Cost benefit studies that support tackling musculoskeletal disorders

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Twenty nine case studies are presented demonstrating ergonomics interventions carried out in organisations to reduce the risks of musculoskeletal disorders (MSDs). Of these, twenty one quantify the costs of the intervention and the benefits that have been gained. The case studies illustrate ways in which investments in reducing musculoskeletal risks have resulted in financial benefits to the company through cost savings, or increased productivity and quality of output.

The case studies have been drawn from a range of industries. The ergonomic interventions took a variety of forms, from addressing the design of the task, the equipment, workstation and environment, to the organisational context in which the work was done. The studies that have been produced vary in complexity and magnitude, containing within their scope simple and inexpensive fixes to aspects of a job, and major projects involving several personnel and quite significant capital outlay.

Benefits were clear to see when a company was already incurring costs due to sub-optimal task design or workplace organisation. Where benefits were difficult to quantify, testimonials were used to describe the benefits.

It is hoped that by making the business case for ergonomic interventions this will promote the benefits of a proactive approach to managing MSD risks.

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EXECUTIVE SUMMARY

Twenty one case studies are presented that show the cost benefit analysis of ergonomic interventions to reduce the risks of musculoskeletal disorders (MSDs). An important tool in persuading UK businesses to adopt good practice in tackling MSDs is to demonstrate that ergonomics interventions at the workplace can prevent MSDs and benefit businesses financially.

In UK business, competing in a market-driven global economy, business owners, shareholders, managers and their advisers need to be persuaded that business investment is sound, that it will provide a good return on investment, and, increasingly, that it will form an integral part of their goal to meet good practice in social responsibility. It is against this background that interventions to improve health and safety must be considered.

The cost of MSDs to UK business and society is well known. The Health and Safety Executive (HSE) estimate that in 1995/96 MSDs cost British society £5.7 billion, with 1.0 million people currently affected each year, resulting in 11.6 million lost working days (2004/05)\(^1\). MSDs most commonly affect the lower back (almost half of those who suffer an MSD), the upper limbs or neck (just over a third of those who suffer an MSD), with fewer people experiencing problems in their lower limbs (almost a fifth).

The case studies that have been produced varied in complexity and magnitude, containing within their scope simple and inexpensive fixes to aspects of a job, and major projects involving several personnel and quite significant capital outlay.

The case studies presented here have been drawn from a range of industries. In many instances the design or organisational ideas will be readily transferable to other industries and situations. The ergonomic principles that led to changes to a packing line in a food processing factory, for example, are likely to apply to a manual assembly line for other goods. The ergonomic interventions took a variety of forms, from addressing the design of the task, the equipment, workstation and environment, to the organisational context in which the work was done.

Benefits were established by calculating the investment required to bring the intervention about and comparing that cost with the quantifiable benefits of the improved work system. It was important therefore to be able to compare the difference in conditions before the intervention and afterwards. The research team therefore considered changes to sickness absence levels attributed to MSDs, productivity rates, staff turnover, and other variables which might apply such as reduced waste of materials and higher quality output. Different factors were applicable to different case studies, and not all companies were able to provide comprehensive data on all potential costs or benefits. Where necessary, assumptions were made about certain costs using the HSE Ready Reckoner cost calculators, published on the HSE’s websites. Where estimates have been made, they are identified as such in the cost benefit analysis calculations. A Chartered Accountant supported the research team by interpreting financial data where necessary and ensuring that calculations were in accordance with good accounting practice.

In situations where companies had used their risk assessment procedure proactively to avoid health problems before they occurred, ‘before’ and ‘after’ data on MSDs could not be used: the potential risks had been avoided before they had begun to emerge. Estimating savings from avoidance of potential MSDs was difficult in these cases because any figure put forward would

\(^1\) www.hse.gov.uk/msd
be based on assumption only. Musculoskeletal injuries are complex and do not follow a linear
dose-response relationship. Benefits were clear to see when the company had already started to
incur costs due to sub-optimal task design or workplace organisation. Where benefits were
difficult to quantify, testimonials (that is, informed statements and comments made by workers,
managers or health and safety staff) were used to describe the benefits.

By way of example two case studies are summarised.

Case study: Controlling handling risks for offshore equipment

The first case study is from the oil and gas industry. Radioactive sources are used to investigate
the density of rock formations. The radioactive material is stored in source containers of various
sizes weighing from 10 to 75kg. Onshore these containers were handled manually into an
overpack which was used for transporting the containers offshore. A back injury had occurred
when an operator was loading the heavier of the containers; this resulted in six months sickness
absence. Another similar incident resulted in 10 days lost revenue from sickness absence.

It was not possible to make the source containers lighter or to change the dimensions of the
overpack which would have improved the postures that could be adopted. Instead, a jib crane
was fitted permanently to the top of the overpack which would take the weight of the containers.
In addition, a trolley was fitted to the interior of the overpack which would allow containers to
be handled without the operator having to reach into the storage space.

One overpack was modified at an initial cost of £2,500 and the system was tested in the
operational environment. After it was found to be successful a further 14 overpacks were
modified at an additional cost of £10,000. As a result of this intervention it has been found that
the cost of injuries has been avoided and the job is reported to be less fatiguing. The total direct
intervention costs were £14,875, the net intervention benefit was £178,671, and the payback
period was 3 months.

Case study: Better workstations to reduce risks to shoulder and neck

The second study relates to the manufacture of medical devices. Attaching ultra-fine sutures,
used in ophthalmic surgery to needles, by a foot operated pneumatic machine was a highly
skilled job. The location of the microscope eyepieces meant that very awkward, and at times
extreme neck postures had to adopted and held to position the needle correctly in the needle
clamp. There was no job rotation from this task. Shoulder and neck discomfort was reported by
40% of the workers carrying out this task.

It was identified that the high ergonomic risk could be avoided if the ultra-fine attaching job was
only performed for four hours per shift. However, four-hour maximum task time significantly
reduced the productivity levels which cost the Company both lost revenue and profit. Therefore
modifications were made to the workstation to improve the posture. Although this reduced the
musculoskeletal risks the Company remained concerned about the residual risk.

As a result the workstation height was raised and a camera and small monitor were installed that
allowed the operator to check the location of the needle without adopting awkward neck
postures. Staff who had not been experienced in the task could now perform it with less training
than had been required before. An ergonomic assessment was undertaken of the revised
workstation which showed that operators could work safely for an additional two hours a day
without being at significant risk of musculoskeletal pain or injury.

The cost of the modification to the workstations and for purchasing the cameras was £9350, the
net intervention benefit was £18,900, and the payback period was 12 months.
To our knowledge this is the first time that an attempt has been made to gather a significant number of case studies that demonstrate quantifiable benefit to organisations from tackling MSDs. Despite certain difficulties that were faced, most notably being able to isolate the required information from the organisations, the required deliverables have largely been met.

The case studies can be used to provide ideas for ergonomic interventions and to support a business case for the investment of time and money which may be necessary to realise them. The organisations that have carried out this analysis have found the exercise to be very worthwhile and it is hoped that the case studies will have a wider implication by indicating the ways in which MSDs cost money and quantify how their elimination can save money. The list of issues to consider which have been used in the cost calculations can be used by organisations wishing to balance the costs and benefits of investing in ergonomic interventions.
1 INTRODUCTION

Case studies that show the benefits of tackling musculoskeletal disorders (MSDs) were produced from a range of industry sectors. The case studies illustrate ways in which investment in reducing musculoskeletal risks has resulted in financial benefits to the company through cost savings, or increased productivity and quality of output.

In most cases there was a short term cost and thereafter the company began to derive a net financial benefit. It is hoped that making the business case for ergonomic interventions will promote the benefits of a proactive approach to managing MSD risks.

The ergonomic interventions presented here took a variety of forms, from addressing the design of the task, the equipment, workstation and environment, to the organisational context in which the work was done. Examples have been drawn from a wide range of industrial sectors, and include interventions to reduce the risks of MSDs in any part of the body. The focus of the research was on preventing MSDs rather than looking at ways in which workers with MSDs were rehabilitated back into work. In practice, the occurrence of MSDs is often the precursor to ergonomic initiatives that benefit the wider workforce.

Some of the case studies show simple and straightforward means by which MSD risks were reduced and savings or productivity gains subsequently made. Others case studies were complex and required expert help in job analysis and the implementation of solutions. Although the level of initial investment was higher in the more complex cases, the returns on investment have tended to be greater.

The following industry sectors or areas of application are represented in the case studies. Manufacturing and engineering have been further described to provide more detailed information:

- Agriculture / horticulture
- Banking
- Construction
- Cosmetics manufacturing
- Engineering – offshore oil and gas equipment
- Food processing and manufacture
- Estate management
- Health care provision
- Laundry services
- Medical devices manufacturing
- Office / clerical
- Pharmaceuticals
- Retailing – electrical goods
- Warehousing and storage

The requirement was to provide 10 case studies for interventions tackling manual handling and upper limb disorder issues, and 5 studies for interventions tackling lower limb disorder issues. This requirement was not completely achieved; in this collection of case studies, upper limb disorders are the most frequently represented type of MSD, closely followed by manual handling. Lower limb disorders are represented in certain case studies in the medical equipment
manufacture and agriculture / horticulture sectors, but these were few. The type of MSD tackled in the case studies was in line with expectations, based on several epidemiological studies of MSDs. Upper limb and manual handling issues are also generally better understood than lower limb disorders and more likely to be the subject of ergonomic intervention. However, it was also found that some interventions tackled MSDs in general and that the interventions made reduced the risk of both back and upper limb injuries.
The cost–benefit argument as a driver for improved health and safety performance is not new. Heinrich and Bird et al were the early pioneers, and others have followed on (e.g. Andreoni). Two important documents were published by HSE in the 1990s: ‘The costs to the British economy of work accidents and work-related ill health’ and ‘The costs of accidents at work’.

These established in Britain the economic model for measuring and demonstrating the costs and benefits of health and safety interventions. The HSE has since published on its website a ready reckoner for calculating the costs and benefits of interventions. This enables businesses to calculate the costs and benefits of health and safety to their enterprise.

In 1999, the European Agency for Health and Safety at Work published ‘Health and safety at Work: a question of costs and benefits?’ Agency director Hans-Horst Konkolewsky noted in his introduction that a “strong and increasing interest” in cost–benefit analysis had been identified during the Agency’s European research in this area.

However, there are few evidence-based case studies published that demonstrate clear cost savings for ergonomics interventions. One series of case studies has been collated by Oxenburgh et al that include studies demonstrating cost–benefit analysis where a variety of health and safety interventions have been applied.

While health and safety professionals may be persuaded of the importance of tackling MSDs through ergonomic interventions, they are often limited in what they are able to do due to financial constraints. They often need to be able to persuade financial controllers or directors or managing directors of the benefit of releasing funds for health and safety interventions, and that this investment will be good for the company’s profitability. This is equally true for small and medium sized enterprises (SMEs) where there may be fewer available resources for health and safety investments.
3 APPROACH

Initial case studies were identified through the ergonomics consultants’ existing industry contacts. The study was also promoted through industrial bodies, trade unions, Business Links, newsletters and trade journals. Some potential case studies were also identified via HM Factory Inspectors who were made aware of the research project.

A briefing document was produced that was sent to potential contributors. It explained the purposes of the study and how it would be carried out. The briefing document is shown at Appendix 1.

In some cases there was sufficient data available for the company to send to the research team without a workplace visit being required. For the remainder, a visit was conducted by one of the ergonomics consultants. Prior to the visit, a second briefing document was issued that indicated the type of information that the researcher would be hoping to obtain. It also suggested personnel whom the researcher might wish to contact during the visit. This could include personnel from the health and safety department, human resources, or financial departments. It also included engineering (or technical services) personnel who might have implemented the initiatives and operators engaged in the tasks. The pre-visit briefing document is shown at Appendix 2.

A pilot study was carried out using case study material already available to the researchers through previous consultancy work. This enabled the process to be evaluated and helped ensure that there was a consistent approach to gathering information and compiling the case studies within the research team.

3.1 IDENTIFYING ERGONOMIC INTERVENTIONS

Ergonomics is defined by the UK Ergonomics Society as the application of scientific information concerning humans to the design of objects, system and environment for human use. In the context of this study, the definition would therefore apply to workers and work systems.

