The \textit{Productivity Assessment Tool}: Computer-based cost benefit analysis model for the economic assessment of occupational health and safety interventions in the workplace

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Abstract

\textit{Introduction and Method:} This paper describes the concepts behind cost benefit analysis in occupational health and safety and introduces the Productivity Assessment Tool, a method by which an analysis may be performed relatively easily in a service or manufacturing workplace. The advantage of using such analyses is to show the important financial role that safe and efficient workplaces play in the workplace. \textit{Results:} By using analytical tools, the effectiveness of an intervention (workplace change) may be estimated prior to its introduction. \textit{Impact on Industry:} This places occupational health and safety on the same financial footing as other proposed workplace changes and thus places occupational health and safety in a strong position to attract scarce resources.

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1. Introduction

If a worker is adversely affected by his or her work, there will be an adverse cost to the employer as well as to the individual worker.

The most visible form of “adverse cost” is time away from work (recorded as a lost time injury). However, productive time will also be lost where workers are not able to work with total efficiency (e.g., due to poorly designed equipment or work procedures causing sore or tired muscles). Poor working conditions (lighting, dust, fumes, bullying, stress, etc.) may contribute to people staying away from work or avoiding time in certain work areas. Poor quality job design and working conditions may also increase staff turnover.

Most managers know the direct wage costs of injury absence but are oftentimes not in a position to know the additional or “hidden” costs. Several attempts have been made to calculate these “hidden” costs. Andreoni showed that the estimated hidden costs varied between 0.5 and 20 times the wage or salary costs (Andreoni, 1986); this variation was both between and within countries. In an unpublished survey we conducted in Australia, employers estimated that hidden costs were between nil and 3.5 times the wages paid for unskilled or semi-skilled workers.

Thus it is difficult to defend a choice of any one ratio for estimating hidden costs. Rather it is better to derive hidden costs for each situation or, at least, each company or organization. The items that constitute the greatest proportion of “hidden” costs include:

- overtime,
- over-employment (extra staffing),
- training,
- supervision,
- employee (labor) turnover,
- waste and rework
- lost production time, and
- reduced productivity.
There are other cost items that may be significant in specific situations and that should be taken into account:

- warranty costs,
- maintenance,
- product and plant damage, and
- equipment downtime (due to injury incidents).

Lowered profit and reduced investment opportunities for the organization are the end results of unnecessary costs due to poor or unsafe working conditions.

Relevant costs need to be included in an analysis to enable a comparison between occupational health and safety funding requests and competing funding demands. To do this the costs due to occupational injury and disease, and consequent reduced productivity, must be calculated and the relative importance of the costs determined for each workplace. This is the rationale behind cost benefit analysis.

Much of the early work in the field of assessing the gross costs of injury to the organization was devised by Dr. Paula Liukkonen of Stockholms University; she was the first to codify occupational health costs in a generic form. Most of her work has been published in Swedish but she has summarized some of her ideas in English (Kupi, Liukkonen, & Mattila, 1993).

2. Methods for cost benefit analysis

2.1. Approaches to costing

There are several ways to cost an occupational health and safety intervention that include, but are not limited to, an insurance model and a cost benefit analysis model.

The insurance model's costing of work-related injuries and injury absence uses the easily obtained workers compensation insurance information; this has the advantage of simplicity but it is also limited. It does not measure, for example, productivity losses and employee turnover and thus may seriously underestimate the total costs of injury absence. As it may underestimate the total injury costs it will likewise underestimate the potential savings from investment in avoidance of these costs. This insurance model will provide no incentive for small organizations with no history of injuries to implement occupational health and safety improvements.

On the other hand, a cost benefit analysis model measures all significant employment parameters that contribute to the product or service. It requires more data but, by assessing the total costs of employment and the losses due to injury or poorly designed workplaces, the model is specific to that organization and is a better reflection of employment costs.

2.2. A specific cost benefit analysis tool

The Productivity Assessment Tool is a cost benefit analysis model. Its emphasis is on employees and the costs and benefits that their employment brings to the organization.

In the first edition of the book Increasing Productivity and Profit through Health and Safety (Oxenburgh, 1991) there were 60 case studies illustrating occupational health and safety solutions to poor working conditions and a paper version of a cost benefit analysis model based on the work of Dr. Liukkonen. Computer software for this model has been developed and the latest version of the software, productAbility, is enclosed as a CD with the second edition of the above mentioned book (Oxenburgh, Marlow, & Oxenburgh, 2004).

