A Methodological Approach for the Assessment of the Non-OSH Costs

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Abstract. Accidents at work represent, globally, a significant social and business cost for all production processes and working sectors. With a view to achieve the Sustainability Goals shared in the 2030 Agenda, it is necessary to design tools that can analyze and monitor the costs related to the accidents phenomenon, to support the Public Administration in defining effective strategies for the implementation of health and safety in the workplace and to reduce the costs related to the phenomenon of injuries. On the basis of an analysis of the literature referring to existing models used to calculate the costs of the accident phenomenon, this research proposes a methodological approach to calculate the costs incurred, both in case and in the absence of injury by the main stakeholders (worker, enterprise, state, society) with reference to four different scenarios. The methodological approach can be used to different product sectors and different geographical contexts and could be used to compare the effectiveness of different political strategies.

Keywords: Health and safety at work · OSH costs · Accidents at work · Sustainability · Social goals

1 Introduction

Sustainable Goals shared in Agenda 2030 set out objectives covering social, economic and environmental aspects. In particular, with reference to the framework of the present research, objectives 3 "Ensure healthy lives and promote well-being for all at all ages" and 8 "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" are to be explored in depth [1]. Those objectives are connected to the mission state in 1947 by the World Health Organization (WHO) to achieve "by all populations of the highest possible standard of health", defined as "a state of complete physical, mental and social well-being' and not simply "the absence of disease or infirmity" [2]. In this sense, it should be highlighted that a safe and healthy workplace contributes to labor productivity and promotes economic growth [3–5] and it is therefore consistent in the pursuit of sustainable objectives.

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Furthermore, it is recognized that accidents at work and occupational diseases represent a significant social and business cost in all production processes. In fact, the International Labour Organization (ILO) estimated in 2012 that globally 4% of GDP is lost due to work accidents and diseases [6]. A recent project by the European Agency for Safety and Health at Work (EU-OSHA) observed that the inconvenience of work injuries and diseases is 3.9% of global GDP and 3.3% of European GDP [7].

In this sense, it is worth pointing out that is estimated that globally every year the death of 2.3 million women and men is caused by work accidents or diseases, corresponding to over 6000 deaths every single day [8]. It means that around 340 million occupational accidents and 160 million victims of work-related illnesses annually occur. To outline the severity of this phenomenon, it should be taken into account that the Covid 19 pandemic has caused over 6 million deaths in almost two years (3 million per year) [9].

With a view to monitoring and analyzing the accident phenomenon, the aim of this contribution is to define a methodological approach to calculate and evaluate the costs related to the management of health and safety in the workplace. In particular, the approach is intended to assess the cost for the stakeholders involved in production processes (entrepreneur, collectivity, workers etc.), both in the event and in the absence of an accident in scenarios with different modalities of Occupational Safety and Health (OSH) management.

The methodological approach allows to calculate the costs resulting from an accident event for each of the above-mentioned stakeholders according to different scenarios. In detail, the proposed evaluation approach is planned to highlight and identify the investment costs in prevention and OSH and also to estimate the costs of non-safety. This is carried out by analyzing the consequences that may fall on the worker, the entrepreneur, both in case and in the absence of an accident. The proposed methodology allows to verify whether, and to what extent, the costs related to investments, both to comply with regulatory requirements and to implement occupational health and safety management systems, are lower than those that would be incurred in the event of an accident.

The work is organized in three Sections. In Sect. 2, an analysis of the current literature on the work-related accident costs and the methods to assess them is reported. In Sect. 3, the methodological approach and its main phases are illustrated. In Sect. 4, the conclusions and possible further insights are drawn.

2 Current Literature

Although an established method is not shared, many contributions aimed at assessing the work-related accident costs can be found in the current literature [10–16].

Assessing the work-related accident costs could be a complex task because the costs are hard to identify and - often - underestimated [17, 18]. In fact, the total costs of occupational accidents and illnesses are often undervalued, both because some costs are external to the company and internal company costs are particularly difficult to be quantified and recognized. Moreover, a large part of the consequences of a work-related accident are often hidden or cannot be financially quantified [3].