The briefing document sent to potential contributors to the study asked companies to consider one or more interventions they have made to reduce the risk of MSDs. It was indicated that ergonomic interventions can include addressing the design of the task, the equipment, workstation and environment, to the organisational context in which the work is done.

The researchers’ expertise in ergonomics was used to identify those case studies that would best fit the requirements of the study.

3.2 DEVELOPMENT OF THE COST BENEFIT MODEL

A cost benefit analysis model was used, wherever possible, that provided a return on investment period. The aim was to encourage organisations to consider the savings that they would make rather than look only at the costs when making decisions about expenditure on measures to reduce MSDs. The case studies showed that initial investment costs were sometimes recovered very quickly.
The return on investment was worked out by comparing the sum of all of the relevant costs with the sum of savings and benefits made over a given time interval. If the total costs were £1,000 and the savings per week were £100; the return on investment period would be 10 weeks. Depending on the scale of the initiative, a week or a month was chosen as the time interval in calculating the payback period.

A crucial aspect of carrying out the cost benefit analysis analyses was capturing all of the costs associated with making changes and all of the savings following those changes. At times, certain costs or savings had to be estimated because the company did not have data available. Many organisations, for example, would be able to say how many staff were off sick over a given time period but would not be able to determine how many individuals were on sick leave due to MSDs.

Cost calculators published by the HSE² were used to assist in the estimation process and were useful as a checklist of possible costs to consider. The research team included a Chartered Accountant to ensure that cost benefit analysis analyses were carried out using appropriate and conventional economic methods.

The costs of implementing changes included:

- Employment costs of personnel investigating workplace ergonomic problems and determining solutions
- Employment costs of operators engaged in user trials
- Costs associated with staff getting used to a new system or carrying out formal training
- Materials costs for new equipment or modifications
- Labour costs for purchasing and fitting new equipment or modifying existing equipment
- Costs of accommodating new designs, which might arise from changing the workplace layout

Cost savings and benefits tended to take two main forms: savings made by avoiding the costs of MSDs; and benefits accrued through increased productivity. Of these two principal benefits, there are a number of sub-categories which were used in the analysis as applicable.

Calculating the costs of MSDs from before and after the intervention could include consideration of the following:

- Instances of musculoskeletal sick leave and their duration
- Ratio of personnel on sick leave because of MSDs before and after
- Staff turnover
- Compensation claims
- Reduced working time leading to reduced productivity on certain tasks because of the risk of MSDs or excessive fatigue

Working out the benefits included possible consideration of:

- Greater output over a given time period
- Reduced wastage of raw materials (occurring for example when personnel were able to work more efficiently because the task had been designed around operator capabilities)
- Higher quality output – fewer mistakes in better designed jobs
- Savings in wage costs from jobs which were made less manually intensive

¹ Ready reckoners for accidents, ill health and incidents can be found via http://www.hse.gov.uk/costs/
Certain benefits were considered to be intangible and were not used in the calculation of the benefits. In some cases the company could not provide the data that would be necessary for the calculations, either because it had not been collected or because it could not be collected (such as the monetary benefit to the company from higher morale).

Where appropriate, unquantifiable benefits were identified in the case study as being likely to have an influence on costs.

Benefits and savings that were generally not included in the analysis included:

- Savings from avoiding future compensation claims; such data not being available or unable to be isolated from the insurance premium or self-insuring funds
- Savings from avoiding recruitment costs could generally not be isolated from operating costs
- Savings from higher staff morale and maintaining the good name of the company because the data is not gathered. This was found to be a concern for companies in areas where skilled workers were difficult to attract, or a good safety record was a discriminator in renewal of business contracts.

3.2.1 The use of discounted rates of return

An 8% discounted rate of return has been applied in the cost benefit analyses. The rate is used to determine the value of the money that the company would have made over a period of time by investing it as cash, rather than spending it on the intervention. If the investment would have produced a greater return by holding onto the money rather than spending it, then the intervention would not have been successful in purely financial terms. Eight percent per annum is a commonly used rate for the purpose of assessing commercial viability across UK industry.³

If it is assumed that the intervention is financed by borrowing and that the cost of borrowing is 8% per annum, then each year’s projected cost savings has to be discounted at 8% per year to the initial time period to reflect the time value of money.

To establish the value of the investment, it was necessary to estimate the length of time (known as the appraisal period) for which the intervention would apply without major change to the work process. On the advise of the economist within the research team, three years was used as the typical length of time were benefits were gained through increased productivity or cost savings through reduced sickness absence. Five years was assumed to be the maximum length of time where capital equipment had been purchased.

3.2.2 Net present value

The net present value method is illustrated by the following example: an intervention requires an initial investment of £1,000 in equipment on the basis that this is expected to result in a reduction of £400 per year in sickness absence and other overhead costs. An 8% discounted rate of return is assumed. There is no discount to be applied in year one, only in years two and three.

³ Eight percent is recommended, for example, by the Department of Finance and Personnel of the Northern Ireland Government http://www.dfpni.gov.uk/
Thus, the savings of £400 realised in the first year after implementation of the intervention is discounted twice at a rate of 8% to yield a present value of £338.56.

3.2.3 The payback period

The payback period is the length of time required to recover the cost of the intervention. It is defined as the time it takes for the cumulative total of net benefits to equal the original investment costs and measures the amount of time it takes to break even. For example, if £1,000 was invested in an intervention yielding an average net benefit (total benefits gained minus the total cost) of £200 per year then the payback period equals five years. The shorter the payback period, the more quickly funds invested in the project will become available for other purposes and hence the more liquid the project.

3.2.4 Base price year

This is the year on which the calculation of the costs and benefits has been based. Thus, for example, wage costs are calculated on the basis of the wages plus overhead costs from this year.
4 COMMENTARY

Some of the organisations participating in the study had taken a proactive approach to health and safety and had identified ergonomic risks before the risks had evolved into complaints of discomfort or pain, or MSD-related sickness absence. In other organisations, the emergence of these indicators of a mismatch between human capabilities and the job provided the stimulus for an investigation into how to address the problem.

There were four principal routes through which musculoskeletal problems would be brought to the attention of management:

- Risk assessment
- Identification of MSD risks from an ergonomics consultant
- Sickness absence data
- Reporting of problems through line management or in a forum for health and safety, without the risks necessarily having been identified through formal risk assessment

A common feature in the case studies was that once MSD risks had been identified, the organisation provided resources to investigate the way the job was being done and find ways of making the most physically demanding aspects of the job easier. This focussed examination of task performance provided in several instances an insight into inefficiencies in the task that had previously gone unrecorded. Addressing ergonomic risks such as poor posture were sometimes achieved by changing an earlier aspect of the work process. For example, supplying materials in easier to handle quantities might be sufficient to avoid having to retrofit a workstation to enable bulky and heavy items to be handled safely there. A benefit of avoiding ergonomic problems in this manner was often that work efficiency was improved; with benefits being accrued through higher productivity and avoiding the unnecessary waste of time, effort or materials.

The requirement was to provide 25 case studies with a cost benefit analysis that support making ergonomics interventions to tackle MSDs. The authors have been able to provide 21 such case studies. In addition they have been able to provide 8 case studies where the data that has been collected, or available, was not detailed sufficiently enough to enable the analysis to be completed with the necessary rigour. Although a formal literature review was not a part of the project, the authors did carry out a moderately detailed review. Very few studies were identified that presented case studies such as those presented here. Therefore, to our knowledge this is the first time that an attempt has been made to gather such a large number of case studies that demonstrate financial benefit to organisations from tackling MSDs. As a result it was difficult to gauge the extent of the resources required, and the extent of the collaboration required with organisations providing the information and data. This proved to be the most problematic aspect of the project. Our experience shows that there are probably four reasons for this:

- Cost-benefit analyses are difficult to conduct in the health and safety arena and it is very difficult to assign costs and benefits to ergonomics interventions.
- Few organizations have the time to carry out such detailed measurements; they are more concerned with overcoming ergonomics problems and getting on with business provided that the costs of so doing are within their budgets.
- Few organizations study their operations in detail as long as they appear to be working satisfactorily.
Many organisations are unable to provide the necessary data and in any case may be unwilling to support a thorough analysis of costs and benefits by an external body. In a few instances the organizations found this exercise to be relatively straightforward because they had adopted a type of cost-benefit analysis in determining whether to proceed with an intervention, or a choice of interventions. This however was the exception rather than the rule. More time than we had expected had to be devoted to gathering this data.

We found that organizations placed much greater emphasis on tackling back and upper limb injuries than lower limb injuries. This is most likely to be because the latter are less common in industry and commerce, and are generally confined to specific types on industrial sector or job.
5 CASE STUDIES

The case studies are presented at Appendix 3. They are presented in no particular order with the exception that case studies from similar industries or applications are positioned together.
Briefing document for industry participation:
Gathering cost-benefit case studies that support tackling musculoskeletal disorders
Hu-Tech on behalf of The Health and Safety Executive

The Health & Safety Executive (HSE) is seeking to publish case studies from UK industry that demonstrate the costs and benefits to a company and its workforce of interventions to manage the risk of musculoskeletal disorders (MSDs). This document describes the way in which the project to identify and work up case studies will be co-ordinated by Hu-Tech.

Why are we being asked to contribute to this research?

Cost-benefit case studies are an important way to show that ergonomics interventions at the workplace can prevent MSDs and benefit businesses financially. Case studies from a range of industries are required to demonstrate that this philosophy can apply across the board.

Companies that contribute case study material will have an opportunity to showcase their proactive approach to cost beneficial health and safety management. The option to remain anonymous is also open.

What will we be asked to do?

In the first instance, companies that wish to participate should consider one or more interventions they have made, or are in the process of making, to reduce the risk of MSDs. Ergonomic interventions may have taken a variety of forms, from addressing the design of the task, the equipment, workstation and environment, to the organisational context in which the work is done. The MSDs targeted may have affected any part of the body. There is no requirement for a cost-benefits analysis to have been carried out as the Hu-Tech study team has been put together to gather this information.

Assuming that the required data were not readily available, we would visit those companies and organisations that have indicated they wished to take part. During the visit the study team would visit the departments or individuals where the data could be found. Information relevant to the production of cost-benefits analyses will be gathered by qualified ergonomists and a senior Chartered Accountant, as appropriate. All data would be processed according to the Data Protection Act 1984. More information on commercial confidentiality is provided below.

Data will be collected on the situation and costs pre-intervention, the costs of the intervention, and the benefits accrued following the intervention.

We would, where possible, also collect photographic records of the intervention, and identify photos or other data concerning the situation pre-intervention. The published case studies may, or may not, show these photographs. This can be determined at a later date.
APPENDIX 1 – BRIEFING DOCUMENT

How much will it cost us?
The study has been designed to minimise the costs to industry partners. The study team combines ergonomists from Hu-Tech with considerable experience in producing case studies for the HSE from industry, and because of the nature of this project, the study team includes professional economists who will be managed by Hu-Tech. Limited demands on resources will be made provided that the study team has access to company records.

What control will we have over how our information is used?
We will be prepared to sign Non-Disclosure Agreements that prohibit the study team (or anyone connected) from passing on sensitive company information: that is to say, data that is not required to be disclosed to Companies House and is not in the public domain.

Before the case studies are used, each company will have the opportunity to review the material and will be asked to formally agree to HSE using it for the purposes of publication (whether or not the company wishes to remain anonymous).

What if we don’t have the costs data?
We would still like to make contact with you. It may be that we can use the information that you have available as a part of the study. We will discuss with you before you/we decide that your case study should be included.

What form will the published case studies take?
The HSE plans to publish the cost benefits case studies so that they can be used to inform businesses of the role that ergonomics can play in reducing MSD risks and providing return on investment.

The case studies will include a concise description of:

- the industry/company and an overview of the work tasks that are performed
- the employee(s) characteristics
- the employee(s) relevant tasks, including a thorough description of the risk factors
- the health problem(s) reported
- the intervention applied to prevent the risk(s) with a statement of the financial cost of the intervention
- how the intervention was monitored to evaluate its impact
- the long term outcomes to the company and the individual, with evidence of how these benefits have been calculated.

