Economic evaluation of occupational safety preventive measures in a hospital

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Abstract.
BACKGROUND: When an organization performs an integrated analysis of risks through its Occupational Health and Safety Management System, several steps are suggested to address the implications of the identified risks. Namely, the organization should make a detailed analysis of the monetary impact for the organization of each of the preventive measures considered. However, it is also important to perform an analysis of the impact of each measure on society (externalities).

OBJECTIVE: The aim of this paper is to present a case study related to the application of the proposed economic evaluation methodology.

METHODS: An analysis of the work accidents in a hospital has been made. Three of the major types of accidents have been selected: needle stings, falls and excessive strain. Following the risk assessment, some preventive measures have been designed. Subsequently, the Benefit/Cost ratio (B/C) of these measures has been calculated, both in financial terms (from the organization’s perspective) and in economic terms (including the benefits for the worker and for the Society).

RESULTS: While the financial ratio is only advantageous in some cases, when the externalities are taken into account, the B/C ratio increases significantly.

CONCLUSIONS: It is important to consider external benefits to make decisions concerning the implementation of preventive measures in Occupational Health and Safety projects.

Keywords: Cost-benefit analysis, financial analysis, occupational accidents, externalities

1. Introduction

Safe and healthy workplaces help businesses and organizations to succeed and prosper and it also benefits the Society as a whole. Work accidents, besides the associated cost in terms of lost lives, injuries and suffering to workers and their families, affect business and also the Society. Fewer accidents means less sick leaves, which results in lower costs and less disruption in the production process. It also saves employers from the expense of replacing the injured workers and/or recruiting and training new staff, and can cut the cost of early retirement and insurance pay-outs [1].

According to the European Agency for Safety and Health at Work [1], slips, trips and falls are the largest cause of accidents in all sectors from heavy manufacturing to office work. Other hazards include falling objects, thermal and chemical burns, fires and explosions, dangerous substances and stress. To prevent accidents occurring in the workplace, employers should establish a safety management system that incorporates risk assessment and monitoring procedures.

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Though there is a natural aversion to reduce health and safety issues to financial terms, money is the metric of business. Indeed, there is a trend to make an evaluation of health and safety issues, including ergonomics-related activities, in monetary terms. Nevertheless, little has been written on the subject of economic analysis of ergonomics-related activities [2].

Several steps are suggested to address risk situation when an organization performs an integrated analysis of risks in evaluating its Occupational Health and Safety (OHS) Management System. The organization should make a detailed analysis of the monetary impact (positive or negative) for the organization of each of the measures considered. However, it is also important to perform an analysis of the impact of each measure on Society (externalities). The measures taken by an organization in the prevention of risks can have a positive indirect effect (positive externality) on Society, while no action due to costs for the organization, can have a significant negative effect on Society (negative externality). Thus, these effects should be duly considered in decision-making regarding the adoption of preventive measures [3].

In the current paper, a case study related to the application of such economic evaluation methodology to a hospital is presented. Firstly, an analysis of work accidents in six selected services has been made. Three types of accidents have been selected: needle stings, falls and excessive strain. These correspond to the most frequent accidents that occurred in the hospital in 2011. Following the risk assessment, a series of preventive measures have been designed. Subsequently, the Benefit/Cost ratio (B/C) of these measures has been calculated, both in financial terms (from the organization’s perspective) and in economic terms (i.e., including the benefits for the worker and for the Society).

Thus, this paper discusses the financial and economic analysis of preventive measures related to Occupational Health and Safety projects based on a case study involving a hospital. The remaining of the paper is organized as follows: next section presents a literature review on economic evaluation of occupational health and safety; in Section 3 a presentation of the case study (including occupational accidents and corresponding preventive measures) is made; Section 4 presents a financial and economic analysis of preventive measures; the paper ends with a final section for the conclusions.

2. Literature review

The evaluation of occupational health and safety issues in terms of costs and benefits is an important issue for the ergonomics-related literature. However, a few references can be found for both conceptual models and field work/applications.

Tompa et al. [4] have made a survey of a large number of studies of workplace-based occupational health and safety interventions and they concluded that very few economic analyses were undertaken amongst such a large number of workplace-based interventions. Indeed, this shows that economic analysis is rarely regarded as a critical component of an intervention study. For a full economic analysis of occupational health and safety, both internal and external impacts of costs and benefits should be taken into account. The concept of externality is a key element in this discussion.