In detail, the Human Capital Approach and the Opportunity Cost Method [19–22] are frequently borrowed for the calculation of occupational accident and/or illness costs. Ma et al. analyze the factors that may influence the planning of strategies to implement safety investments in China from the point of view of the opportunity cost, intended as the ratio between the costs due to the occurrence of accidents and the costs related to investments in prevention [23]. Furthermore, the Friction Cost Method is often used [24], in particular for those accidents that causes long term consequences to the workers and create vacancy to be covered by an unemployed person [25] and when it is needed to specifically consider productivity [26, 27].

The methods and the approaches are various and heterogeneous in terms of type of costs studied and perspective of stakeholders involved. It is also necessary to highlight that an exhaustive and shared list of the cost items to be considered has not been developed, as some of them are immediately evident and quantifiable in monetary terms, whereas others are harder to be monetized [20, 28–32].

The OSH costs are assessed by many other points of view, by investigating the relationship between accidents at work and climatic condition [33] and the benefits of implementing an OSH management system [34, 35]. Furthermore, many studies relating the assessment of non-OSH costs on the communities have been carried out [36–38].

The definition of the he methodological approach requires the identification of the stakeholders involved and the costs to be considered. EU-OSHA [39] defines a framework that individuates: the main stakeholders involved (Table 1); the four potential outcomes of an accident; five main cost categories summarizing the consequences of accidents in economic terms (Table 2); the appropriate methods for each cost category; the distribution of the specific costs within each of the five categories among four types of stakeholders bearing the effects of accidents.

Table 1. Stakeholder involved

Name	Definition
Worker (W)	Person affected by the accident or their family members
Enterprise (E)	Company or organization where the individual works
State (C)	Public authority competent for social security benefits
Society (So)	All stakeholders - effect on society at large

Elaboration on EU - OSHA 2014 [39].

For the specific objectives of this study, the *Society* stakeholder and the cost category related to *quality of life* are excluded.

Table 2. Cost categories

Category	Costs related to
Productivity (P)	Decreasing of yield or production
Health (S)	Both direct and indirect medical services
Administrative (Am)	Social security benefits
Insurance (As)	Insurance benefits
Quality of life (Q)	The decrease in quality of life

Elaboration on EU - OSHA 2014 [39].

3 Methodological Approach

By borrowing the EU-OSHA framework, the proposed methodological approach considers: three stakeholders (worker, entrepreneur, collectivity); four cost categories (productivity, healthcare, administrative, insurance); four types of an accident (death, permanent inability, temporary inability and no consequences).

In addition to these elements, it is necessary to define [40]:

- connotation of accident categories;
- scenarios and alternatives to assess;
- stakeholder characteristics;
- time horizons and reference periods;
- list of macro-cost items and their declination.

3.1 Connotation of Accident Categories

It should be highlighted that the methodological approach only takes into account the consequences related to accidents and does not consider the occupational disease. Referring to the consequences of a work-related accident, this classification has been introduced: the death of the victim (D); a permanent disability (IP); a temporary disability (IT). The case of non-occurrence of the accident (NA) is also considered.

In order to quantify the monetary cost of the accident's consequences, an analysis of the main accidents dynamics has to be carried out, by examining the values published by Social Security and Insurance Institutions of the reference context and by detecting the most frequent accidents connotation related to the nature of the injury (e.g. wound, broken bone, fracture) and the body part injured. Having identified the most frequent data for the sector under consideration, the prognosis range, the type of disability and the type of compensation provided by the health/insurance system must be defined.

3.2 Scenarios and Alternatives

Scenarios

It is essential to establish the four scenarios taken as reference. The characteristics to be considered relate to: the contractual regularity of the company's workers (whether

or not there are illegal or undocumented workers); the compliance or non-compliance with health and safety regulations with respect to the legislative apparatus in force; the compulsory registration by the company with social security institutions; the possession of a certification relating to the occupational health and safety management system with requirements in accordance with the ISO 45.001 "Occupational health and safety management systems — Requirements with guidance for use" standard [41].

From the combination of the occurrence or non-manifestation of the conditions mentioned above, the four scenarios could vary from Scenario 1 (S1) where all conditions are non-compliant, to Scenario 4 (S4) where the conditions are compliant.