Will participating in this project help us in future investment planning?
Yes. The management accounts costing template that will be developed in the first phase of this research will be made available to our industry partners so that they can use it in the future to assist with their own planning for future investment.

The study will show that investing in health and safety can offer a good return on investment. As the cost benefits of MSD related ergonomics interventions are not readily quantifiable, one of the outcomes of this research will be to demonstrate the value of releasing funds for health and safety interventions. The value will not only
be seen in improved health and well being but in company profitability too. This is equally true for small and medium sized enterprises (SMEs) where there may be fewer available resources for health and safety investments. This research should give confidence in health and safety planning for the future.

**What happens next?**

If you would like to, or are considering whether to take part in the study, please contact Arran Mitchell at the address below. We will then ask you to complete a short questionnaire (over the phone, via email or the post) asking about the information that is available and its accessibility. If necessary, we will visit the data holder to explain the purpose of the research and to gain authority to collect or gather the information and data. If sufficient information appears to be available the detail required would be obtained by a visit to the company which would involve an interview with the point of contact to gather details of the intervention and the costs and benefits.

The estimated timescales of this research are shown below:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Timescale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish links with companies</td>
<td>September 04 – March 05</td>
</tr>
<tr>
<td>Data collection and evaluation</td>
<td>October 04 – April 05</td>
</tr>
<tr>
<td>Development of case studies</td>
<td>November 04 – May 05</td>
</tr>
</tbody>
</table>

**Contact details:**

Arran Mitchell  
Hu-Tech Associates Ltd,  
Saxon Court  
29 Marefair  
Northampton, NN1 1SR  
Tel (01604) 233428  
Fax (01604) 604967  
Email arran@hu-tech.co.uk

Hu-Tech’s website: [www.hu-tech.co.uk](http://www.hu-tech.co.uk)
Questionnaire for industry participation:
Gathering cost-benefit case studies that support tackling musculoskeletal disorders
Hu-Tech on behalf of The Health and Safety Executive

This questionnaire seeks to establish what information is available for the production of cost benefits case studies for tackling MSDs. As explained in our previous communication, there is no requirement for all of the information to be available at this time. At the moment we are interested in knowing how much information is available and how much will need to be gathered by the study team. Your answers will not be considered to be binding but will help us plan the study.

Personal information
The information requested below is for our internal administration purposes. We will assume that the person named below will be our initial point of contact.

Your name ..........................................
Job title ..........................................
Contact telephone number ......................
E-mail .............................................

Case study background
1. Is information available that describes the type of work carried out, the risks involved and the characteristics of the employees carrying out these tasks?
Yes / No / Partial information available (please circle as appropriate)

Explanatory note
The level of detail required is that which would be sufficient for the task and hazards to be described in broad terms. The characteristics of the employees may be limited to a description such as ‘building workers’, ‘engineers’, or ‘nursing staff’, depending on context.

2. Will information be available to the study team regarding the related health problems?
Yes / No / Partial information available (please circle as appropriate)

Explanatory note
The information we would require includes the incidence of MSDs and sickness absence attributed to MSDs.
APPENDIX 2 – SITE VISIT INFORMATION

3. Is costing information available to the study team regarding the health problems pre-intervention? For example, lost production costs per day or hour, costs involved in replacing staff, liability costs etc
   Yes / No / Partial information available (please circle as appropriate)

Action taken to reduce MSD risks

4. Is information about the intervention including monitoring procedures and costs available to the study team?
   Yes / No / Partial information available (please circle as appropriate)

Outcomes

5. Will the study team have access to post-intervention information, such as sickness absence data, productivity data, and subjective responses from workers?
   Yes / No / Partial information available (please circle as appropriate)

6. Is cost-benefits information (such as improved productivity, reduced wastage, reduced accidents etc) relating to the outcome available?
   Yes / No / Partial information available (please circle as appropriate)

7. If the answer to question 6 was ‘No’ or ‘Partial information available’, will the study team have access to any of the following? Please circle those that apply:
   • Productivity data
   • Sickness absence records
   • Liability costs
   • Cost data relating to remedial steps (these may include the costs of replacing staff, or the costs of making special allowances because of staff health problems or difficulty in task performance)
   • Relevant personnel and departments

Identification

8. Does your company wish to be identified in case study material published by the HSE?
   Yes / No (please circle as appropriate)

9. Will photographs of the workplace intervention be made available for publication by the HSE? Please note that individuals within photographs can be rendered anonymous, as can signs or logos that would otherwise identify the company or location involved.
   Yes / No (please circle as appropriate)

Please return your completed questionnaire to Arran Mitchell at the address below.
APPENDIX 2 – SITE VISIT INFORMATION

Contact details:

Arran Mitchell
Hu-Tech Associates Ltd,
Saxon Court
29 Marefair
Northampton, NN1 1SR

Tel  (01604) 233428
Fax  (01604) 604967
Email  arran@hu-tech.co.uk

Hu-Tech’s website:  www.hu-tech.co.uk
1. Improving the workstation layout for gift box packing

- Packing cosmetics gift boxes by hand involved some operators rushing and others reaching excessively with the risk of upper limb disorders
- Redesigning the layout led to better team working and efficiency
- With a better layout, productivity targets were met and space saved.
- Upper limb disorders risks were reduced with a net saving after three years of £68,247 and a payback period of less than 3 weeks

The task

Gift boxes were packed with a variety of cosmetic products (shampoo, body wash, sponge etc) by a team of eight operators located along a 20m conveyor line. The assorted products, flat packed inner boxes and an insert card arrived on the conveyor and were packed into boxes by the operators. Each operator undertook a different stage of the assembly process (see Figure 1.1). At the end of the conveyor, six gift boxes were placed in an outer box which was then palletised.

There were delays in the process as some of the packing tasks took longer than others. The line speed tended to be set to the output of the slowest operator which meant that often the operator at the end of the line was waiting for boxes to pack onto the pallet. This led to unproductive working and under-achieving on production targets. As a result, management had to bring in temporary staff outside normal working hours in order to finish some orders.

Musculoskeletal risks

The operators worked a 37 hour week, and had two 15 minute breaks and one 30 minute break during the day. Job rotation was used to reduce the risk of work related upper limb disorders and to provide variety. However:

- Inconsistent packing rate encouraged the faster operators to stretch to reach the approaching products on the conveyor
- Some packing jobs were quicker to do than others. Because the cosmetics products arrived on the same conveyor, it was not possible to find a speed that suited all of the products, resulting in some operators having to rush and some waiting for others to finish – both of which can be stressful
- At some workstations there was little time available to clear away surplus packing material which increased the workload of the operator in charge of Materials Supply.

Identifying the problem

Risk assessments were carried out by the health and safety department as part of their routine management of workplace risks. They concluded that the risk of upper limb disorders remained too great and that a more efficient solution might be found that smoothed the workflow and reduced the need to rush tasks or reach across the work area.

What was done?

The Company considered changing the process so that workers passed items to one another when required instead of the process being driven by the speed of the
conveyor. A trial was arranged to look at different ways of organising the work so that the bottlenecks were removed and teamworking could be improved.

Figure 1.1 shows the original layout schematically.

![Figure 1.1 Original line layout (not to scale)](image)

The original layout involved in-built delays because some of the initial packing tasks took longer than the subsequent packing tasks. There was also a tendency to overload the workstation with materials or product by those who undertook the quicker tasks (while waiting for the slower elements to be completed). The company trialled other layout and organisational options, and while these were found to produce some benefits, there were constraints in terms of floor space availability which meant that such options were ultimately not feasible. A short, straight line was found to be the most successful. Figure 1.2 shows the shorter line schematically. Operators could now pass items to one another as they were needed. Tasks were redistributed between workstations to ensure better balance in the duration of each task. The majority of the work was now completed along a 6m length of the conveyor.
Figure 1.2. Reorganised layout on a substantially shortened line (not to scale)

The new layout and organisation of tasks reduced excessive reaching, and walking between workstations. Tasks were evenly distributed between the different workstation positions, so that there was no need to stockpile materials or product by those undertaking the quicker tasks. This allowed operators more time to carry out tasks and reduced the workload of the operator in charge of Material Supply. Job rotation continued to be used to reduce risks and provide variety.

**Costs and benefits**

The trial took two hours to set up and involved all eight operators. The cost of setting up the trial, which included the time of operators and management, was estimated to be £1120. The cost was low because there was no equipment to buy and the trial was conducted in ‘real time’.

The time taken for packing different products in the existing layout was recorded. This showed that the distribution of workload was uneven with some positions often overloaded causing delays at other positions. In the trial, more people were assigned to the slower tasks and minor, quick tasks were combined where possible. The optimum team size, layout and organisation of tasks were established by trying a few alternatives and recording operator preferences and productivity levels.
The efficiency improvement calculated for the short line arrangement was as follows:

<table>
<thead>
<tr>
<th></th>
<th>PPOH</th>
<th>Additional efficiency gain over requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing conveyor set up</td>
<td>50 (baseline for comparison)</td>
<td>N/A</td>
</tr>
<tr>
<td>Short line conveyor</td>
<td>60</td>
<td>20%</td>
</tr>
</tbody>
</table>

* PPOH = Packets (outer boxes) Per Operator Hour

The labour cost saving was £2523 p.a. as additional temporary staff did not need to be brought in to finish the orders on time. Reducing the risk of musculoskeletal disorders is likely to have avoided other costs too, such as reduced capacity to work, higher staff turnover and potential claims for damages.

By increasing the productivity of the packing line, the company was able to re-allocate staff to new tasks, while maintaining the existing level of output. 2,112 hours of staff time (per annum) were freed to be utilised in other areas of the plant.

The space required for the short line was 24m², whereas the original line layout required a space of 80m². The company released the space on the assumption that the space would be utilised within 3 years for other packaging processes.

The principal ergonomic benefits were as follows:

Table 1.1 Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A consistent work rate and a reasonable target pace of work were established.</td>
<td>The time taken at each operator position to carry out the tasks was evenly distributed.</td>
</tr>
<tr>
<td>Reduced risk of upper limb disorders.</td>
<td>No need for stretching or leaning, rushing was not necessary. Unnecessary movement was eliminated.</td>
</tr>
<tr>
<td>Greater job satisfaction.</td>
<td>The arrangement encouraged better teamworking, improved communication and greater social support.</td>
</tr>
</tbody>
</table>
Economic analysis

Costs and Benefits.

Direct intervention costs:  
Operator time for running the trials  
12 hours @ £10 per hour  £120  
Estimate of management time and lost production  £1,000  

Total direct intervention costs  £1,120

Post-intervention benefits  
Additional temporary staff costs  £2,523  
Productivity increase of 20% above target requirement: -  
6 staff at 1760 annual available hours @20%  2112  £21,120  

Additional annual benefits  
Utilisation of additional floor space: -  
Released area of 56m² @ £38.25 per m²  
Year 1 estimate of space utilised: 25%  £536  
Year 2 estimate of space utilised: 60%  £1,285  
Year 3 estimate of space utilised: 100%  £2,142  

Conclusion  
The process lifecycle is assumed to be 3 years from the date of intervention.

Total cost of intervention  £1,120  
Net present value of post intervention benefits over the process lifecycle at an 8% discount rate  £23,643 for 3 years + £536, £1,285, and £2,142 in years 1, 2 and 3.  £69,367  

Net intervention benefit  £68,247  
Payback period  0.58 months  

Base price year is 2001
2. More efficient handling in cosmetics production

- Handling bulk quantities of a cosmetic product involved repeated manual handling in awkward postures
- A close look at the flow of work revealed areas where handling could be avoided
- New equipment was bought at a cost of £9,500 to cut manual handling drastically, with a payback period of one and a half months

The task

A factory making a cosmetic product was concerned about the musculoskeletal risks associated with movement of the product within the factory. Material emerging from the manufacturing area was tipped into containers, then checked, stored and transported to packing halls where it was loaded into a bottle filler machine. The movement of the product from manufacture to loading into the bottle filler took 67.5 hours. There were considerable delays built into the process.

Much of the transfer of the product required it to be handled manually (e.g. scooped in and out of containers) which could involve the operator stooping and reaching. The product was easier to handle when it was fluid, but it became difficult to handle when cooled as it became viscous and jellylike. The main problem was that the material was repeatedly handled during the process, and to handle it effectively, it often had to be heated up and manually stirred.