The simplest and most frequent use of the Productivity Assessment Tool is to measure the increase in cost effectiveness of employees after an intervention. More specifically, it is time based and can compare a “before” and “after” situation.

The model can also be used for analysis of, and comparison between, two or more proposed interventions; it can assess the cost effectiveness for each intervention although it will not determine which is the most effective in injury prevention terms. The purpose of the model is to examine cost effectiveness rather then injury effectiveness.

An interesting feature of the model is the use of sensitivity analysis. Organizations often do not realize which are the most sensitive cost parameters (especially if they are “hidden”) and, by entering workplace data, modifications to this data will demonstrate the relative importance of each cost parameter (overtime, down-time, injury absence, employee turn-over, etc.).

The software for this model can also be used to measure the cost-effectiveness of rehabilitation for even a single worker.

The Productivity Assessment Tool has been developed to consider the costs and benefits of an intervention within a relatively short time period. It is assumed that the value of the money used to fund the intervention will remain exactly constant over the course of the project and it is usual to use the input data and resultant data without currency modification. In our experience this assumption of a short term is valid; we have found that in most interventions we have examined that the pay-back period was short (frequently less than six months).

3. Concepts behind cost benefit analysis

3.1. Overview of the Productivity Assessment Tool

Cost benefit analysis is a time-based differential model based on the difference in specific aspects of the workstation
before and after an intervention. Thus the pertinent summated data collected after an intervention is subtracted from the pertinent summated data before the intervention takes place. The calculations determine the differences (savings and pay-back period) between the initial case (before) and the test or intervention case (after).

There are four parts to the analysis in the Productivity Assessment Tool (see Table 1):

- data concerning the employees includes the number of employees, their working time and wages, overtime, and productivity;
- data concerning the workplace includes supervisory costs, recruitment, insurance, and other general overheads, maintenance, waste, and energy use, as applicable;
- the intervention (in the test cases the costs, or estimated costs, for the intervention); and
- the reports (cost benefit analysis calculations and reports of the workplace and the employees).

The basic version of the software, which is supplied with Increasing Productivity and Profit through Health and Safety, is restricted to the analysis of one test case and one employee group for any particular workplace. The complete computer program (ProductAbility, 2004) allows up to four interventions (test cases) and up to five employee groups for each workplace.

3.2. Concept of productive time

If you are producing solid materials (nuts and bolts, textiles, pencils, etc.), then machine or material productivity may be measured in terms of output per hour. Some types of worker productivity may also be measured as the output that a worker makes in a unit of time, but often this is not the case. One measure, and in some cases the only measure, of productivity is the ratio between the time paid for by the employer and the time the employee spends actively working; the productive hours.

Productive hours are defined as the total hours paid for by the employer LESS hours not actively producing, over a one-year period. These “non-productive” hours, which are paid for by the employer, include:

- injury (workplace) absence,
- illness absences,
- training,
- vacation and statutory holidays, and
- other absences (e.g., maternity leave, military service).

The call center industry, for example, regards daily telephone time as a measure of productivity and takes great pains to ensure that each day the operators are plugged into the telephone system for as long as possible. Eighty percent of the time plugged into the telephone system is assumed to be more than 75% productive.

However, it is not sufficient to look at each day at work but to look at the total picture over a longer period, say a year. Unnecessary days off work due to a poor working environment will lead to a loss in productivity, which may not be measured by the daily productive time.

The so-called knowledge industry (architects, scientists, physicians, authors, etc.) is an example where quality is the crucial parameter, not numerical output. In many cases an approximation to productivity may be measured by productive time; within reasonable limits professional people will produce more if he or she is at work for a longer period over a year than for a shorter period; for many the total productive time may be the only productivity parameter that is easily measurable.

Clearly, the drawback with the concept of productive time is that it takes no account of quality. We make no apologies for this when presenting a simple analytical tool; attempts have been made to quantify quality but they tend to be difficult to use. In measuring the productivity of a law court it is hardly sufficient to look at the productivity of a judge (the number of cases each year) unless one looks at the quality of each judgment (fairness and agreement with the law). Hence, in many cases productive time may be the only reasonable measure.

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<th>Table 1</th>
<th>Overview of the Productivity Assessment Tool</th>
<th>Data concerning employees</th>
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<td>Initial case—data on:</td>
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<td>Cost benefit analysis calculations; savings and payback period</td>
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<td>Test cases—expected changes for:</td>
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<td>costs, or estimated costs, for the intervention</td>
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3.3. Measuring productivity losses from the ‘ideal state’

This cost benefit analysis model, the Productivity Assessment Tool, distinguishes two types of time; daily time and longer periods. As noted above, the productive time is measured in yearly periods.