For Varian [5], the definition of externality is that the action of an agent directly affects the living conditions of another agent. Externalities can also be defined as: “the uncompensated impact of a person’s actions on the well-being of a bystander”. The externalities consist of social costs or benefits that come up beyond the scope of the project and influence the well-being of others without monetary compensation [6].

According to Cullis and Jones [7], externalities consist of social costs or benefits that manifest themselves beyond the realm of the project and influence the welfare of third parties without any monetary compensation. In general, an externality is present when the welfare function of some economic agent (utility or profit) includes real variables whose values are chosen directly by others, without special attention to the effect on the welfare of the agent that they affect. Where the project needs or deserves an evaluation by a public entity, the externalities generated are taken into consideration. However, the evaluation of projects of a private nature does not consider the effects on third parties arising from associated externalities. Indeed, the externalities generated by a project are in many cases difficult to quantify. This is the case, for example, of calculations related to the “value” of human life.

In this context, a cost-benefit analysis should take into account the costs throughout the life cycle of the subject under study, involving both economic costs and benefits “accountable” but also the impacts that are not “accountable”, known in literature as externalities [3]. Thus, a full evaluation of OHS shall consider the costs and consequences for the injured worker and his/her family and also for third parties, in particular for public and private players [8].
that match the value of pain and suffering, whose mon-
costs and other costs. There are also intangible costs
wages, compensation costs, health and rehabilitation
tative and legal costs.

The HSE computed the total an-
place accidents as a cost to the company, to the worker
Britain carried out a study that counts the cost of work-
tal distinction between direct and indirect for classify-
sis as it is defined in the economics literature.
Furthermore, Cagno et al. [10] have made a review
of the economic evaluation of occupational health and
safety in Small and Medium-sized Enterprises (SMEs),
starting with more than 500 studies published since
2000. Despite differences in detail and/or terminol-
ogy, most authors and institutions adopt the fundamen-
tal distinction between direct and indirect for classifying
and valuing both costs and benefits. Accordingly,
Cagno et al. concluded that this topic needs more mul-
tidisciplinary research.

The Health and Safety Executive (HSE) in Great
Britain carried out a study that counts the cost of work-
place accidents as a cost to the company, to the worker
and to the Society. The HSE computed the total an-
ual costs of accidents at work, taking average estimated values for the period between 2009 and 2012,
as a reference [11]. This study estimated that in Great
Britain nearly 638 000 workers suffered occupational accidents every year, of which 368 000 were of low-
gravity (with absence from work less than 4 days) and
271 000 with 4 or more days of absence. In this study,
165 fatalities have been identified. As a result of these accidents, it is estimated that 16 000 workers had to
leave work permanently. This study counts the cost of workplace accidents as a cost to the company, to the worker, as well as to the Society.

In the HSE’s study, the cost to the employer includes payments during the absence of the worker, insurance premiums, costs of production losses and administrative and legal costs.

Furthermore, the costs to the employee include lost wages, compensation costs, health and rehabilitation costs and other costs. There are also intangible costs that match the value of pain and suffering, whose monetary value was estimated based on a methodology developed by Gordon et al. [12]. Finally, the costs to the State are considered, which includes all costs not borne by employers or workers (e.g. costs related to the reduction of taxes, payment of benefits, medical treatment rehabilitation, administrative and legal related activities).

In this context, intangible costs must be estimated. According to Targoutzidis and Karypidou [13], in individual terms, one can estimate the value that people assign to their life and health in monetary terms, using two criteria: the willingness-to-accept and the willingness-to-pay. The former estimates the monetary value that individuals accept for being exposed to a higher risk level. For example, a construction worker may accept a job where the risk of falling is high considering the associated monetary compensation. The latter assesses the monetary value that individuals would be willing to pay to reduce a risk to their life or health.

The non-consideration of external costs may bias decision-makers’ behavior in terms of OHS. Thus, prevention has been encouraged by some European Union countries, including Portugal, through the principle of internalizing the costs of workplace accidents. The principle of internalization of costs is based on the allocation of costs to the employer or the individual that caused the costs [8].

Table 1 explains the social benefits and costs in terms of their external and internal dimensions.

In this context, a cost-benefit analysis and related tools and models should provide answers to the following questions: What investments in OHS should be done? How much should be spent on preventive measures? When should each investment be made? [3].