![Figure 2.1. Lifting bulk material out of the container](image)

Musculoskeletal risks
- Frequent handling and stirring of the material required manual effort
- Awkward upper limb and trunk postures because of the design of the storage drums and transfer containers

Identifying the problem

A risk assessment of the manual handling tasks showed that the likelihood of musculoskeletal disorders was high. The assessment showed that the best way to reduce the risks was to avoid having to handle the material.

What was done?

Although it was possible to identify some solutions such as handling aids, these would not deal with the root cause of the risks which was that the material was difficult to work
with. Major restructuring and other long term solutions would require significant capital investment and were not thought to be feasible.

A project team was set up, comprising:

- two operators (one with NVQ training in production management)
- a Team Leader from both Manufacturing and from Packing
- an engineer
- an ergonomist as project facilitator.

The project ran for five months at a total wages cost of about £1,500. The team met for an hour a week for the first 3 months, then reduced this frequency to once a fortnight.

The operator who had undergone the NVQ training used a process mapping technique over two days to record in real time the activities carried out during the process. He was able to do this while carrying out his normal role. The process mapping allowed identification and quantification of unnecessary movements of the product and inappropriate processing. The project team investigated ways in which these activities could be avoided.

Table 2.1. Example process activity map

<table>
<thead>
<tr>
<th>Description</th>
<th>Distance (m)</th>
<th>Time (min)</th>
<th>Operation</th>
<th>Handling</th>
<th>Transport</th>
<th>Inspection</th>
<th>Delay</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>Wait for microwave to become available before next tub can be prepared</td>
<td>0</td>
<td>05:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Dig material out of drum into plastic tub ready for microwave</td>
<td>0</td>
<td>02:20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Walk to microwave with tub</td>
<td>12</td>
<td>00:32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Melt material in microwave, stopping to stir periodically</td>
<td>0</td>
<td>15:02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>… [continues]</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>TOTAL</td>
<td>460 m</td>
<td>67.5 hours</td>
<td>30 times</td>
<td>86 times</td>
<td>4 times</td>
<td>0 times</td>
<td>10 times</td>
<td>0 times</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>235 min</td>
<td>101 min</td>
<td>34 min</td>
<td>0 min</td>
<td>368 min</td>
<td>0 min</td>
</tr>
</tbody>
</table>
The project team suggested the use of a smaller manufacturing vessel that could keep the material warm using hot water and also allow it to be transported. Vessels were identified from another process at the plant and adapted to be transportable. A pump could be used to transfer the fluid material into the bottles at the end of the process. The process mapping and risk assessment were repeated for the new process to establish the effect of the changes.

Costs and benefits
The new vessel and supporting equipment cost £8,000. Following the change the job took 2.5 hours (with no waiting time) instead of 10.5 hours. Data collected during the task analysis was used to justify the cost of the intervention.

The total wages cost for the time devoted by the project team was estimated to be in the region of £1,500.

The physical waste created when producing each batch (that is, loss of material, cleaning wipes and gloves used in handling the product into the hoppers) totalled approximately £128 per batch which equated to £44,800 per annum. This figure is based on the production cost value of the material.

Addressing musculoskeletal risks by looking at the task in a structured way revealed that there were inefficiencies in the process which had been costing the company money.

Table 2.2 Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>No manual handling of the bulk material was required.</td>
<td>Musculoskeletal risks were virtually eliminated.</td>
</tr>
<tr>
<td>Waste and risk of contamination was dramatically reduced because of the reduction of handling operations.</td>
<td>The task analysis revealed that there had been significant inefficiencies in the process that had gone unnoticed by management. Better operational management procedures were introduced. The waiting time for the product was reduced by 57 hours. Waiting time plus time on task previously took 67.5 hours, as shown in the process activity map.</td>
</tr>
<tr>
<td>Low capital investment to make adjustments.</td>
<td>Very short payback period.</td>
</tr>
</tbody>
</table>
Economic analysis
Costs and Benefits.

Direct intervention costs:
- Wages costs for project team meetings: £1,500
- Manufacture of vessel and supporting equipment: £8,000
- Total: £9,500

Post-intervention benefits:
- Saving:
  - Time saving of 8 hours per batch at labour cost of £13 per hour for 7 batches per week over a 50 week annual production cycle: £36,400
  - Estimated annual value of reduced waste at production cost: £44,800
- Total: £81,200

Conclusion
The process lifecycle is assumed to be 3 years from the date of intervention.

Total cost of intervention: £9,500

Net present value of post intervention benefits over the process lifecycle at an 8% discount rate:
- £81,200 per annum for 3 years: £226,001

Net intervention benefit: £216,501

Payback period: 1.51 months

Base price year is 2001
3. **Re-organising a hand packing line**

- Packing tablets by hand involved repetitive handling and awkward postures because of poor workstation layout
- Risk of musculoskeletal disorders, particularly to upper limbs
- The flow of work was examined to identify imbalances and causes of awkward postures
- With work better organised, productivity targets can be met and ergonomic risks reduced significantly
- Cost of intervention about £12,000; payback period approximately 3 months

**The Task**

In a pharmaceutical plant, tablets were packed into vials by hand. It had been done this way for 10 years. Figure 3.1 shows the original layout of the packing area.
Hand packing was undertaken for orders for small quantities of tablets because it was more cost effective than running the large capacity automatic packers. All stages of the process were undertaken manually except for the counting of tablets which was done with a machine (see Figure 3.2). There were five stages to the process: inserting silica gel, tablets and foam (1 operator); capping (1 operator); packing and weighing (2 operators); tagging (1 operator); shrink wrapping and collating (1 operator). Once each operator had finished their part of the process the vials were moved on to the next stage. Stockpiles of part-finished product would build up as some stages were faster than others.

![Figure 3.2. Manual and semi-automatic stages involved in processing the vials](Image)

The organisation of the work area resulted in the following problems:

- Long cycle time – it took over three hours for a pack to go from start to finish of the line.
- As a result work-in-progress was often 1500 packs part-finished.
- It was difficult to estimate how long jobs would take – additional operators were often brought in to help clear backlogs and overtime was costing approximately £55,000 a year.
- Storage of components was inadequate which resulted in operators frequently having to collect supplies.
- Working conditions were cramped because of the need to store items that were waiting to be progressed.
- Communication between operators was difficult because of the layout.
- Although staff were working continuously, production targets were often not achieved.

Operators worked a 7.5 hour day, with two fifteen minute breaks and a thirty minute break in the middle of the day.

**Musculoskeletal risks**

In addition to inefficiencies in the process, there were ergonomic problems that made the job difficult to do and increased the risk of musculoskeletal disorders.
• Operators had to twist to communicate with one another as most were not facing each other.
• A number of stages required the operators to twist to collect or move the vials.
• Tables were at different heights and some were unstable which made the transfer of materials more awkward. The tables tended to bow in the middle.
• Some of the chairs were broken; most were not adjustable.
• The work process appeared to be disorganised and was unclear. Team morale was low.

The nature of the job meant that most activities were carried out sitting down and required repetitive movements of the upper limbs. There was a risk of staff developing upper limb disorders and back discomfort.

Job rotation was carried out to give operators variety in their work and allow different muscular activities to be carried out. While the job rotation was beneficial in reducing the risk of musculoskeletal disorder and avoiding fatigue, it was not sufficient to overcome the ergonomic problems associated with the work.

**Identifying the problem**

The Company was aware that production targets were frequently not achieved. Initial investigations into productivity levels established that morale within the team was low. Operators were working continuously, but missing targets nevertheless. The investigation also revealed that operators were working under pressure and frequently adopting poor postures. Both of these factors are associated with increased risk of musculoskeletal disorder. Recognising this, the Company decided to act.

The process required rethinking to provide a better ergonomic layout, better storage facilities, improved flow of the vials and better ways of passing items between operators.

The Kanban method of workflow was used to investigate the process to make it more efficient.

The six person team working at the hand packing line attended a training course to understand the principles behind Kanban and the system of continuous improvement.

**What was done?**

Following their training the team reorganised their work area in a series of trials to remove imbalances in the process. They held meetings to discuss ideas to improve the layout, and made video recordings so that they could take an overview of the workflow.

The team aimed to design a layout that allowed the vials to be passed on by hand in a comfortable manner (i.e. with no extended reaching, or twisting of the trunk). They also wanted to enhance communication between team members.

After considering a straight line and a U shaped arrangement, the team decided that an L shaped option would be best. The new layout is shown in Figure 3.3.

The other activities shown in figure 3.1 - Shrink wrapping, collation and storage tables were located nearby. The L shaped layout allowed all components to be passed by operators.

---

4 First developed in the Japanese car industry. Kanban translates literally as ‘ticket to work’ – it is a visual signal to start or stop a task. The thinking behind it is that work flow should be smooth with a minimum amount of work in progress between sequential operations. If there is no space at the next stage of the operation, the operator must wait. Long waiting periods indicate that the line is imbalanced and an improvement should be sought.
hand in a comfortable manner; there was no over-reaching or twisting. Communication was found to be easiest with this layout.

Figure 3.3. L shaped layout. The dotted lines represent sectioned areas of the table where packing and tagging supplies were kept

The team presented their proposal to managers who agreed a budget of £5,000 to bring about the changes. Quotes were obtained from local shopfitting firms and one was engaged to install the new layout.

In addition to the layout, better tables and chairs were bought. The tables were specified by the team so that they had no sharp edges, were resistant to vibration (which affected the weighing scales) and did not bow in the middle. Adjustable chairs were selected, which all members of the team could use comfortably. Mobile storage units were selected which would fit under the tables. These allowed operators to keep their work area tidy and reduced the number of trips made to retrieve components. Other changes were made to the workstation and area to improve the amount of space available e.g. providing smaller boxes for components (see Figure 3.4); allowing the bins to be stored under the tables (see Figure 3.5). The new line layout is shown in Figure 3.6.
Operators rotated jobs every hour to provide variety of postures and movements, and reduce the risk of fatigue associated with repetitive actions.

**Costs and benefits**

Workflow and productivity benefits were as follows:

- Cycle time was reduced from three hours to five minutes as stockpiling was avoided
- Work in progress reduced to 50 packs part-finished
- Productivity targets could be consistently met
- 25% increase in productive hours for the line.

The principal ergonomic benefits were as follows:

**Table 3.1. Summary of benefits**

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjustable seating, better work surfaces.</td>
<td>Personnel can adapt seating to suit their needs, rather than have to compromise their posture to fit the workplace.</td>
</tr>
</tbody>
</table>
Efficient use of space. | Layout reduced awkward postures and improved communication.
---|---
Improved morale. | The working conditions were better and each member of the team was able to contribute significantly to the improvements made.
Better work flow, layout and organisation. | Reduced risk of musculoskeletal disorders through reduced twisting and stretching, balanced work flow and job rotation.

The equipment, materials and installation costs amounted to £2,900 (although £5,000 had been budgeted for). The Kanban training was carried out in-house. The wages cost of the training and the subsequent project meetings were estimated at £9,000.

The 25% increase in productive hours brought about a saving of nearly £55,000 in overtime payments during the following 12 months.
Economic analysis

**Costs and benefits**

**Direct intervention costs:**
- Staff time for Kanban training, and implementation of proposals: £9,000
- Purchase of equipment, tables and chairs: £2,900
- **Total**: £11,900

**Annual pre-intervention costs**
- Overtime payments: £54,815
- Work in progress costs - labour included in overtime payments: £4,688
- Work in progress costs - materials (note 2): £156
- **Total**: £59,503

**Annual post-intervention costs**
- Overtime payments (note 1): £5,000
- Work in progress costs - materials (note 2): £156
- **Total**: £5,156

**Annual post-intervention cost savings**: £54,347

**Conclusion**
The process lifecycle is assumed to be 3 years from the date of intervention.

**Total cost of intervention**: £11,900

**Net present value of post intervention cost savings over the process lifecycle at an 8% discount rate**: £59347 per annum for 3 years = £151,262

**Net intervention benefit**: £139,362

**Payback period**: 2.83 months

Base price year is 2000
### Note 1

**Overall reduction in overtime hours with no change in line output**

<table>
<thead>
<tr>
<th>Hours</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1541</td>
<td>£28,647</td>
</tr>
</tbody>
</table>

**Reduction in WIP repackaging labour costs**

Overtime at £18.59 per hour (including overhead costs) cost 5% of the packs part finished (1500-50) over 250 days at 5.1 minutes per average repack

<table>
<thead>
<tr>
<th>Honors</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1541</td>
<td>£28,647</td>
</tr>
</tbody>
</table>

**Increase in productive hours with an increase in line output**

<table>
<thead>
<tr>
<th>Hours</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2112</td>
<td>£26,168</td>
</tr>
</tbody>
</table>

**Total**

<table>
<thead>
<tr>
<th>Hours</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>4653</td>
<td>£54,815</td>
</tr>
</tbody>
</table>

### Note 2

**Work in progress costs**

The additional labour cost is included within the overtime costs.