Alternatives (An)
Combining the outlined four scenarios and the four accident's categories it is possible to obtain sixteen alternatives that allows to assess how specific costs could change (e.g. same accidents occurring in different scenarios or different accident in the same scenario).

3.3 Stakeholder Characteristics

To identify those factors whose variability could have the utmost impact on the assessment of costs, it is mandatory to consider "ordinary" characteristics of the stakeholders. The data should be taken from statistical institutes or pension funds for the production sector examined.

For the worker, it is necessary to consider: working condition, sex, familiar composition, classification by type of work, workplace, type of contract, theoretical annual working hours, average annual working hours worked.

For the enterprise, it is necessary to collect information about average number of workers, average annual revenue, number of accidents in the two years prior the accident occurred.

For the State, noteworthy characteristics are to be found in the State articulation, in particular with reference to the Social Security and Insurance Institutions that directly manage the costs related to the work-related accident like healthcare and welfare costs.

For the Society, the main indicators are those that refer to the quality of life of citizens and the well-being and how the work-related accident could affect it.

3.4 Time Periods

Significant time periods should be defined (Ya, Yb and Yc), by considering three milestones: the first one is the average age of the worker in the year of the accident (Ea), the second one is the age the retirement age under current legislation (Er), the third one is referred to the age relative to life expectancy for the country in question (Ed). Named Ya the first year after the accident, the reference periods Yb and Yc can be determined and assessed through Eqs. (1) and (2):

$$\mathrm{Yb} = \mathrm{Er} - \mathrm{Ea} \tag{1}$$

$$\mathrm{Yc} = \mathrm{Ed} - \mathrm{Er} \tag{2}$$

If the worker is involved in an accident with a fatal outcome, the costs relating to the survivor after the date of the worker's assumed life expectancy should not be considered because the variables - closely linked to family conditions - cannot be traced back to an ordinary condition.

3.5 List of Macro-cost Items and Their Declination

For each stakeholder considered, it is necessary to define a list of specific items useful for the calculation of the cash flows. In Tables 3, 4 and 5 a brief classification of costs is reported, based on the cost categories identified above. All the costs' items must be specifically tailored to the context in which the methodological approach is to be applied, by considering the obligations deriving from the current legislative framework of the Entities responsible for managing accident costs. E.g., for the wage charges the national collective bargaining agreement adopted in the context of reference and its parameters in terms of minimum wage and hours worked should be considered.

Table 3. Macro-cost items for the worker

Cost category	Macro-cost items	Breakdown of cost items
Productivity	Wage charges	Hourly wage base non-regular worker
		Hourly wage base regular worker
		Annual salary for non-regular workers (in S1)
		Annual salary for regular workers (in S2; S3; S4)
	Tax and social security charges	Taxable income
		Contribution for worker's spouse
		Contribution for worker's ki
		Burdens on the employee
		Severance indemnity
	Insurance deductions	Employee's cash account
Healthcare costs	Costs for disability reduction	Removal of architectural barriers Prosthesis supply Supply of specific equipment
Administrative costs	Fines	Labor contract violations
		OSH-related violations
	Fees for the lawyer	Civil Proceedings
		Penal Proceedings
	Funeral expenses	*(only in case of death of the worker)*

(*continued*)

Table 3. (*continued*)

Cost category	Macro-cost items	Breakdown of cost items
Insurance costs	Indemnity	Temporary daily allowance
		Permanent daily allowance
		Survivor's pension

Table 4. Macro-cost items for the enterprise

Cost category	Macro-cost items	Breakdown of cost items
Productivity	Salary	Annual salary for non-regular workers (in S1)
		Annual salary for regular workers (in S2; S3; S4)
	Tax and social security charges	Contribution fees
		Severance indemnity
	Basic personal protective equipment	Safety helmet
		Safety shoes
		Gloves
		Goggles
		Disposable overall
	Replacement worker salary	*(for the friction period considered)*
	Average Annual Revenue	
Healthcare costs	Cost of appointments by position of responsibility	Competent occupational doctor Health Monitoring Protocol
Administrative costs	Fines	
	Costs worker's training	
	Fees for the lawyer	Civil Proceedings
		Penal Proceedings
	Costs relating to the production of documentation required by law	Risk assessment documents
	Cost of health and safety management system according to ISO 45001	
Insurance costs	Indemnity	Temporary daily allowance
		Permanent daily allowance