Thus, a robust, properly tested and systematized methodology for economic assessment in the context of risk management will support a better decision making within the OHS. This represents a natural extension of ISO/IEC 31010 [14] in terms of techniques and tools for economic evaluation in risk management and assessment, using the cost-benefit analysis (CBA).

The authors have developed a model for Cost-Benefit Analysis in OHS [3], which allows perform-
3. Case study

The case study presented in this study regards to a public Portuguese hospital, covering an area of approximately 2000 km$^2$ and a target population of 250 000 inhabitants. The hospital has more than 400 beds and a total of about 2500 workers.

The hospital is a public corporate entity incorporated in the National Health Service and is accredited according to CHKS (Caspe Healthcare Knowledge Systems) Healthcare Accreditation Standards. In terms of OHS activities and organization, the Hospital has its own internal OHS Services, which has five health and safety technicians, four of which have high education. This study focuses on six of the services of the hospital, namely three medicine services, two orthopedic services and the emergency services. These services were chosen in collaboration with the OHS services of the hospital, as these are the services in which there is a higher accident rate. The year of 2011 was considered due to the availability of data.

3.1. Occupational accidents

The occupational accidents in 2011 in these services have been studied using official statistical indexes, which allowed prioritizing the measures to be implemented. Furthermore, the costs corresponding to these occupational accidents have been calculated.

The main occupational accidents that occurred in the hospital in 2011 were the following:
- Needle stings: these accidents can lead to the risk of infection of the medical staff, namely of the transmission of the HIV and hepatitis virus;
- Falls: especially due to slippery floor;
- Excessive strain: due to the mobilization of patients and handling loads.

The direct costs of the accidents have been estimated taking into account the labor cost of each injured worker, as well as the costs incurred by the hospital for the treatment and rehabilitation.

The indirect costs of the accidents have been calculated using the simple methodology proposed by Heinrich [15], since this approach is the one used by the hospital. According to this methodology, indirect costs can be estimated as being four times the direct costs, so the total costs are five times the direct costs.

Table 2 presents the direct costs by typology of accident and the total costs of accidents occurred in 2011 in the six services that have been studied.

Costs with needle stings, falls and excessive strain are presented autonomously, as these accidents have been studied in more detail. Total costs presented in the last column include both direct costs as well as indirect costs.

3.2. Preventive measures

A semi-quantitative method of risk assessment has been applied in the hospital. The semi-quantitative method permits to determine a numerical value of the magnitude of occupational risk based on the product of the probability of occurrence of the professional risk by the expected severity of injuries: $R = P \times S$, where $R$ is the level of risk, $P$ the probability and $S$ the severity.
Following the risk assessment evaluation, a series of preventive measures has been defined.

As mentioned before, the risk evaluation has been made in six services. Following this risk assessment, a detailed plan of the preventive measures to be implemented has been designed, with an estimate of the corresponding costs. The preventive measures for the three major risks are presented in next sections.

### 3.2.1. Needle stings

The main preventive measures identified can be summarized as follows:

- Developing training/information actions concerning the use of cut-drilling objects in the workplace;
- Place cutting and piercing objects in the appropriate container without exceeding 2/3 of capacity, according to the institutional procedure;
- Continuous and annual training in the prevention of work accidents – needle stings.

Given the risk of needle stings within the emergency service, the implementation of retractable mechanisms (retractable needle) is particularly recommended in this service.

The costs of these preventive measures have been calculated. The costs have taken into account the number of hours needed for information and training actions, including both the working time of the internal trainers and the trainees involved in each service. In case of the use of retractable needles, the excess of cost of these needles compared to traditional needles has also be taken into consideration, based on the average annual consumption of needles in the emergency service.

Table 3 presents the estimated costs of these preventive measures in each service.

### 3.2.2. Falls

The main preventive measures related to falls that have been identified can be summarized as follows:

- Place warning signs highlighting the fact that the pavement is wet when it is cleaned and implement corresponding training and information sessions for professionals;
- Clearing of the passageways (especially in emergency service);
- Placement and storage of sera media and of the screens (placed in the users’ bathroom) in a proper place that does not constitute a risk factor for falling, both for professionals and for users;
- Training and information sessions related to physical agents: slips and falls in the workplace.