A shorter time period, termed “Reduced Productivity,” is used for both short periods of time and for the more usual productivity measurement of countable objects. These both relate to output, usually on a shift basis, and are reduced to a percentage of either the maximum or the optimum output; the “ideal state.”

In any workplace there is always some knowledge of this “ideal state;” if all the machinery worked perfectly and if people did not get tired or wished to talk to their colleagues or even go to the toilet, what we could only achieve! This cost benefit analysis assumes that this figure is known and asks “how close are you to this 100% ideal state?” and thus “what is your reduction in productivity?”

In some industries this “ideal state” can be determined accurately. In manufacturing, the number of items that a particular machine can make in a certain time period is taken to be 100% and anything less than this is converted to a percentage reduction. The reasons for any loss may be due to a poor working environment, poor training, breakdown of machinery, and so on.

In other industries the “ideal state” is more difficult to measure and that is why the concept of daily time is used. In a call center one can look at the daily time required for breaks, supervisor and team meetings, training, and any “paper work” and then make a determination of a reasonable time plugged into the telephones; less than this will be a loss of productivity.

One can make a similar determination of productivity loss about white collar work such as retail shop staff, secretaries, and similar employment.

3.4. Allocating indirect or ‘hidden’ costs

Some of the input data require an allocation, or a proportion, of the indirect employment costs. For example, allocation can be made for the cost of supervision within a company: if five employees share a supervisor who spends 50% of his/her time with them, or on matters connected with them, then the employee group has a 50% share of the supervisor’s wages as a cost factor.

The same is true for the personnel/human resources department. If there are 100 people in the factory then one percent of the wages for the personnel/human resources department are allocated as an additional cost for each employee.

3.5. Reduction in productivity and the role of interventions

The points above are intended to focus the mind on the workplace and to ask the question “are we achieving optimal productivity?” Measurement will tell us “yes” or “no” and, if “no,” will lead us to the next question “why?” followed by “what can be done?”

The reasons that employees give lower than optimum productivity may include:

- too much physical stress
- too much mental stress
- too few breaks
- poor supervision
- poor lighting or ventilation
- uncomfortable seating
- low pay
- low status
- equipment breakdowns
- poor job design

Some of these are within the scope of occupational health and safety practitioners and some are beyond their scope. It is true that occupational health and safety practitioners are not usually in a position to influence pay but it is possible to influence job design, supervision, training, and work methods as well as other and more obvious aspects of poor lighting, ventilation, and uncomfortable seating. It is in these areas that cost benefit analysis should be involved.

4. Discussion and a case study

4.1. The intervention

The intervention is the change proposed to ensure better and safer working conditions. Once one has measured the conditions before the intervention it is then necessary to measure the same parameters after the intervention (the changes to the workplace).

Clearly, if the intervention has not yet taken place the data has to be estimated. This is no different from a manager or engineer planning to make changes to a service or manufacturing facility — the outcome has to be estimated. There is always the possibility of bias in the data chosen or estimated but, in our experience, if the data used is that agreed to by management, bias is restricted to management perception and not to the occupational health and safety personnel.

4.2. Data collection

Readily available data can be found from the accounting and payroll systems. These sources will give routine information about direct wage costs as well as paid absences (e.g., vacation and public holidays, sick leave, injury absence) and additional costs of overtime, labor turnover, and training. Tax, insurance, and other obligatory costs can also be found. Mostly the data will be reasonably accurate; certainly accurate enough for most analyses.
Some of the data may only be available for the entire organization, so you may need to take a proportionate or allocated cost for the specific workplace where the intervention is to take place, as noted above for supervisory staff (see 3.4 Allocating indirect or “hidden” costs).

Productivity data should be relevant to the intervention and may include training time, error rates, warranty and repair costs, waste and energy costs, maintenance of equipment, as well as output, both qualitative and quantitative.

For many companies, especially smaller ones, there is often a lack of written information concerning productivity. The reason for this may be:

- lack of time or skills to collect relevant information,
- the lack of ability to analyse such information, and/or
- that relevant information is kept in the head and not committed to paper (or computer).

Whatever the reason, management and employees involved in the intervention will be an invaluable source of verbal information. Information should not be discarded because it is not written down or does not carry as much accuracy or detail as one would like. Clearly, one has to sift information carefully to ensure that exaggerations do not creep in; but generally the information is good and, in any case, may be the only source.

