_i u_{ij}, where \sum_{i=1}^{r} \alpha_i = 1 \quad (3)$$

Step 3. Choose the project that corresponds to the maximum global utility.

$$\max\{UG_j\} \Rightarrow V_j,\ j = 1,.....n \quad (4)$$

For the division of some decision V_i variants (n variant) and for the selection of the best one offered by the simultaneous consideration of several criteria of appreciation (Cj, j = 1,…, n) and the global utility. Finding the best combination of attributes (characteristics of a variant) forms the object of the multi-attribute problem.

This involves the transformation of all numerical values a_{ij} (expressed in associated units of measure) and qualitative characteristics into utilities u_{ij}, ie numerical values located in the interval [0, 1]. The basic assumption in the correct function of the weighted sum method is the independence of the criteria. The largest of the synthesis utilities indicates the best option.

3. Results and discussion

Table no.1 presents the information base of the study, respectively the share of the importance that the managers give to each component of the work system.

Tabel no. 1. The importance of the work system

WORK SYSTEM	FIELD OF ACTIVITY			
	IT % *(v1)*	AUTOMOTIVE % *(v2)*	ENERGY % *(v3)*	FOOD % *(v4)*
C1. Means of production	14.55	28.15	17.59	12.5
C2. Work task	17.75	17.75	19.19	23.61
C3. Work environment	9.12	16.61	14.8	10.54
C4. Performer	27.05	18.60	12.12	26.95

Source: developed by the authors based on the collected data

Results show the fact that managers take into account the first *C4.Performer*; the possible deviation of the performer from the ideal line that must be followed in order to fulfill the work task is always an error. The error of the performer materializes in an inappropriate behavior from the point of view of work safety, in the form of a wrong action or omission.

In the last instance, managers take into account *C3.Work environment* (Figure no. 1). The physical environment may have deviations in the form of exceeding the level or functional intensity of specific parameters (microclimate, noise, vibration, chemicals, radiation, lighting), or characteristics that represent inadequate working conditions (physical over-bidding). The social environment is characterized by psychic risk factors whose result is the overload of the *Performer*.

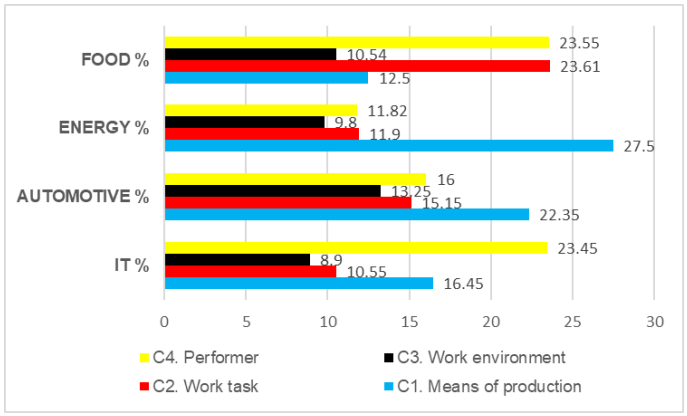

Figure no. 1. Share of work system components

Source: developed by the authors based on the collected data

Going through the calculation algorithm involved:

Step 1 - building the unit matrix with the elements x_{ij} Figure no. 2

$$\begin{bmatrix} 0.26 & 0,66 & 1,00 & 0,00 \\ 1,00 & 0,65 & 0,90 & 0,00 \\ 0,00 & 1,00 & 0,21 & 0,38 \\ 0,99 & 0,36 & 0,00 & 1,00 \end{bmatrix}$$

Figure no. 2. The matrix of units

Source: developed by the authors based on the collected data

Step 2 - Calculation of global utilities for each organization (Table no. 2):

Table no. 2. Results of the calculation of global units

FIELD OF ACTIVITY	RESULT
ENERGY	2.25
AUTOMOTIVE	2.66
IT	2.10
FOOD	1.38

Source: developed by the authors based on the collected data

Step 3 - From the analysis Table 2 highlights the greatest global utility of companies in the field of AUTOMOTIVE.

