An exploratory study on workplace accidents and illnesses cost analysis tools

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Abstract. Until the present, addressing the economic dimension of work accidents and occupational diseases in Romania has been sporadic, relatively unsystematic and unenforceable. Any quantitative assessment of the consequences of accidents and occupational diseases involves determining the cost associated with these undesirable events, which can be used as an economic indicator. Embedding the labor safety criterion among the performance criteria of a company makes its profit directly conditional on the fulfillment of legal requirements on working conditions, so that general management must include among its objectives and maximizing the results of preventive activity. In this context, the paper presents the results of a critical comparative analysis conducted on tools developed worldwide to analyze the costs associated with accidents. The main purpose of the study was to establish the feasibility of introducing the most appropriate tools in the practice of romanian companies, in order to optimize the cost-benefit of investments in occupational safety and health.

1 Introduction

The number of economic and human accidents at work and occupational illnesses is considerable. According to EU-OSHA, in 2017, 3.2 million accidents and occupational illnesses with temporary work incapacity and 3757 fatal accidents were reported and the cost of these accidents is 476 billion euros [1]. These undesirable events are a significant economic burden on employers, workers, their families and the entire community. Occupational health and safety costs can be classified into two major categories:

- Costs related to injury and occupational diseases prevention;
- Costs related to the consequences of accidents and occupational diseases.

Figure 1 illustrates the magnitude of labor-related and occupational disease losses in financial terms in 2017, globally and in the European Union [1].

A quantitative assessment of all the consequences of work related accidents and illnesses, or at least those measurable, would determine the cost of a type of event that can be used as an economic indicator.

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Consequently, the economic dimension of the phenomenon of injury and occupational illness includes two components: the economic effects of these events and the cost of accidents and illnesses, as an economic indicator reflecting all the measurable effect of these events. Among the consequences of accidents and occupational diseases there are social consequences which are unquantifiable and can not be expressed quantitatively (pain, physical and mental suffering) and economic consequences which are quantifiable and can be expressed in direct and indirect costs (Table 1).

Table 1. Categories of accidents and occupational diseases consequences.

| Consequences    | Quantifiable                                    | Unquantifiable                                |
|-----------------|-------------------------------------------------|-----------------------------------------------|
| Victim          | • Loss of salary and bonuses                    | • Pain, suffering                             |
|                 | • Decrease of professional capacity             | • Decrease, loss of work capacity             |
|                 | • Medical costs                                 | • Lost time (medical treatment)               |
|                 | • Expenses for various services, and            | • Moral and psychological suffering           |
|                 |   medical care and recovery, if they are not    | (especially in case of permanent disability)  |
|                 |   fully covered by insurance                    | • Change of social and professional status    |
|                 |                                                 | • Fear of causing another similar accident    |
| Family and      | • Financial loss                                |                                               |
| friends         | • Additional costs                              | • Moral and psychological suffering           |
| Colleagues      | • Lost time and eventually, lost bonuses        | • Psychic pain                                |
|                 | • Increased work volume                         | • Fear of not having a similar accident for    |
|                 | • Training temporary workers                    |   those with the same job                     |
|                 |                                                 | • Panic in the case of occupational illnesses |
| Company         | • Decreased production                          | • Company’s image                             |
|                 | • Decreased profit                              | • Working relationships and the social        |
|                 | • Loss of materials                              |   climate                                     |
|                 | • Internal Audit                                |                                               |
|                 | • Training new staff                            |                                               |
|                 | • Increased production costs                    |                                               |
|                 | • Deterioration of fixed capital                |                                               |
|                 | • Increased insurance bonus                     |                                               |
|                 | • Legal penalties                               |                                               |
| Society         | • Increased social costs                        | • Reduced potential of human workforce       |
|                 | • Medical and rehabilitation treatment costs    | • Reduced quality of life                     |
|                 | • Early retirement                              |                                               |
|                 | • Decrease of living standards                  |                                               |
Direct costs include the costs of hospitalization, treatment, re-employment, employee compensation, training new employees, accident investigation, loss of productivity and the repair of damaged equipment.

Indirect costs are considered economic losses that are not covered by accident and illness insurance, and they influence both the national budget and the enterprise: costs of repairing or replacing damaged cars, loss of materials, working time while giving first aid to the victim, cost of replacement workforce, penalties for delays in delivering products, company’s image, and so on.

Companies spend huge amounts of their profit to cover the costs associated with work accidents and occupational illnesses. This increases re-qualification costs and compensatory payments, work absence and lack of productivity, but the profit decreases.