What is included in the database and what is not may also be a matter of organizational procedures. Some companies do not recognize that product warranty costs should be a cost against the work area where the errors occurred or that a proportionate cost for down-time should be allocated to various work areas. If these cost parameters are critical values to the intervention, then they need to be included; excluding them will disguise or dilute the value of the intervention.

4.3. Case study

The case study concerns a four star hotel that had seen its workers compensation insurance premium rise to an extent that was affecting the overall company profit.

The reasons for the rise in workers compensation insurance included musculoskeletal injuries to the back and upper arms of the room attendants (cleaners or chambermaids). The main factors that led to the injuries were found to be:

- stretching when cleaning the bathroom tiles, mirrors, and windows;
- force and repetitive actions in vacuum cleaning; and
- bending and force when moving beds.

Other factors that were identified as leading to injuries were organizational and time pressures and uneven workloads.

We were brought in to advise management on injury reduction and hence cost reduction. We chose to take a participative approach to job design. Working committees were set up, consisting of representative room attendants and the hotel’s occupational health and safety manager, to determine better working methods and work schedules.

The committee identified workplace training as an aspect that required considerable improvement and the training manuals were re-written to include the methods identified as safe.

The intervention costs were $96,000 and included improved equipment and maintenance, improved training, work procedures, and organizational changes. These led to a marked decrease in both the incidence and severity of injuries and the workers compensation insurance costs came down substantially. There was also a reduction in labor turnover from 60% to 40% per year and an increase in the quality of work.

Table 2 shows the Initial case and the situation that we forecast it would be after the intervention (Proposed intervention); the calculations were based on the same mix of employees and a conservative estimate of a 50% reduction in injury absence and insurance experience costs. This estimate was agreed as reasonable by the hotel management and was sufficiently favorable to convince the management team to implement the intervention strategy we proposed.

We reassessed the work situation one year after the intervention. Due to a change in the employment mix (reduction in contract staff and replacement by casual staff),

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<th>Table 2</th>
<th>Cost benefit analysis of the intervention made to the hotel attendants’ equipment, training and work procedures</th>
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<td>Initial case Proposed intervention Actual conditions after one year</td>
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<tr>
<td></td>
<td>Full-time, 66 Contractors, 30 Full-time, 66 Contractors, 30 Full-time, 55 Contractors, 8 Casual, 73</td>
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<td>Full-time equivalent employees 96 96 96</td>
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<td>Wages</td>
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<td>Supervision and quality costs 000$/year 703 703 703 512</td>
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<td>Insurance 000$/year 173 104 173 104 104 55</td>
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<td>Total employment costs 000$/year 3,970 3,901 3,071</td>
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<td>Intervention costs 000$ – 96 96 96</td>
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<td>Savings 000$/year – 69 898 898</td>
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<td>Payback period (months) – 17 2 2</td>
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Note: this is a simplified version of the case study and full details may be found in Oxenburgh, Marlow, and Oxenburgh (2004), page 84 et seq.
reduced employee turnover, improved work quality, and a greater-than-expected reduction in the insurance costs, the actual payback period was only two months (actual conditions after one year).

A better-than-expected outcome is not unusual; by asking relevant questions, in this case the employment mix, brings into focus many cost parameters not otherwise noted.

References


ProductAbility (2004). Software for the Productivity Assessment Tool (full version) (Copyright; Oxenburgh, M. and Matchbox Software Ltd., UK). See www.productAbility.co.uk or e-mail maurice_oxenburgh@compuserve.com.

Maurice Oxenburgh graduated from the University of New South Wales with a doctorate in biochemistry but, for the past quarter of a century, has worked in occupational health and safety. While working in industry he realized that although managers wanted efficient workplaces they only saw safety as a cost; his experience showed otherwise. Dr Oxenburgh is presently Emeritus Research Scholar at the National Institute for Working Life (Sweden) continuing his work on developing methods for measuring worker safety and productivity. He is a Fellow of the Ergonomics Society of Australia.

Pepe Marlow is a graduate in Physiotherapy and post-graduate in Economics. She is a consultant specializing in short-term projects in the occupational health, safety and injury fields and her clients include both private and public organizations. Prior to her consultancy, she was a Manager at the National Occupational Health and Safety Commission (Australia) where she was responsible for oversight of contracts for the analysis of the cost-benefit of proposed new occupational health and safety standards. Both authors have worked together for a number of years on various aspects of cost-benefit analysis in occupational health and safety.