Following the methodology used for the case of needle stings, the costs of these preventive measures have been calculated. The costs have taken into account the number of hours needed for information and training actions, including the working time of both the internal trainers and the trainees involved in each service.

The estimated costs in each service are presented in the third column of Table 3.

### 3.2.3. Excessive strain

The main preventive measures related to excessive strain that can lead to musculoskeletal injuries can be summarized as follows:

- Ergonomic improvements in working equipment and furniture: acquisition of height adjustable beds;
- Specific training of staff in manual handling and services involving loads and mobilizing patients;
- Training and awareness about manual handling of loads in the workplace;
- Training/information actions about surface cleaning, adoption of incorrect postures in the workplace and about mobilization of patients;
- Other preventive measures to be adopted: storing heavier materials on shelves at the height of the arms or lower and corresponding training and information of the professionals.

The costs of these preventive measures have been calculated as explained before. The costs have taken
into account the number of hours needed for information and training actions, including the working time of both the internal trainers and the trainees involved in each service. Concerning the cost of the height adjustable beds, the initial cost has been divided by five, supposing a linear depreciation during a period of five years (no salvage value was considered for the existent equipment).

The estimated costs in each service are presented in the fourth column of Table 3 and the total cost of all preventive measures is given in the last column.

4. Financial and economic analysis of preventive measures

Firstly, a financial analysis (i.e. from the hospital’s perspective) has been made for all the preventive measures that can be adopted. Furthermore, an estimate of the benefits of these measures, in terms of the hospital and also of the society, has been made, based on the model developed by the authors and previously reported [3]. The model is based on an eight-step methodology, including the computation of the costs of accidents, identification of the preventive measures, computation of investment costs (i.e. the cost of the preventive measures), computation of the benefits (from an estimation of the reduction of accidents and corresponding cost reductions) and finally a cost-benefit analysis, both in financial and economic terms.

4.1. Financial analysis

The benefits for the hospital are mainly linked to the expected reduction of the costs of the accidents. According to an optimistic scenario, supposing that the preventive measures have been well designed and will be successfully implemented, it has been estimated that, after the effective implementation of the preventive measures, there will be a reduction of:

- 80% of the accidents due to needle stings;
- 30% of the accidents due to falls;
- 50% of the accidents due to excessive strain.

These estimations are in line with the expectations of the OHS services of the hospital, which take into account previous experience and the strategic objectives defined in terms of accident reduction. The higher value in the case of needle stings is foreseen due to the effectiveness of the implementation of retractable mechanisms in the Emergency services, where the accidents due to needle stings are higher. In the case of accidents due to excessive strain, the estimated value of reduction took into account the acquisition of electric adjustable beds, while in case of falls it is not expected to reduce so significantly these accidents, due to the unpredictability of this risk. The financial benefits for the Hospital correspond to the reduction of the costs of accidents.

Table 4 presents the Benefit/Cost (B/C) ratio in the six selected services, using the above mentioned methodology, for the impact to the hospital of the preventive measures related with the three types of accidents: needle stings, falls and excessive strain.

In the first case, related with needle stings, the amount of benefit was calculated considering the total cost of the accident (direct and indirect) and the estimated 80% of reduction in accidents and respective total costs, presented in Table 2, after the implementation of the preventive measures (e.g. in case of Medicine B: 6 000 € = 0.80 × 5 × 1 500 €). Subsequently, the B/C ratio was computed, expressing the relation between the estimate benefits and the cost of the preventive measures presented before in Table 3 (e.g. in case of Medicine B: 5.05 = 6 000 €/1 189 €). If the B/C ratio is higher than 1, the preventive measures are effective, because the benefits outweigh the costs. Thus, high values of the B/C ratio correspond to very effective preventive measures.

Considering this, it is possible to see that in all the services in which accidents have occurred in 2011, there is a financial advantage of implementing the measures related with needle stings, as the B/C ratio is higher than 1.

In terms of falls, the measures foreseen are only cost-effective for the two orthopedic services, which are the services in which accidents are more frequent.