Occupational Safety and Health Administration of the U.S. has developed a program called Safety Pays, which covers various types of ordinary accidents and the real costs associated with an accident [2]. Once completed, the program provides the direct, indirect and total estimated costs of an accident and the amount needed to cover these costs. This is an excellent tool to understand how much a work accident costs, and why it’s better to be proactive with the company's health and safety program, avoiding such work accidents. The Safety Pays program is designed to raise awareness of how accidents and occupational illnesses can influence a company's profitability, not necessarily to provide a detailed analysis of the costs associated with an accident or occupational illness. The results provided by the program are illustrated in Table 2.

| Table 2. „Safety Pays” program results [2]. |
|---------------------------------------------|
| Estimated Direct Costs | Fracture | 58.458 USD | Asbestosis | 67.433 USD |
| Estimated Indirect Costs | 58.803 USD | 74.176 USD |
| Combined Total (Direct and Indirect Costs) | 112.261 USD | 141.609 USD |
| Sales To Cover Indirect Costs | 1.960.126 USD | 2.472.543 USD |
| Sales To Cover Total Costs | 3.742.033 USD | 4.720.300 USD |

2 Materials and methods

In order to establish the cost-benefit feasibility analyzes in the field of security interventions in Romanian companies, three instruments from the specialized literature were selected and analyzed conceptually, principally and methodologically, in order to conduct a SWOT analysis that facilitates the decisions regarding the use of the most appropriate method [3-14].

2.1 Modular Method IFCE (Individual-Company-Insurance Company-National Economy)

The principle of the modular method is to identify, with the help of a certain and predefined list, all the measurable consequences of the work accident, and to determine their monetary value. Using the predefined list, facilitates the operation of identifying the actual consequences of the events for which the calculation is made, and excludes the possibility of omitting any significant type of consequence.

The application of the method must follow a clear sequence of steps, which are basically the stages of calculating the cost of an accident at work:

- Establishing the reference level for which the calculation will be made (victim, company where the event occurred, insurance company, national economy)
• Identifying the certain measurable consequences (select from the list of measurable consequences the losses and expenses considered as certain)
• Filling in the "Questionnaire for primary data collection regarding the consequences of the accident"
• Establishing the calculation modules to be used to determine the cost of an accident at work, taking into account the identified measurable consequences
• Selecting the primary data specific to each selected module
• Calculating the extent of consequences by applying the calculation method within each selected module
• Final calculation of the work accident cost

Calculation modules are algorithms that need to be completed in order to determine the segment of the total cost of the work accident generated by a certain type of consequence.

2.1.1 Module 1 – Calculating the loss of income the victim and / or his dependents will bear

Following the work accident or occupational illness, the personal income of the victim may decrease, and in case of death, the loss of income of the people in the care of the victim, is the difference between the share of their salary and the survivor's pension. The data used for the calculation is the date used for the calculation of the personal income loss and comes from the primary data collection questionnaire. Using the list of measurable consequences of accidents at work and the data sheet for calculating the personal income loss, the mathematical relationships of calculating the size of the personal income loss are:

- work accident followed by temporary incapacity to work and returning to the same job:

\[
\Delta V_P = \frac{(\bar{S}_0 - I_B) \times Z_{ITM}}{\beta} + C_s N_s + C_m + C_{SS} + C_{MED} N_{LMED} + C_{AS} - A_{BS} L_{BS} - A_{BL} L_{BL} - A_F L_{F} - A_C L_{C} - A_{NG} L_{NG} - A_{PF} L_{PF} - \sum A_i N_{A_i}
\]

where:
\[
\begin{align*}
\bar{S}_0 &= \text{net monthly salary at the time of the accident;} \\
I_B &= \text{monthly illness allowance;} \\
Z_{ITM} &= \text{duration of temporary work incapacity;} \\
\beta &= \text{coefficient of converting of the monthly income into daily income;} \\
C_s &= \text{expenses from personal budget for hospitalization;} \\
N_s &= \text{number of hospitalization days;} \\
C_m &= \text{expenses from personal budget for health care;} \\
C_{SS} &= \text{expenses from personal budget for health services;} \\
C_{MED} &= \text{expenses from personal budget for medication;} \\
N_{LMED} &= \text{number of months with expenses from personal budget for medication;} \\
C_{AS} &= \text{expenses from personal budget for other health-rehabilitation services;} \\
A_{BS} &= \text{state budget support for victim and / or descendants;} \\
L_{BS} &= \text{number of months with state budget help;} \\
A_{BL} &= \text{help from local budgets for victim and / or descendants;} \\
L_{BL} &= \text{number of months with help from the local budget;} \\
A_F &= \text{help received by victim and / or descendants from the firm where the accident occurred;} \\
L_{F} &= \text{number of months with help from the firm;} \\
A_C &= \text{benefits received from the insurance company;} \\
L_{C} &= \text{number of months with help from the insurance company;}
\end{align*}
\]
\[ A_{NG} = \text{help received by the victim and / or descendants from non-governmental associations}; \]
\[ L_{NG} = \text{number of months with help from other organizations}; \]
\[ A_{PF} = \text{help received by the victim and / or descendants from individuals, including compensation established by final court sentences}; \]
\[ L_{PF} = \text{number of months with help from individuals}; \]
\[ \Sigma A_i = \text{other facilities for the victim and / or descendants}. \]