**Material wastage:**

Repackaging costs estimated at:

<table>
<thead>
<tr>
<th>Description</th>
<th>Hours</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% of 1500 packs part finished * 250 days *£0.25</td>
<td>4848</td>
<td>£4,688</td>
</tr>
<tr>
<td>5% of 50 packs part finished * 250 days *£0.25</td>
<td>120</td>
<td>£156</td>
</tr>
</tbody>
</table>
4. Manufacturing process using attaching machines

- In a manufacturing process, material was attached using a foot operated pneumatic press, but a lack of adjustability meant that some workers couldn’t fit the machine and others had to work in awkward postures
- Newer machines that could be adjusted were installed. These allowed for more production flexibility and a greater number of employees could now use them
- Reduced musculoskeletal disorders sickness absence and labour costs
- Purchase of new machines cost £400,000; payback period of nearly 22 months

The task

Medical suture material was attached to needles using a foot-operated pneumatic press. The job involved activating the press and checking the attachment using a microscope. The presses were bulky, noisy and required the operator to adopt awkward postures due to the lack of adjustment on them. A microscope was placed beside each press for inspection tasks, which required operators to lean over to use. While working at the press the operators’ hands and arms also tended to be held away from the body to carry out repetitive actions, which was fatiguing.

Work place fitting trials and experience had shown that operators over 5’7” in stature could not work at the workstation for long periods because of discomfort. Consequently the management had adopted a selection process of assigning employees below this height to the task. This selection process meant that 50% of male operators were unable to carry out work on this type of attaching press, which severely limited production flexibility.

![Figure 4.1. Awkward posture while using the press](image)

Musculoskeletal risks

Awkward leaning and stooping postures, together with repeated awkward upper limb movements, particularly of the shoulder, were causing pain and discomfort to operators, especially the taller one. Particular areas of discomfort reported were in the neck, shoulder and upper back.
**Identifying the problem**

The Company management had been aware for some time that the job was only suitable for workers shorter than 5'7" because of complaints of discomfort.

**What was done?**

Trials of raising or lowering the height of the presses did not solve the problem as it simply changed the proportion of the population that could be comfortably accommodated at the machine. Setting the presses at a range of heights throughout the work area was considered to be impractical as different shifts needed to use the presses and this would be awkward to manage.

Parallel investigations were also being undertaken by the engineering department to develop an improved attaching machine that could work on a larger range of sutures. Engineering, health and safety and management met to look at ways in which the production range and postures could be improved to reduce the risks. The Company decided to invest in new equipment to improve working postures and avoid the problem of not being able to assign half of the available male operators to the task.

New lightweight attaching machines were purchased which allowed a greater range of product to be attached. The machines had a range of adjustment features including height, angle of attachment and fore and aft location on the work surface. The microscope was fitted onto the attaching machine in the primary viewing area, which avoided the need for operators to lean to the side to carry out the inspection task. The press die units were redesigned to allow fitters to change dies more easily and quickly after each batch run.

Each new machine cost £4,000 and the Company initially purchased sixty machines and then a further forty following subsequent validation checks. Sickness absence from this key production area of the factory has fallen in the four years since the introduction of the new attaching presses.

![Figure 4.2. New press and microscope equipment](image)
**Costs and benefits**

Table 4.1 Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Musculoskeletal disorders reduced on new attaching press compared with original type.</td>
<td>Estimate of 60 staff days sickness absence avoided each year.</td>
</tr>
<tr>
<td>Deployment of staff to meet production needs is easier.</td>
<td>Height restriction has been avoided on new attaching press.</td>
</tr>
<tr>
<td>20% extra product codes can now be attached on the new attaching machines. The Company has estimated that this gives rise to an annual productivity gain of 5% of direct annual labour costs.</td>
<td>New machines can handle more product types.</td>
</tr>
<tr>
<td>Increased working space on attaching table.</td>
<td>Location of auxiliary equipment can be optimised.</td>
</tr>
<tr>
<td>Lighter press unit.</td>
<td>Allows easier movement of equipment to different production cells to meet fluctuation in specific product demands.</td>
</tr>
<tr>
<td>Quick release press dies.</td>
<td>Allows easier and quicker tool changes which reduces production downtime. Estimated time saving of two hours per week.</td>
</tr>
</tbody>
</table>
### Economic analysis

**Costs and benefits**

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Intervention Costs</td>
<td>£400,000</td>
</tr>
<tr>
<td>100 new attaching machines @ £4,000</td>
<td></td>
</tr>
<tr>
<td><strong>Total costs</strong></td>
<td><strong>£400,000</strong></td>
</tr>
<tr>
<td>Post intervention benefits</td>
<td></td>
</tr>
<tr>
<td>Reduced sickness absence of 60 days / year</td>
<td></td>
</tr>
<tr>
<td>based on a day rate of £108.03 (note 1)</td>
<td>£6,482</td>
</tr>
<tr>
<td>Annual labour cost saving from quicker tool</td>
<td></td>
</tr>
<tr>
<td>change @ 2 hours per week and £14.40 / hour</td>
<td>£1,325</td>
</tr>
<tr>
<td>employment cost</td>
<td></td>
</tr>
<tr>
<td>Annual productivity gain estimated at 5% of total</td>
<td></td>
</tr>
<tr>
<td>direct labour costs (note 2)</td>
<td>£248,469</td>
</tr>
<tr>
<td><strong>Total annual benefits</strong></td>
<td><strong>£256,276</strong></td>
</tr>
</tbody>
</table>

**Conclusion**
The process lifecycle is assumed to be 5 years from the date of intervention.

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cost of intervention</td>
<td>£400,000</td>
</tr>
<tr>
<td>Net present value of pre-intervention costs over the process lifecycle at an 8% discount rate</td>
<td>£1,105,093</td>
</tr>
<tr>
<td>£256,276 per annum for 5 years</td>
<td></td>
</tr>
<tr>
<td><strong>Net intervention benefit</strong></td>
<td><strong>£705,093</strong></td>
</tr>
<tr>
<td>Payback period</td>
<td>21.72 months</td>
</tr>
</tbody>
</table>

Base price year is 2003

**Note 1**
Obtained from the HSE Ready Reckoner for manufacturing industry (£11.08 per hour plus 30% overhead costs)

**Note 2**
Calculated on the basis of 100 attachers on 2 shifts for 7.5 hours/day & a 5 day week for 46 weeks per year at an average hourly wage cost of £14.40 (incl 30% overhead costs) obtained from the HSE Ready Reckoner for manufacturing industry

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total annual cost</td>
<td>£4,969,380</td>
</tr>
<tr>
<td>Estimated saving at 5% of £4,969,380</td>
<td>£248,469.00</td>
</tr>
</tbody>
</table>
5. Better workstations to reduce risks to shoulder and neck

- Attaching ultra-fine sutures was a skilled job that required intensive hand-eye work – much of it in a poor posture
- Assessing the aspects of the task that required awkward postures led to changes which reduced musculoskeletal risks. This allowed 50% more time on the task than was previously possible
- Operators do not need as much experience and training to perform the task reliably. There was greater job satisfaction and less wastage
- Direct intervention costs of £9,350 with a payback period of 12 months

The Task

Ultra-fine sutures, used in ophthalmic surgery, were attached to needles by a foot operated pneumatic swaging machine (a special type of sewing machine). This was a highly skilled job that required six weeks of intensive training and a high level of dexterity. The operator first had to ‘peep’ around the microscope eyepieces to position the needle correctly in the needle clamp. This involved adopting awkward and, at times, extreme twisting and bending of the neck (see Figure 5.1). As the needle was small and the field of view was slightly obscured the extreme neck posture was held during each needle placement procedure. Once the needle was correctly clamped it was cut to the correct length. Fine gauge suture material was then inserted into a holder and then using the microscope the alignment of the suture and needle was checked before the machine was activated to attach the components together. After the suture was attached, the operator tested the strength of the connection using a standard weight. Another microscope was then used as a final quality check. Acceptable sutures were placed in a book for packaging at a later stage. There was no job rotation from this task.

Figure 5.1. Awkward neck postures required to view the needle location

Musculoskeletal risks

The workstation was cramped and the task required awkward shoulder and neck postures with the potential to lead to upper limb disorders. Shoulder and neck discomfort was reported by 40% of the ultra-fine attaching workforce.
Identifying the problem

The Company’s ergonomic risk assessment tool indicated that the high ergonomic risk could be avoided if the ultra-fine attaching job was only performed for four hours per shift. This routine was put into place but due to the high production needs, the lack of trained personnel and sickness absence among the operators, four-hour maximum task time significantly reduced the productivity levels which cost the Company both lost revenue and profit.

What was done?

The company decided to investigate ways of reducing the risks associated with the attachment task rather than rely on reducing the time to which operators were exposed to them. An ergonomist and the line managers carried out the investigation in-house with input from operators.

The clamp at the workstation was reshaped, and screws, which had protruded into the line of sight, were countersunk to give the operator a better view of the clamp and needle area. White tape was put on the base of the clamp to provide a better visual contrast behind the needle. These adjustments were inexpensive to make and they slightly reduced the amount of neck movements by the operators. The situation was reviewed again and the musculoskeletal risks were found to be reduced but still present, and continued to give cause for concern.

It was decided that more drastic workstation modifications would be required to effectively remove the ergonomic issues. The workstation height was raised and a camera and small monitor were installed that allowed the operator to check the location of the needle without adopting awkward neck postures (see Figure 5.2). The angle of the suture cutter was tilted towards the operator so that less stretching forward was needed to see that everything was aligned properly. Staff who had not been experienced in the task could now perform it with less training than had been required before.

Figure 5.2. Monitor and camera installed to allow flexibility of operator posture, and more upright, neutral postures

Following these changes, an ergonomic assessment was undertaken of the revised workstation. The re-assessments showed that operators could work safely for an additional two hours a day without being at significant risk of musculoskeletal pain or injury. In addition, feedback from the operators was also positive with the revised viewing position allowing more comfortable neck postures to be adopted. The modifications also meant that staff did not need as much experience to perform the task consistently. The enlarged image of the needle location also allowed operators to identify potential needle faults earlier before attaching took place, thereby increasing productivity levels and reducing waste.
The workstation modifications included raising the height of the workstation by 50mm to 760mm, which allowed more legroom for the taller operators. Shelving was provided to store items off the work surface thereby allowing more free working space, and a stand was provided for locating the needle tray closer to the swaging machine. This reduced right arm movement when collecting needles.

When not engaged in attaching, the operators would work on the next stage of the process which was winding the ultrafine material to make ready for packing. The costs of the redesign for all the three workstations were as follows:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour costs of the assessment</td>
<td>£400</td>
</tr>
<tr>
<td>Three cameras</td>
<td>£6,000</td>
</tr>
<tr>
<td>Three monitors of appropriate size and resolution</td>
<td>£450</td>
</tr>
<tr>
<td>Meeting costs</td>
<td>£1,750</td>
</tr>
<tr>
<td>Joinery costs</td>
<td>£500</td>
</tr>
<tr>
<td>Reassessment of the risks</td>
<td>£250</td>
</tr>
<tr>
<td><strong>Total costs</strong></td>
<td><strong>£9,350</strong></td>
</tr>
</tbody>
</table>

The benefits were calculated in the following way:

- Previously, an operator working for 4 hours would typically have made 225 suture attachments a day. With the extra 2 hours working time available, each operator made around 300 attachments per day, improving efficiency by 33.3%.