In terms of excessive strain, the preventive measures foreseen for the two orthopedic services are clearly cost-effective. Finally, the measures for Medicine C and Emergency services are also justified from a financial point of view.
Table 5
Relationship between the cost to the worker, the Society and the company

<table>
<thead>
<tr>
<th>Type of accident</th>
<th>(C_{\text{worker}}/C_{\text{company}})</th>
<th>(C_{\text{society}}/C_{\text{company}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident that does not lead to sick leave or whose sick leave is equal to or less than 3 days</td>
<td>0.67</td>
<td>5.33</td>
</tr>
<tr>
<td>Accident leading to sick leave for more than 3 days</td>
<td>4.22</td>
<td>1.30</td>
</tr>
<tr>
<td>Fatal accident</td>
<td>7.93</td>
<td>0.96</td>
</tr>
</tbody>
</table>

\(C_{\text{worker}}\) – Costs for the worker; \(C_{\text{society}}\) – Costs for the society; \(C_{\text{company}}\) – Costs for the company.

Table 6
Economic benefits of preventive measures

<table>
<thead>
<tr>
<th>Externalities</th>
<th>Related with</th>
<th>Benefit * (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implications in terms of family stability, including pain and suffering</td>
<td>Worker</td>
<td>Intangible, estimated at 1 005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intangible, estimated at 5 933</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intangible, estimated at 1 615</td>
</tr>
<tr>
<td>Reduction of the family income</td>
<td>Worker</td>
<td>337</td>
</tr>
<tr>
<td></td>
<td>National Health System</td>
<td>704</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>Cost to the National Health System in terms of expenditure of hospitalizations, treatments and recovery</td>
<td>Society</td>
<td>Intangible, estimated at 9 905</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intangible, estimated at 1 828</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intangible, estimated at 12 846</td>
</tr>
<tr>
<td>Implications in terms of productivity and competitiveness for the economy</td>
<td>Prevention campaigns related to needle stings/falls and slips/ excessive strain, extending to other entities in the health system</td>
<td>Society 7 500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intangible, estimated at 7 030</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intangible, estimated at 12 050</td>
</tr>
<tr>
<td>R&amp;D activities (development of new needles with safety mechanism)</td>
<td>R&amp;D activities</td>
<td>Intangible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>Other</td>
<td>Other National Health System Society</td>
<td>Intangible, not quantified</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intangible, not quantified</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intangible, not quantified</td>
</tr>
<tr>
<td>Total</td>
<td>Total</td>
<td>16 500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 832</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 511</td>
</tr>
</tbody>
</table>

*Economic benefit per type of accident avoided and by accident.

The overall values in Table 4 reflect the weighted B/C ratio of preventive measures by typology of accident, which considers the different impact of such measures in the six services studied.

4.2. Economic analysis

If only the organization’s perspective is considered, the analysis of occupational safety preventive measures in a hospital results on an incomplete assessment of the impact of such investments. Thus, it is also important to perform an analysis of the impact of each measure for the society, i.e. to measure the involved externalities [3].

To calculate the externalities, some questions from the model “Cost-Benefit Analysis in Occupational Health and Safety” of Ramos et al. [3] have been used and new items were also added, based on the study conducted by the Health and Safety Executive (HSE) [11].

Regarding externalities related to the worker, we have to consider the benefits related to intangible aspects, including the implications for family stability, including worker’s pain and suffering. To convert these externalities in monetary terms, the methodology proposed by Gordon et al. [12] has been followed, using for this purpose the most recent data published in the study conducted by the Health and Safety Executive and taking as reference average values estimated for the period between 2009 and 2012 in Great Britain [11].

These studies of the Health and Safety Executive consider “costs to the government” as all costs resulting from the workplace accidents that are not supported by the company or by the worker. Therefore, they can somehow be extrapolated as costs to the society. Table 5 shows the relationship between the cost to the worker and to society in terms of the costs related to the company, depending on the severity of the accident – calculated from the statistics published by HSE [16].

These relationships allow us to make an estimate of the external costs to the company (externalities) from the computed internal cost of the accidents (from the perspective of the company).

For the economic analysis it is important to take also into account the work incapacities resulting from accidents. There is a direct relationship between the ma-
terial agent of the accident and the type of disability originated. In the case of the hospital, the “excessive strain/mobilization of patients” is the material agent that originates a higher (or more prolonged) temporary absolute incapacity, and instead the “needle sting” a material agent that does not originate any type of incapacity.

The economic analysis of the measures to prevent accidents is presented in Table 6, which includes the benefits for the worker and for the society related to the reduction of accidents due to needle stings, falls and excessive strain. Part of the intangible benefits was converted into monetary units, according to Table 5. The values presented concern the benefit related to each accident avoided.