- an accident at work with temporary incapacity for work and return to another job;
- an accident at work with temporary incapacity for work; temporary retirement and return to the same job;
- an accident at work with temporary incapacity for work, temporary retirement period and return to another job;
- work accident immediately followed by disability;
- an accident at work with temporary incapacity for work and disability subsequently manifested;
- work accident resulting in the victim’s subsequent death.

### 2.2 Accident Consequence Tree Method (ACT)

Identifying the consequences of accidents has a major importance in calculating costs. Different classifications of consequences have been published, but it is necessary to further develop them. The Accident Consequence Tree Method was developed based on the fault tree method for calculating the cost of accidents. Using the consequences tree, the consequences of an accident for the injured person, company and economy can be identified.

The basic chain of events through the Accident Consequence Tree methodology is: i) There is an event; ii) Consequences and activities are identified and recorded in real time; iii) The consequences are quantified, (number of hours, number of visits, quantity etc); iv) Unit costs are identified; v) Cost calculation.

Social costs are the direct costs resulting from accidents, namely costs for ambulance, and physicians involved etc. The costs of the injured worker include income cuts and any additional costs borne by the worker or by his family because of the accident.

There are 6 main categories used in the Accident Consequence Tree Method to classify the consequences of occupational accidents. These are:

1. Loss of working time that includes (loss of working time due to diminished production, payment of sick leave for which the company receives nothing in return, etc.);
2. Loss of short-term assets (loss of raw materials and products due to the event);
3. Loss of long-term assets (loss of machines or tools due to the event);
4. Different short-term costs (transport costs, consultants and fines);
5. Reducing revenue (lost contracts or price cuts);
6. Receipts, such as reimbursements from insurance companies.

A feature of the method is that it materializes in real time - the recording of consequences and costs are made immediately after the occurrence of the accident.

Users are trained in applying survey forms, which are then used as soon as the event takes place. Also, the real-time appearance of the method depends on the users of the method actually filling the forms at the time of the event.

The method was tested in the Scandinavian furniture industry, where 214 occupational accidents were analyzed in 18 companies. By applying the method, average costs for occupational accidents at company and employee level were calculated. In total, 70 consequences of accidents involving the loss of more than 9500 hours of work have been identified.
2.3 Systematic Accident Cost Analysis Method (SACA)

As a consequence-based methodology, as ACT, SACA method focuses on the consequences of occupational accidents and the costs of these consequences. The main procedure is to identify, first of all, the activities generated by the work injury analyzed, and the next step is to calculate their costs for the company. It focuses only on the costs of the company and not on the costs of the injured worker, such as the ACT method. The SACA method is based on a series of forms and checklists that are just for guidance. The main purpose of the method is to provide managers with an accident cost identification tool without having to have a rich experience of financial analysis methods to do so. The method is based on interviews and is not intended to be used in real time.

The cost of work accidents is classified into six general categories:
1. Costs due to the absence of the injured employee (payment of sick leave)
2. Communication costs (formal communication of employees, staff and general management, as well as informal communication between employees)
3. Administration costs (wage management, administration of health and safety regulations and reporting requirements)
4. Risk prevention costs (training, maintenance)
5. Costs of discontinuing operations (formation of replacements, diminishing of revenue, overtime of colleagues and diminution of production)
6. Other costs (fines and compensation to the injured employee)

The actual costs measured within these categories are grouped into four categories:
1. Time: hours used by employees and management for accident-related activities, and hours for which the company pays salaries without gaining any benefit in return.
2. Materials and Components: costs of materials and components purchased or lost as a result of the accident, such as car spare parts, replacement of damaged materials and the equivalent of products not made.
3. External services: the cost of external services contracted due to the accident, such as temporary replacement, consultants and legal assistance.
4. Other costs: costs incurred by the company, such as fines and rehabilitation.