- With needle faults being identified earlier in the process, wastage was reduced.

Prior to the intervention which changed the time on task from four to six hours, the operators spent the extra two hours per day on the background task of winding the sutures onto holders for storage and transportation.

The company did not have a record available of the productivity ratio between the suture attachment and winding tasks. The cost benefits calculations have therefore considered the labour costs of the time spent on each task, rather than the value of the work done.

**Costs and benefits**

Table 5.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>The safe working time was raised from four to six hours per operator per day</td>
<td>This meant that output levels were raised significantly per operator.</td>
</tr>
<tr>
<td>The job was easier to do and there was greater job satisfaction.</td>
<td>Positive effect on staff morale.</td>
</tr>
<tr>
<td>Less wastage reduces costs.</td>
<td>Faulty needles spotted earlier in the process.</td>
</tr>
<tr>
<td>Training costs for new staff are reduced.</td>
<td>Length of on the job training was reduced for new operators.</td>
</tr>
</tbody>
</table>
**Economic analysis**

**Costs and Benefits**

**Direct intervention costs:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour cost of the assessment</td>
<td>£400</td>
</tr>
<tr>
<td>Three cameras</td>
<td>£6,000</td>
</tr>
<tr>
<td>Three monitors of appropriate resolution</td>
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</tr>
<tr>
<td>Meeting costs</td>
<td>£1,750</td>
</tr>
<tr>
<td>Joinery costs</td>
<td>£500</td>
</tr>
<tr>
<td>Reassessment of the risks</td>
<td>£250</td>
</tr>
</tbody>
</table>

**Total cost**  

| Total cost | £9,350 |

**Annual post intervention benefits**

<table>
<thead>
<tr>
<th>Description</th>
<th>Saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour saving across the 6 staff team at 33.3% of the annual labour cost of £85,800 = £28,600</td>
<td>£7,150</td>
</tr>
<tr>
<td>Annual wages cost for time no longer spent on background task = £21,450</td>
<td>£500</td>
</tr>
<tr>
<td>Therefore annual post intervention labour saving =</td>
<td></td>
</tr>
<tr>
<td>Estimated reduced training costs per year</td>
<td>£500</td>
</tr>
<tr>
<td>Estimated saving from reduced wastage per year</td>
<td>£2,500</td>
</tr>
</tbody>
</table>

**Total benefits per year**  

| Total benefits per year | £10,150 |

**Conclusion**

The lifecycle of the process is assumed to be 3 years from the date of intervention.

Total cost of interventions  

| £9,350 |

Net present value of post intervention benefits over the process lifecycle at an 8% discount rate  

| £10,150 per annum for 3 years | £28,250 |

**Net intervention benefit**  

| £18,900 |

**Payback period**

12 months

Base price year is 2003
6. Handling chemicals mechanically

- Changing a chemical that was used in wax stripping involved a risk of back injury from prolonged stooping and handling heavy loads
- The development of a trolley system for taking away old chemical and replacing them with new has reduced exposure to the musculoskeletal and hazardous waste risks
- With the investment of £7,340 the task is now performed ten times more quickly, with a payback period of less than thirty two months

The task

Trichloroethylene (TCE) was used to strip wax from surgical material prior to hardening the tip of the material. TCE is carcinogenic and requires careful handling. It can cause health problems if it comes into contact with the skin, is inhaled or ingested. The TCE had to be replaced approximately every six weeks. This was done by bringing a drum of fresh TCE on a trolley from the chemical store and emptying the old TCE from the container using buckets (as shown in Figure 6.1). The fresh TCE was then decanted from the drum into the TCE container.

TCE was reclassified by the company to a higher risk category. The Company was therefore concerned that this method of emptying and refilling the container exposed employees to risks to their health despite the wearing of appropriate personal protective equipment (PPE). The method of emptying and refilling also involved a lot of stooping and handling, as may be seen in Figure 6.1, increasing the potential for back discomfort.

Musculoskeletal risks

The emptying task required repeated handling of heavy buckets (each weighing around 25 kg) and was time consuming. Pouring was done relatively slowly to minimise the risk of spills. Emptying and refilling the container took around 2½ hours.

Figure 6.1 Scooping the TCE out of the TCE container
There were risks of lower back injury due to poor postures (stooping) and handling heavy loads from the ground.

*Identifying the problem*

A risk assessment was carried out by the Company’s health and safety department on TCE handling, to consider both the manual handling and chemical exposure risks. The hazardous nature of the chemical meant that it was important to consider how it was being handled to minimise the risk of exposure or spillage.

Although it was performed infrequently, the job of refilling the TCE container was considered by the Company to involve a moderate to high risk of musculoskeletal injury because of the extended period for which heavy loads were held and awkward postures were adopted.

*What was done?*

Previous attempts at pumping the chemical in and out of the container were unsuccessful due to the corrosive nature of the chemical on the pumping equipment and rubber hoses. Also the waste TCE was impregnated with fibre material, which tended to block the pump after several chemical changes.

The health and safety department were assigned the task of reviewing the procedure. They consulted operators who were involved with the task, an engineer and an ergonomist from the Company. Initially two buggies were manufactured which could safely transport fresh and waste TCE between the TCE container in the textile preparation area (the place of use) and the chemical service area (where chemicals were stored and sometimes processed). A specialised pump and non-corroding hose was used to suck out the waste and a similar device was used to transfer fresh chemical to the TCE container.

This approach was partially successful – it drastically reduced exposure and TCE handling, but employees still had to clean the TCE container by hand before new TCE could be added. This required awkward stooping into the container.

A second and successful method implemented was a new portable TCE container. A specially adapted tank was manufactured to hold fresh and waste TCE. A second spare tank was also manufactured to ensure manufacturing output was maintained during tank changeover periods. An electric pallet truck was purchased that could move the fresh TCE tank from chemical services area to the place of use. The new tanks were also fitted with more efficient heating coils thereby improving product quality and usage of the TCE. The tanks could be easily decoupled and returned to chemical services on the electric pallet truck. Waste TCE was then decanted under gravity in the well ventilated chemical services area – this area was a better place for transferring hazardous chemicals from one vessel to another as it was designed specifically to support hazardous chemical handling.

At the chemical store, the tanks were filled and emptied using gravity. This was achieved by using a pallet forklift truck to lift the tank above a chemical drum for draining, or the tank would be slid underneath a drum of new TCE for filling. The company invested in non-corroding chemical hoses, which would fit between the tanks and the drums so that there was no risk of spillage. Tanks were steam cleaned to remove the excess wax, debris etc.

Following the intervention, the job could be done in 15 minutes whereas previously it took 2 ½ hours.
Costs and benefits

The following costs were incurred in assessing and reorganising the provision of TCE:

- Electric pallet truck to transfer the tanks to and from the chemical store and textile preparation area: £2,000.
- Two tanks to hold the TCE, including parts (plus hoses), manufacture and labour: £3,000.
- Wages costs of operators, engineer and ergonomist working on the project: £1,800.

The total cost was £6,800.

The benefits were worked out as below:

- Labour cost saving from using the tank system was 2 ¼ hours at £20 per hour for four operators= £180
- The task was done every six weeks which means £30.00 saved per week.

This does not take account of the potential costs associated with staff exposure to TCE and musculoskeletal problems for four operators.

Total savings per week were £30.00.

Table 6.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual handling activities reduced.</td>
<td>Hazardous manual transfer of TCE into and out of the container was avoided. A manual handling related injury that led to a worker being absent for 10 days would cost the Company between £3,200 and £4,800.</td>
</tr>
<tr>
<td>Risk of contamination avoided.</td>
<td>The risk of contamination from exposure to the chemical has been almost eliminated.</td>
</tr>
<tr>
<td>Efficient process.</td>
<td>The job now takes 15 minutes instead of 2 ½ hours.</td>
</tr>
</tbody>
</table>
Risks reduced to acceptable level.
Method of work now meets the company’s safe working procedures and UK legislative requirements.

**Economic analysis**

**Costs and benefits**

**Direct Intervention Costs**
- Electric pallet truck £2,000
- Manufacture and labour for two tanks, parts and hoses £3,000
- Wages costs plus oncosts of operators assigned to the project, engineer and ergonomist £2,340

**Total costs** £7,340

**Post intervention benefits**
- Labour cost saving was 2.25 hours @ £20 per hour plus oncosts for four operators = £234 per TCE change
- TCE change was once every 6 weeks = £39 per week saving £1,950

**Total annual benefits** £1,950

**Conclusion**
The process lifecycle is assumed to be 5 years from the date of intervention.

Total cost of intervention £7,340

Net present value of post-intervention benefits over the process lifecycle at an 8% discount rate
- £1950 per annum for 5 years £8,409

**Net intervention benefit** £1,069

**Payback period** 31.42 months

Base price year is 2004
7. Trolley design for tin lid transportation

- Bread making involved repeated manual fitting, removing and transportation of tin lids, with a risk of back and shoulder injury
- Lids were manually lifted from a trolley and placed on dough tins before they were placed in ovens to bake bread
- Existing trolleys were modified at a cost of £5000 using equipment available on-site. The payback period was 31 months
- This reduced the risk of back and shoulder injury

The task

In bread making, bakery operators had to manually place lids onto the tins containing dough before the tins entered the oven. Operators lifted lids from a trolley positioned next to the workstation (see Figure 7.1); lids could be above shoulder height or below knee height when on the trolley. When the bread had been baked the lids had to be manually removed and placed back on the trolleys. The ovens worked on a conveyor system which meant that the lids were removed from the tins at a different location to where they were fitted. Therefore, when a trolley was filled with tin lids it was pushed manually from the ‘lid removal workstation’ to the ‘lid fitting workstation’ so that the lids could be used again. This process was a manually intensive and highly repetitive operation (with 16-18 lids being fitted per minute). Each operator spent one hour on the tin lid operation every 2.5 hours. They also carried out bread mixing – making up batches of dough from dry and wet ingredients. After two hours of work the operators had a 30 minute break, after which time they commenced the work cycle again. The operators worked a 12 hour shift.

Musculoskeletal risks

There were three principal components to the risk of musculoskeletal injury:

- the need to handle below knee height
- handling above shoulder height
- the repetitiveness of the task.

There were risks both of back injury and upper limb disorders from carrying out the lidding operation.

The lids weighed 2 kg each and were handled between 16 and 18 times per minute. Thus in each work cycle each operator handled up to 1080 tin lids, or up to 5400 lids per shift. Apart from those lids positioned between waist and chest height, handling the lids required awkward reaching and stretching to take them to or from the trolley. The full trolley was heavy to move and awkward to manoeuvre. The operator used the caged sides of the trolley for handholds when pushing it. The height of the tin lids loaded in the trolley hindered the view of the operator pushing the trolley. The height of the trays of bread on which the lids were placed was acceptable (approximately waist height).
Identifying the problem

The company monitored sickness absence records as part of their health and safety policy, which indicated that staff working in this area were experiencing musculoskeletal disorders. The Company identified this task as posing a medium risk of musculoskeletal disorders, though their routine programme of health and safety risk assessments. The action plan put in place was to reduce the risk of injury in the medium term by changing the design of the trolley. In the long term it was recognised that an automated process would be required so as to remove the risk of injury altogether.

What was done?

The financial returns of using a modified trolley were examined. A business proposal was prepared based on the expected annual productivity cost of sickness absence associated with this work activity. A projected return on investment was quantified based on 2003 data. The site management accepted this proposal and changes to the design of the trolleys were made.

Table 7.1. Comparison of work activity before and after the intervention

<table>
<thead>
<tr>
<th>BEFORE</th>
<th>AFTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stooping to reach the lowest lids on the trolley.</td>
<td>Raised base incorporated into the trolley design reduces stooping.</td>
</tr>
<tr>
<td>Reaching above shoulder height for the uppermost lids.</td>
<td>Height of trolley reduced so that lids were not stored above shoulder height.</td>
</tr>
<tr>
<td>Heavy load to manoeuvre on each trolley.</td>
<td>More trolleys were purchased to make up for the reduced capacity of each modified trolley. As a result productivity was unaffected.</td>
</tr>
<tr>
<td>Full trolleys were heavy and required significant initial force to start them moving.</td>
<td>The trolley weight was reduced by 180 tin lids at 2 kg each; which is equal to 360kg. This reduced the amount of pulling or pushing force required to move the trolley.</td>
</tr>
</tbody>
</table>
New trolley

Original trolley

Figure 7.2. The new trolley with an original trolley in view for comparative purposes

Costs and benefits

In the year before the intervention (2003) there had been 200 hours of sickness absence through musculoskeletal disorders to the operators in this area. In 2004 there were 120 hours of musculoskeletal disorder related sickness absence to the operators in this area.