4.2.1. Needle stings

To calculate the value of the first row in Table 6 (implications in terms of family stability, including pain and suffering), it was used the factor presented in the second column of Table 5 (accidents not leading to a sick leave) and the average cost of accidents due to needle stings (0.67 \times 1 500 €). To calculate the value of the fourth row (implications in terms of productivity and competitiveness for the economy), it was used the factor of the third column of Table 5 and the average cost of accidents due to needle stings (5.33 \times 1 500 €).

Every year there are more than 5 000 work accidents in Portuguese hospitals due to needle stings. According to the opinion of medical staff and Health and Safety experts in this area, prevention campaigns are very important to reduce these accidents, extending the experience of the hospital to other entities in the health system. Taking into account these facts, it was estimated that for every accident prevented in the hospital studied, five accidents in Portuguese hospitals could be avoided. The corresponding benefit to society will then be 5 \times 1 500 €.

Given that in 2011 there were 18 accidents with stings in the studied services of the hospital and that it was estimated that there would be an 80% reduction of accidents due to needle stings after the effective implementation of preventive measures, 14 accidents can be avoided. The benefits external to the company can then be estimated as being 14 \times 16 500 = 231 000 €. Thus, taking into account the external benefits that were quantified, the economic B/C ratio of these measures will be 23.1 (Benefits: 21 600 € + 231 000 € = 252 600 € and Costs: 10 940 €). The benefits for the organization are equal to the total costs of accidents avoided, computed from Table 2. Annual costs of the preventive measures are presented in Table 3.

This means that the impact of these measures, from the society standpoint, is very high: more than 23 euros for every euro invested. That is, while the financial B/C ratio considering only the benefits to the Hospital, is only 1.97, the economic B/C ratio, regarding the external benefits that were quantified, is 23.1, amply justifying the investment in economic terms, i.e. if the social impact of these measures is considered.

4.2.2. Falls

Accidents due to falls can lead to work incapacity. In the studied services, in 2011 some accidents occurred which led to absolute and partial temporary incapacities.

The average cost of each occupational accident due to fall in the services studied was estimated taking into account the number of accidents by fall (10) and the total cost of accidents by fall (14 059 €). Thus, the average cost per a fall accident was estimated to be approximately 1 406 €.

The economic analysis of measures to prevent falls is presented in the corresponding column of Table 6, considering their external benefits, both for the worker and for society. Part of the intangible benefits was converted into monetary units, according to Table 5 (accidents leading to a sick leave). Values presented in Table 6 refer to one accident per fall.

To calculate the implications in terms of family stability, including pain and suffering, we used the amount of the second column of Table 5 and the average cost of accidents with falls (4.22 \times 1 406 €). The calculation of the reduction of family income was based on the total loss of salary (30%) for temporary incapacity (partial and absolute) in 2011 in the services studied (3 366 €) divided by the total number of accidents due to falls (3 366/10 = 337 €). The third value (cost to the National Health System in terms of expenditure of hospitalizations, treatments and recovery) was calculated taking into account the average daily cost in Orthopedics (335 €), the fact that 3 out of 10 accidents have led to work incapacities, an average of 7 days of admission for temporary absolute incapacity, divided by the total number of accidents (3 \times 335 \times 7/10 = 704 €). The implications in terms of produc-
tivity and competitiveness for the economy have been estimated using the amount of the third column of Table 5 and the average cost of accidents with falls (1.30 × 1 406 €). To estimate the value of the benefit coming from campaigns related to preventing falls, extending to other entities in the health system, it was considered that for every accident prevented the hospital studied, five accidents in Portuguese hospitals could be avoided (5 × 1 406 €). The proportion of one to five has been estimated in the same manner as the case of the accidents due to needle stings.

Given that in 2011 there were 10 accidents due to falls in the studied services of the hospital and that it was estimated that there would be a 30% reduction of accidents due to falls after the effective implementation of preventive measures, 3 accidents can be avoided. The benefits external to the company can then be estimated as being 3 × 15 832 € = 47 496 €. Thus, taking into account only the external benefits that were quantified, the B/C ratio of these measures will be 7.5 (Benefits: 4 218 € + 47 496 € = 51 714 € and Costs: 6 902 €).