Table 5. Macro-cost item for the Society

Cost category	Macro-cost items	Breakdown of cost items
Productivity	Tax and social security charges	
Healthcare costs	Costs for disability reduction	Removal of architectural barriers Prosthesis supply Supply of specific equipment
	Costs related to treatment provided by the national health service	
Administrative costs	Fines	Labor contract violations
		OSH-related violations
	Trials	Civil Proceedings
		Penal Proceedings
Insurance costs	Indemnity	Temporary daily allowance
		Permanent daily allowance
		Survivor's pension

3.6 Assessment of the Costs

Once the list of cost items has been defined, the cash flows relating to the three time periods (F_1 for the first period Ya, F_2 for the second Yb and F_3 for the third period Yc) are determined. At the end, the sum of the cash flows F_{tot} is calculated by Eq. (3) for each alternative A*n* (considering *n* varying between 1 and 16).

$$F_{tot}(z)\forall An = F_{1(z;An)} + F_{2(z;An)} + F_{3(z;An)} \tag{3}$$

For each stakeholder (indicated generically with *z*) and for each alternative to evaluate (A*n*) the costs K can be calculated by Eq. (4):

$$F_1 f(z; A_n) = \Sigma_{Ya} f(z; A_n)\,[K_{Ya(P)} + K_{Ya(S)} + K_{Ya(Am)} + K_{Ya(As)}] \tag{4}$$

Consequently, F_2 can be determined by Eq. (6), taking into account that K_r represents the recurrent costs, K_b is the basic costs, y_{ir} is the year immediately following that of the accident:

$$K_{ir} = K_r + K_b \tag{5}$$

$$F_2 f(z; A_n) = \{\Sigma_{yir} f(z; A_n)\,[K_{ir\,(P)} + K_{ir\,(S)} + K_{ir\,(Am)} + K_{ir\,(As)}]\} * Yb \tag{6}$$

Finally, F_3 can be obtained through Eq. (7), by adding up the cost items related to pension contribution (K_3):

$$F_3 f(z; A_n) = \{\Sigma_{Yc} f(z; A_n)\,[K_{3(P)} + K_{3(S)} + K_{3(Am)} + K_{3(As)}]\} * Yc \tag{7}$$

In order to be able to assess the convenience to invest in OSH, the output obtained for each alternative must be compared, by considering the "best" accident consequence categories, that corresponds to the maximum positive value.

4 Conclusions

The issue of occupational health and safety management is closely linked to the Sustainable Goals of the 2030 Agenda [1]. It is clear that the implementation of working conditions, in particular safety management measures and all related prevention activities, could generate benefits in terms of: quality of life and overall well-being of workers; cost savings and increased productivity for the company; reduction of health costs for the community. The methodological approach developed in this research allows to assess the degree of benefit for each stakeholder considered, in relation to the scenarios foreseen. The articulation of the methodological approach takes into account the most influential factors that could change the costs related to the management of health and safety in the workplace.

By modifying the origin of the input values, the method can be applied to multiple contexts, considering any sector of economic activity and any legislative apparatus. The construction of the methodological approach allows, if the boundary conditions may vary, or if the approach should be adapted to contexts that do not provide for the collection of some specific data, to be used even partially to calculate the costs of interest. The research aims to be a useful reference for the awareness of entrepreneurs in the field of health and safety, highlighting the onerousness of the consequences related to the non-application of mandatory legislation on the subject and the convenience of investing in prevention. Moreover, the method could be an effective tool to support the public entities involved in the reduction of the accident situations and the spread of the safety culture at work.

Future insights of the research foresee a systematic application of the methodology to national data in order to outline a picture of which sectors and types of accidents have the greatest impact on the State budget and to support policy-makers in a more effective strategic planning of State investments in prevention, health and training.

The issue dealt with has strong ethical implications, as it affects the health and well-being of workers and citizens [2]. By recalling the words of the President of the Italian Republic in his inauguration speech for his second term in office (on the 3rd of March 2022), "the safety of work, of every worker, concerns the value we attribute to human life" [42].

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