The cost of modifying ten trolleys and providing the additional ones needed was £5,000. The expected life cycle of the trolleys is five years.

The cost to the Company of each hour of sickness absence was calculated by the site management team to be £16.95 per hour. This included the loss due to slower production and production delays, more wastage, labour replacement costs, plant damage and sick pay. The operators’ hourly rate of pay was £6.50. Simple site investigations were carried out as a result of each lost time injury at an estimated average length of 1.5 hours of management time per incident. Formal investigations were carried out as a result of the lost time, following the intervention but no bakery management time was expended on these investigations.

Table 7.2. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced sickness absence and risk of musculoskeletal injury</td>
<td>Handling is limited to between about knee and shoulder height.</td>
</tr>
<tr>
<td>Relatively inexpensive medium term solution put into place</td>
<td>Capital expenditure was controlled</td>
</tr>
<tr>
<td>Less sickness absence</td>
<td>Greater level of productive working from employees</td>
</tr>
</tbody>
</table>

“This safer by design solution reduced the risk of upper limb and low back problems amongst bread tin handlers, resulting in both business and health gains” Joe Patton, Senior Occupational Health and Ergonomic Adviser; Allied Bakeries
**Economic analysis**

**Costs and Benefits**

**Direct intervention costs:**
Investigation of problem, consultation and implementation of proposals, 0.5 management days at a day cost of £675  
£338  
10 trolleys modified and new trollies purchased  
£5,000  
**Total cost**  
£5,338  

**Annual post-intervention benefits (see note 1)**  
£2,396  

**Conclusion**
The equipment lifecycle is 5 years from the date of intervention.

Total cost of intervention  
£5,338  

Net present value of annual post-intervention cost savings  
over the process lifecycle at an 8% discount rate  
£2,396 per annum for 5 years  
£10,334  

**Net intervention benefit**  
£4,996  

**Payback period**  
31.0 months  

Base price year is 2003  

**Note 1 - Comparison of pre and post intervention costs**

<table>
<thead>
<tr>
<th>Annual pre-intervention costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Based upon 200 hours of lost time injury absence arising within 2003</td>
<td></td>
</tr>
<tr>
<td>Immediate incident intervention: -</td>
<td></td>
</tr>
</tbody>
</table>
| Management time; 9 hours | £810  
| Investigation, report and follow up; 9 hours | £810  
| **Total** | £1,620  
| Cost of sickness absence: - |  |
| 200 hours @ £16.95 per hour | £3,390  
| **Annual pre-intervention costs** | £5,010  

<table>
<thead>
<tr>
<th>Post intervention costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Based upon 120 hours of lost time injury absence arising within 2004</td>
<td></td>
</tr>
<tr>
<td>Immediate incident intervention: -</td>
<td></td>
</tr>
</tbody>
</table>
| Investigation, report and follow up; 6 hours | £540  
| Cost of sickness absence: - |  |
| 120 hours @ £17.28 per hour | £2,074  
| **Annual post-intervention costs** | £2,614  
| **Annual post-intervention benefits** | £2,396 |
8. Avoiding the hand rolling of fish meat

- Repetitive hand and arm movements were required to form a food product
- Part automation of the process avoided personnel being engaged in these risky tasks
- Risk of upper limb disorder and back pain was avoided
- Cost of new machine was £8,000; savings in wage costs meant a payback period of approximately 12 weeks

The task

Fish balls were one of the products made at a fish processing factory. Two operators stood at a conveyor line and rolled the fish meat into balls by hand (see Figure 8.1).

Musculoskeletal risks

Hand rolling was light work, but repetitive, and operators reported becoming uncomfortable during the course of a shift. The arms could not be rested on the conveyor which meant that the upper arm and shoulder muscles could not rest during the shift. Shorter than average operators in particular found the work fatiguing, as in order to get the hands on the conveyor, the elbows tended to be held out to the sides which increased the loading of the shoulder and arm muscles.

Identifying the problem

Operators reported discomfort in the upper arms and shoulders as well as the neck, lower back and legs. Two staff working at this line had been absent with musculoskeletal problems; one for four days and the other for 12 days within a few months of each other. Management also knew that the job was disliked by operators.

What was done?

The company investigated ways in which the equipment and task could be better adapted to the operators, but found that there was no real scope for adjusting the layout of the conveyor line without significant cost. Making the conveyor optimal for an
average height operator would in fact fit relatively few people. The nature of the product could not be changed to make the job less intensive. Job rotation was already practised, but this did not change the fundamental ergonomic problems associated with the work.

Figure 8.2 Automated fish ball rolling machine

The company contacted their machinery supplier to cost the development of an automated system. This would cost £8,000; it was decided to install the system. The productivity rate of the automated machine was approximately the same as that of the two human operators. The cost saving in wages was £500 per week, as two operators were redeployed to other areas of the factory.

Labour costs of maintaining and cleaning the machine were equivalent to those associated with maintaining and cleaning the conveyor line. Labour costs of periodically filling the machine are estimated to be £15 per week. This task carried with it a low risk of musculoskeletal disorders.

Costs and benefits

Table 8.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A task which had been associated with musculoskeletal sick leave was removed</td>
<td>The automated system took out virtually all manual effort</td>
</tr>
<tr>
<td>No redundancy</td>
<td>Operators were redeployed to other areas of the factory</td>
</tr>
<tr>
<td>The solution was moderately cheap</td>
<td>A relatively simple means of automating the hand rolling was found</td>
</tr>
</tbody>
</table>


**Economic analysis**

**Costs and benefits**

**Direct Intervention Costs**

- New machine
  - Cost: £8,000

**Post intervention benefits**

- Saved wage costs:
  - 2 full time employees at £250 per week: 26,000
  - Wage oncosts at 30% of wage costs: 7,800
- Opportunity cost of labour used to cover sickness absence:
  - It has been assumed that the 16 days absence occurred within a 4 month period; thus the cost of labour to cover at overtime rates is:
    - 48 days at £62.50 plus wage oncosts per day: 3,900
  - Total: £37,700

**Post intervention cost**

- Additional labour costs for machine filling at £15 per week: 780

**Post intervention benefit**

- Total: £36,920

**Conclusion**

- The process lifecycle is assumed to be 3 years from the date of intervention.

- Total cost of intervention: £8,000
- Net present value of post intervention benefit over the process lifecycle at an 8% discount rate:
  - £36,920 per annum for 3 years: £102,758
- Net intervention benefit: £94,758
- Payback period: 2.80 months

Price base year was 2002.
9. Automating manual box packing

- Multi-bags of snack foods were packed by hand into boxes ready for transport to distribution warehouses
- The work posed a risk of upper limb disorders
- Automating the process avoided the need for repetitive handling, but at a cost of over £1.3 million. The payback period was 47 months

The task

Operators stood at a workstation beside a conveyor line packing multi-bags of crisps and other snacks into boxes. The task involved assembling a box, taking multi-bags from the conveyor and placing them in the box, and folding the box lid closed when the box was full. The full box was pushed along the line. Two packers and a supervisor worked at each multi-bagger machine for an eight hour shift, with two 15 minute breaks and one 30 minute break for lunch.

Figure 9.1. Multi-bag packing workstations

Figure 9.1 shows the multi-bags emerging from the bagging machine. Up to 50 multi-bags were delivered to the packing area (two operators) per minute. The speed of the packing was determined by the rate of issue from the machine; if the operators did not keep up, the conveyor would fill up with multi-bags, meaning operators tended to work rapidly and under pressure. Up to 21 multi-bags were packed into each box.

The musculoskeletal risks

Taller packers tended to stoop to work due to the fixed workstation and conveyor height and shorter operators tended to work with their arms raised in order to be able to place items into the boxes. Although the loads handed (multi-bags) were light, they were handled frequently, and a range of arm movements had to be made between the conveyor and the box. Large arm movements were also required when assembling the boxes (at least once per minute). Operators were also standing for prolonged periods. Aches and pains were reported to be commonplace, with taller operators usually at risk of back discomfort and shorter operators at risk of upper limb disorders.
Identifying the problem

Problems at the packing line were brought to the attention of senior management via the occupational health department which had seen an increase in complaints associated with the line. One packer had been signed off on long term sick leave after having been diagnosed with an upper limb disorder.

What was done?

The Company investigated ways in which the multi-bagger equipment could be made adjustable so that it could accommodate a wider range of operators. After consideration of various options, including raising the overall conveyor height and providing a platform for shorter operators, it was decided to automate the lines. Six out of the seven multi-bagger lines were automated. The staffing requirements therefore changed from two packers and a supervisor per multi-bagger to a single team member per machine, plus a floating supervisor to provide assistance where needed. The multi-bagger staff on the automated lines were retrained for deployment elsewhere at the site.

The occupational health department continued to monitor reports of pain and discomfort reported by staff working at the multi-bagger lines. The importance of good posture and work breaks was emphasised via line management.

The costs and benefits

Productivity was unaffected as the automated machines worked at an equivalent rate to the manual lines which they replaced. The amount of sick leave taken by staff at the multi-bagger lines has reduced significantly. Anecdotal evidence suggests that most of the sick leave taken prior to the changes was due to musculoskeletal problems but this information was not recorded prior to the intervention.

The benefits arising from this intervention included reduced labour costs from the automation of six of the seven lines and reduced levels of sickness absence. The one incidence of long term sick leave due to upper limb disorder was estimated to have cost the Company £18,000.
Table 9.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisory and operator requirement was substantially reduced.</td>
<td>Automation removed many of the manually intensive tasks and reduced the need for direct supervision of the operation.</td>
</tr>
<tr>
<td>The risk of musculoskeletal disorders was greatly reduced.</td>
<td>Prior to the change, the Company had lost an estimated £18,000 because of one upper limb disorders case.</td>
</tr>
<tr>
<td>It was estimated that 25 management days per year were saved.</td>
<td>This would be worth £15,625 annually of management time being made available for use on other projects (based on 25 days at £625 per day).</td>
</tr>
</tbody>
</table>

Economic analysis

Costs and benefits

Direct intervention costs
6 machines @ £220,000 each  £1,320,000

Post intervention cost savings
Labour cost savings (note 1) £375,600

As a result of the reduced level of supervision it was estimated that management time in excess of 25 days per annum was saved and utilised on other projects Creating an annual cost saving of 25 days at £625 per day. £15,625

Total post intervention cost savings  £391,225

Conclusion
The process lifecycle upon which the decision to purchase was made was 5 years

Total cost of intervention  £1,320,000

Net present value of annual labour cost savings and management time savings over the process lifecycle at an 8% discount rate £391,225 per annum for 5 years  £1,687,012

Net intervention benefit  £367,012

Payback period  47 months

Base price year is 2002
### Note 1 - Analysis of labour cost savings

**Original direct wages costs:**
- 14 operators for each of 2 shifts: £364,000
- 7 line supervisors for each of 2 shifts: £224,000
  
  **Labour costs covering 7 lines:** £588,000

  **Estimate of the annual cost of long term MSD sick leave:** £18,000

  **Estimate of the annual cost of short term MSD sick leave:**
  - 8 days per annum per operator: 28 operators @ £50 per shift = £11,200

  **Total Original direct labour costs covering 7 lines:** £617,200

**Post intervention labour costs:**

- **For the 6 automated lines:**
  - 6 operators for each of 2 shifts: £156,000
  - 1 supervisor for each of 2 shifts: £32,000

- **For the remaining manual line:**
  - 2 operators for each of 2 shifts: £52,000

  **Estimate of the annual cost of short term sick leave:**
  - 2 days per annum per operator: 16 operators @ £50 per shift = £1,600

  **Total direct labour costs covering 7 lines:** £241,600

**Annual labour cost saving:** £375,600
10. Patient transfers in operating theatres

- Manual transfer of patients from bed to trolley in theatre led to significant lost time due to back and neck disorders
- A very cheap and simple solution meant a substantial reduction in back and shoulder injuries over the following 4 years
- Direct intervention costs of £8,545 with a payback period of just over 1 month

The task

Theatre staff are routinely required to manually lift and move comatose patients from their hospital beds onto the operating theatre tables. The task is usually performed by four staff, who are typically female. Staff position themselves either side of the patient on the bed and the operating table and, on a command, lift the patient and transfer them from the bed to the table. The reach requirement is excessive because staff have to reach over the bed / table as they move the patient. Patients can be very heavy and, being comatose, they are unable to provide any assistance in the transfer process. The procedure had to be reversed when moving patients from the table to a recovery bed.