This means that the global net benefit of such preventive measures is equivalent to more than 7 euros for every euro invested. That is, while the financial B/C ratio considering only the benefits to the hospital, is just 0.61, which does not justify the investment, the economic B/C ratio, regarding the external benefits which were quantified, is 7.5. Thus, the investment is fully justified in economic terms.

It should be noted that in the study conducted by EU-OSHA [17], the B/C ratio in the Austrian case involving the prevention of falls was 6, which means that profitability was six euros for every euro invested, value not stray too far from the value obtained in this study.

4.2.3. Excessive strain

Accidents due to excessive strain can also lead to work incapacity, but in 2011, in the services studied, there were no accidents that led to absolute and partial temporary incapacity.

The average cost of each occupational accident due to excessive strain in the services studied was estimated taking into account the number of accidents due to excessive strain (10) and the total cost of accidents due to this cause (24 100 €). Thus, the average cost per accident due to excessive strain is 2 410 €.

The economic analysis of measures to prevent accidents due to excessive strain is presented in the corresponding column of Table 6, considering their external benefits, both for the worker and for society. Part of the intangible benefits was converted into monetary units, according to Table 5 (accidents not leading to a sick leave). Values refer to one accident due to excessive strain.

The calculations concerning the benefits in the reduction of one accident due to excessive strain has been made in a similar way as for the needle sting case.

Given that in 2011 there were 10 accidents due to excessive strain in the studied services of the hospital and that it was estimated that there would be a 50% reduction of accidents due to excessive strain after the effective implementation of preventive measures, 5 accidents can be avoided. The benefits external to the company can then be estimated as being 5 × 26 511 € = 132 555 €. Thus, taking into account the external benefits that were quantified, the B/C ratio of these measures will be 20.6 (Benefits: 12 050 € + 132 555 € = 144 605 € and Costs: 7 022 €).

In the case of excessive strain, the impact of the preventive measures is very high: more than 20 euros for every euro invested. Again, like in the accidents to needle stings and falls, the economic B/C ratio is much higher than the financial B/C ratio (which in this case is only 1.72).

Table 7 summarizes the financial and economic B/C ratio of the preventive measures related to the three types of accidents which were studied.

The economic B/C ratio is much higher than the financial B/C ratio, due to the significant benefits estimated both for the worker and for the society. The higher economic B/C ratio corresponds to the case of the prevention of accidents due to needle stings, due to the high number of accidents that can be avoided and the corresponding high benefits for the society.

5. Conclusions

This paper presents and discusses the application of Cost Benefit Analysis (CBA) in Occupational Health and Safety (OHS) in the particular case of a Public Hospital. This approach permits to perform an economic evaluation of risks and prevention initiatives from both the company and the society perspectives.

Nevertheless, like all the techniques and tools, CBA has its own strengths and limitations [14]. Some of these strengths should be highlighted. Firstly, CBA allows the comparison between costs and benefits using a single metric (money). Secondly, it provides transparency for the decision-making process. On the other
hand, some weaknesses may be also identified, namely the fact that it requires detailed information to be collected, and benefits, which accrue to a large population, are difficult to estimate, particularly those relating to public goods, which are not exchanged in markets. Furthermore, the practice of discounting future cashflows assumes that benefits in the long term have little or negligible impact; which means that this method does not take into account risks affecting future generations unless very low or zero discount rates are set.

Given the apparent lack of studies on the use of cost-benefit analysis related to Occupational Health and Safety projects, this paper presents an analysis of the impact both for the organization, for the worker and for the Society, of preventive measures. A case study in a Portuguese Hospital due to needle stings, falls and excessive strain was used for this purpose.

The analysis of the financial Benefit/Cost ratio showed that, for the Hospital considered in this case study, only part of the preventive measures defined in the risk assessment process are cost effective. It was shown that the financial B/C ratio considering only the benefits to the Hospital is relatively low and in some cases below 1, but the economic B/C ratio is significantly high, fully justifying the investments. This fact should be taken into account by the administration of the Hospital in the moment of deciding to implement the preventive measures resulting from the risk assessment. Indeed, it is important to consider the effect of the preventive measures on the workers and on the Society.

Nevertheless, additional work should be done. This study can be replicated and extended in several ways. For example, for the preventive measures with B/C ratios lower than 1, changes or alternatives can be proposed to improve their cost effectiveness. One direction for future research could be extending the methodology to other preventive measures, studying different services, and adopt a multi-industry or multi-case background.

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