The method has been tested in a number of companies for different types of occupational accidents. By applying the method, indirect costs were calculated, accounting for an average of 35% of the total cost of accidents, and smaller companies had, on average, higher costs. The cost of accidents at work in a company may be significant depending on the type of accident, medical leave payments and how the accident affects production.

3 Results

Considering the quasi-incipient stage in Romania of the economic analysis of the costs associated with the undesirable events occurring in the occupational environment, the comparative study conducted on the three investigated methods and techniques aimed to investigate their practical feasibility in socio-economic conditions particular and specific.

Table 3 summarizes the results obtained in the form of a Strengths-Weaknesses synthesis that highlights the advantages of the methods in contravention of their limitations, providing a first selection basis for their application in the practice of companies that realize that investing in security means investing in profit and do not lose financial resources (and implicitly human, materials etc.).
Table 3. Results: Advantages and limitations of investigated methods

| Strengths | Modular Method IFCE | Accident Consequence Tree | Systematic Accident Cost Analysis |
|-----------|---------------------|---------------------------|-----------------------------------|
| Cost calculation for any level (victim, company, society). | It can be integrated into the continuous collection of data on occupational accidents. | Simple, unrecoverable approach to cost classification. |
| Taking into account, at all levels, only the certain, recorded or deductible losses and expenses in the specific records. | It can be applied in real time, which minimizes the risk of certain activities being omitted. | An aposterior application that offers the possibility to select an accident portfolio so as to be representative of the accidents that can occur in the company over a certain period of time. |
| Including all types of costs (direct and indirect). | Graphic presentation of the consequences for an overview. | Forms and complete lists, tested in practice to simplify implementation. |
| Possibility of calculating before and after the events. | Employee training in applying the method focuses on the cost of accidents | They can be communicated within the organization to become aware of the cost of an accident |
| There is a difference in establishing the relationship between the cost of the event and the loss for the firm. | It involves costs because it requires the training of those responsible for the application of the method in real time. | Adequate application that can influence the results through the time interval between the accident and the consequences assessment. |
| Completing lists and tables requires an extremely long period of time. | Requires strict definitions of cost categories to ensure validity | It requires strict definitions of the cost categories used to ensure validity. |
| The method was tested only in Romanian companies. | The method was tested only in Scandinavian companies. | The method was tested only in Danish companies. |
| Records the consequences at a time after the accident, which could lead to event omissions or subjective interpretations. | It focuses only on a limited period and the accident that occurs at that time, which could endanger its validity. Also, real-time recording may not capture costs that occur at a certain time after the accident. | Records the consequences at a time after the accident, which could lead to event omissions or subjective interpretations. |

4 Conclusions

Developing and implementing preventive measures should be considered as investments that result in a reduction or elimination of avoidable costs. In this way, investment in security and health creates benefits equal to reducing avoidable costs. It is obvious that the potential user of a work-based costing tool needs first of all to make the right choice by a suitable model or tool for his or her particular situation before the actual implementation of the instrument or model.

In this paper, we presented three main methods among the many tools available to estimate the cost of accidents at work. Some of these methods are useful for estimating specific cost components, while others can be used to obtain a more general estimate of costs. In theory, it is relatively easy to draw up a list of the costs that could result from accidents at work, but it is more difficult to obtain data on some of these costs. For example, the availability of reliable national statistical data means that costs related to loss
of reputation, loss of contracts, processes and are often ignored, despite their magnitude. Human costs are often ignored for the same reasons. On the other hand, no analysis of the cost of unwanted events is complete without taking into account occupational illnesses. However, taking such diseases into consideration can sometimes create confusion in interpreting the results. Some occupational diseases are declared and become visible only after a few years of exposure. Thus, the costs of these newly reported cases do not reflect the actual occupational risk levels at the time of the actual exposure of the workers. On the other hand, by omitting occupational diseases, it becomes impossible to obtain a complete picture of the associated costs. It is clear that the choice of method and cost components to be considered will have a significant impact on the results of the estimates. Practitioners in Romania will have to select a method of estimating the cost of work accidents that is in line with the company's objectives, philosophy and policy in the field of safety and health at work, and for which reliable data are available.

Employers typically apply technical, organizational, hygienic and other measures to prevent accidents at work. But effective risk mitigation may in many cases require a change in organizational security culture, a shift initiated by the awareness of the level of losses associated with unwanted events on all levels.

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