Therefore, following the application of the algorithm for calculating the maximum global utilities method, it can be concluded that the AUTOMOTIVE organization has best assessed the importance of the work system. The analysis of occupational disease or injury risks can lead to optimal decisions of managers who organize production flows without having huge costs of adapting machinery, equipment or production lines.

Thus, the employer is obliged to take all measures for labor protection, regardless of the field of activity. The main objectives in terms of safety at work should be:

- Defining the existing risks at work;
- Analysis of the nature of the risks and the necessary measures to neutralize them;
- Taking the necessary measures to rectify the dangerous situation;
- Verification of the measures taken and their effect. If the measures taken are true, the effect obtained is the desired one.
- Control of the occurrence of new risks through periodic evaluations.

Conclusions

From a theoretical point of view, the results obtained provide a perspective on managers' perceptions of occupational safety and health management from the perspective of the work system (performer, work environment, workload, means of production).

From a similar research perspective, occupational safety and health provides the employee with the necessary safety during work, helps him to maintain his health and ability to work in the work schedule. At the same time, labor protection prevents accidents at work, prevents diseases caused by the type of activity and identifies the dangers to which the employee is subjected.

The risk assessment described in the research study opens up new directions for research into the calculation methods or tools that underlie investment decisions. That is, more complex calculation tools can be developed, including occupational risks of injury or occupational improvement in terms of occupational safety and health. These occupational risks can influence work processes in terms of costs, efficiency, economic satisfaction. Thus, work scenarios can be constructed for making investments in the design / design phases, including the results obtained with the method of risk assessment of occupational injury or illness taking into account the presence at work of specific risk sensitive groups.

Managers must have information on the presence of occupational risks of occupational injury or illness, at all stages of the organization. Namely: conception, design, construction, investment, operation, maintenance, modifications, modernizations, technological accidents, crises, accidental or organized shutdowns, legislative changes. In all these phases, the information must be provided taking into account the four elements of the work system: performer, means of production, production environment and workload.

The methods analyzed so far do not cover, cumulatively, the requirement to analyze occupational risks taking into account the four elements of the work system: performer, means of production, production environment and workload, and the presence at work of workers who they are part of risk-sensitive groups, along with colleagues who are in full capacity. Another shortcoming would be that the current methods do not take into account the interaction of all positions in the work process, analyze them sequentially, which does not provide a complete picture of occupational risks of illness or injury from the point of view of the manager of occupational safety and health. .

For future research directions, an identification of a risk assessment method based on the following objectives could be an important research:

- To be stated and analyzed the job, individually, and in cohesion with the other positions that may influence it. The analysis on this post is done during the whole period of activity, respectively, the preparatory operations and those of the completion of the activities carried out on the analyzed work position must be analyzed,
- To have the way to quantify the risks, in order to be able to quantitatively analyze the evolution of these risks. Using the same method, at different times, with different equipment or personnel, it is possible to identify the increase or decrease of the risk level, so the manager has concrete information with the evolution of professional risks,
- Cover the four elements of the work system: performer, means of production, production environment and workload,
- Include workers in risk-sensitive groups. They often work in the same positions with colleagues who are not part of this group. By default, performance and occupational hazards will be influenced by this mix of workers,
- Quantify the occupational risks for each identified risk,
- To take into account the number of workers for each risk identified, as the rank of the risk factor,
- Also have a graphical interpretation of the risks identified at work,
- To provide solutions for the elimination or reduction of occupational risks, with priority for the elimination of the risk factor, its reduction, or its isolation. Ultimately, if these priorities are not met, means of personal protection for workers are provided.

In conclusion, occupational risk assessment, taking into account the presence at work of groups sensitive to specific risks, helps the manager to make decisions regarding the occupational risk of illness or injury at work.

The limits of the study undertaken are diverse, from which we point out: the time horizon chosen by us is quite narrow, because the research topics often generate studies of 10-50 years; the scientific approach was focused on the interpretation of the studies and not on the explanation of the use of the findings obtained; the inductive research methodology was easy to achieve.

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