Musculoskeletal risks

Moving the patient requires awkward postures and high muscle activity in the staff’s lower back, neck and shoulders. This poses a risk of injury. The risk is affected by the frequency of transfers, the individual weight of the patients and the number of staff available to carry out the transfer. An added risk arises from the potential for over-rotation around the waist whilst reaching and lifting, possibly affecting safe footing whilst lifting, and leading to slips.

Identifying the problem

The occupational health department of the NHS Trust identified that staff working in the operating theatres had a significant rate of lost time injuries. Analysis of the accident and sickness absence records showed that the cause of many of the injuries was lifting patients from the trolley beds onto the operating tables.

What was done?

The occupational health department conducted research on alternative means of undertaking the patient transfer. This involved investigating devices and equipment that could be used in the theatre environment and which would reduce the risk of injury to the theatre staff.

One option was favoured, and the department purchased a patient transfer canvas and board on a trial basis. Some of the staff were instructed in its use and were asked to assess its function and performance. The trial was regarded as a success based on the feedback from the theatre staff and the assessment of postures made by the occupational health department. As a result a new system of patient transfer using the canvas and board was put into place; all of the 56 theatre staff were provided with suitable training in its use.

The new equipment consists of a canvas with hand loops attached along both sides. This is placed on top of the hospital bed and underneath the patient before the patient is moved to the theatre. If the patient cannot position themselves on the canvas, it can be positioned so that they can be rolled onto it.
Figure 10.1. The trolley (representing the operating table) with transfer board and hospital bed with canvas in position

When the patient arrives in theatre the bed is positioned next to the operating table onto which has been placed a patient transfer board. The patient is rolled in a secure manner inside the canvas and the board is then slid from the bed onto the table so as to act as a bridge between the bed and the table (see Figure 10.2; a member of staff is playing the part of a patient).

Figure 10.2. Rolling the patient to slide the board in position

The patient is then rolled back onto the board. Four theatre staff are involved in the transfer movement. They each grasp two of the canvas handles, passing them through their hands and around their wrists before grasping the canvas. The patient is dragged using the canvas from the hospital bed to the theatre table (see Figures 10.3-5).
The stages in the patient transfer movement

Finally the board is removed from the table and the surgical procedure can begin. The canvas is kept under the patient throughout their stay in theatre. It is removed when appropriate in post-operative care.
One additional advantage that has been realised is that the canvas can be used safely and appropriately to help to restrain very agitated patients coming round from the anaesthetic.

![Figure 10.6. Use of the canvas post-operatively](image)

**Costs and benefits**

**Table 10.1. Summary of benefits**

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of a canvas and patient transfer board significantly reduced the musculoskeletal related lost time incidence for theatre staff.</td>
<td>There has been a decrease in the number and frequency of musculoskeletal injuries associated with patient lifting. This means that staff availability is greater, there is less demand for temporary staff, and overtime costs can be more easily controlled.</td>
</tr>
<tr>
<td>Capital outlay is relatively low</td>
<td>The equipment is readily available, cheap to purchase and the training costs are relatively low.</td>
</tr>
<tr>
<td>There has been universal acceptance of the procedure.</td>
<td>Uptake of the new method has been good which indicates that the training and material purchased will be put to intended use.</td>
</tr>
</tbody>
</table>

The patient transfer boards were already used in the Hospital and did not need to be purchased. The unit price for 500 canvasses was £14.83. The total cost of the purchase of the equipment was £7,415. Additional staff training was estimated to have cost £1,130 per year, to include the cost of the trainers.
The cost to launder each canvas ready for re-use is 28p. On average it is estimated that each canvas is re-used every 20 days, making an annual laundry cost per canvas of £5.11. It has been assumed that this cost has remained constant over the 5 year period even though staff numbers have increased.

Sickness absence data for the theatre staff was collated by the Workforce Planning and Implementation Department at the Trust. The data consisted of the number of days lost due to back and neck disorders; the percentage of the total number of days lost due to sickness and the number of staff taking time off due to this cause. The data covered a time period from one year pre and three years post intervention. In addition, mean staff replacement costs were recorded in the form of overtime and temporary staff that were brought in to cover the sickness absence.

The average daily rates for a temporary worker (D grade) was £10 per hour, and overtime for an existing member of staff covering an additional shift over and above full time hours would be £15 per hour (excluding weekends). As data was not available detailing the ratio of overtime cover to temporary worker cover, the mean hourly cost of cover was calculated and used to equate total sickness absence cover costs. This came to £12.50 per hour, or £93.75 per day based on a 7.5 hour working day. The hourly rate plus 30% overhead costs is £16.25.

Between 2000-2001 and 2004-2005 there was a 33% increase in theatre staff in response to the Government’s initiative on waiting times. In the same period there was a decrease of 63.68% in the occurrence of sickness absence reported as result of neck and back injuries, as detailed in Figure 10.7 and Table 10.2.

<table>
<thead>
<tr>
<th>Fiscal period</th>
<th>Total number of days lost due to back and neck disorders</th>
<th>Percentage of total sickness absence</th>
<th>Number of theatre staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01</td>
<td>633</td>
<td>22.1</td>
<td>70</td>
</tr>
<tr>
<td>2001-02</td>
<td>461</td>
<td>26.4</td>
<td>94</td>
</tr>
<tr>
<td>2002-03</td>
<td>290</td>
<td>12.6</td>
<td>96</td>
</tr>
<tr>
<td>2003-04</td>
<td>411</td>
<td>11.8</td>
<td>105</td>
</tr>
<tr>
<td>2004-05</td>
<td>318</td>
<td>8.0</td>
<td>105</td>
</tr>
</tbody>
</table>
Economic analysis

Costs and Benefits

Direct intervention costs:  
Purchase of 500 canvases @ £14.83 ea  
Cost: £7,415  
Additional Staff training  
Cost: £1,130  
Total cost: £8,545

Annual pre-intervention costs

Overtime payments due to sickness absence  
in 2000 - 2001: 633 days @ £93.75 per day (plus 30% overhead costs)  
Cost: £77,147

Annual post-intervention costs

Overtime payments due to sickness absence (all plus 30% overhead costs) plus annual laundry costs of canvasses of £2,555  
2001 - 2002: 461 days @ £93.75 per day  
Cost: £58,739  
2002 - 2003: 290 days @ £96.50 per day  
Cost: £38,936  
2003 - 2004: 411 days @ £99 per day  
Cost: £55,451  
2004 - 2005: 318 days @ £101.75 per day  
Cost: £44,818  
Annual staff training costs  
Cost: £1,130

Annual post-intervention cost savings

As a decrease in MSD sickness related absence  
(pre intervention sickness costs - post intervention sickness costs)  
2001 - 2002  
Cost: £17,278  
2002 - 2003  
Cost: £37,081  
2003 - 2004  
Cost: £20,566  
2004 - 2005  
Cost: £31,398

Conclusion

The process lifecycle upon which the decision to purchase was made was 4 years  
Total cost of interventions  
Cost: £8,545  
Net present value of the annual labour cost savings over the equipment lifecycle at an 8% discount rate  
£17,278, £37,081, £20,566 and £31,398 over the 4 years  
Cost: £94,169

Net intervention benefit  
Cost: £85,624

Payback period  
1.09 months

Base price year is 2001
11. Facilitating change in sonographers’ work

- Sonography requires relatively frequent and forceful upper limb postures and movements
- In one Hospital in an NHS Trust 60-70% of sonographer were reporting upper limb disorders whereas in another only 10% were experiencing these
- A different patient management system and saddle seats were introduced at the first Hospital
- One sonographer who had been on long term reduced duties returned to full productivity. With intervention costs of £3,296 and annual post intervention benefits of nearly £14,000, the payback period was 39 months

The task

Sonographers in two hospitals carried out ultrasound scans according to two regimes: wholly in an antenatal clinic (Hospital 1) or in a general hospital environment (Hospital 2). In Hospital 2 the sonographers carried out scans by referral from other departments, typically general medicine and obstetrics and gynaecology. The most regular types of scans were vascular, abdominal and antenatal.

The 12 sonographers in Hospital 1 completed up to a maximum of 20 antenatal scans in the morning and up to 10 scans in the afternoon each working day. Their diary was managed by the antenatal clinic and they had no control over how many patients they saw per day or over when they had breaks from their work. It was unusual for the sonographers to have any breaks in the morning session. Most of the scans were of patients in the 2\textsuperscript{nd} or 3\textsuperscript{rd} trimester of their pregnancy and each scan would routinely last for 10 – 25 minutes. If a potential problem with the pregnancy was identified then the scan could take longer.

The 10 sonographers in Hospital 2 were located in their own department. They made all their own appointments and had control over the way that their work was completed. Their work was more varied because of the range of the types of scans undertaken.

Saddle seats had been provided at both hospitals, but were only being used in Hospital 2. The idea behind the design of the saddle seat is that it allows freedom of movement and encourages the maintenance of the natural curve of the spine. Sitting in a conventional seat, particularly when leaning forward, can cause the spine to bend into a C shape which compresses the vertebrae.

Musculoskeletal risks

It has been known in the profession that upper limb disorders commonly occur as a result of the sometimes awkward and forceful postures that are required to manipulate and hold the scanning device; the long reach distances that are involved in reaching to the patient while sitting at the equipment (see Figure 11.1); and the long periods that sonographers work in these postures. A study in 1997 by The Society of Radiographers stated that 70 – 80% of sonographers suffer work related pain, and according to a report in 2003 by the Society of Diagnostic Medical Sonography, 20% are forced to end their career because of this. Poor equipment design is often cited as one of the contributory factors.
Identifying the problem

The ergonomist employed by the Trust was made aware by the occupational health department that between 60-70% of the sonographers at Hospital 1 were suffering with upper limb disorders (ULDs) manifesting as mild through to significant aches and pains. One sonographer was on a greatly reduced scanning regime whereby her line manager advised that she should only complete 5 scans per day. Less physically demanding work was available as she was the line manager’s deputy and could assist with management duties. In Hospital 2 however, only about 10% of the sonographers was suffering any sort of ULD symptoms.

On visiting the two hospitals the ergonomist found that the main differences between them were:

- the different systems in place for managing the work
- the fact that saddle seats (see Figure 11.2) were being used by the sonographers in Hospital 2.

What was done?

The ergonomist took videos of the scanning procedures at both the hospitals and showed them to all of the sonographers in two stages; first to each group...
independently at each Hospital, followed by a showing to all the sonographers meeting together. All the sonographers agreed that the use of the saddle seat as seen in use at Hospital 2 offered significant ergonomic advantages. As a result the sonographers at Hospital 1 agreed to start using the seats.

At the same time the ergonomist arranged for a physiotherapist to provide the sonographers with stretching, or counterbalance exercises, and with training on what constituted good posture at the sonography workstation. Thereafter the ergonomist arranged for peer reviews to see how each sonographer was getting on with the saddle seat and the exercises. A checklist was devised to ensure that there was a consistent approach to this peer review process. Finally the ergonomist made a presentation to the Senior Management Sonography Group in the Trust to gain their support and encouragement by the line managers for the sonographers to follow the good practices established.

About 2 – 3 weeks after the sonographers at Hospital 1 started to use the seats they realised that using them was advantageous and they began to like them and use them routinely.

With senior management support a new appointments system was introduced for the sonographers at Hospital 1. First the number of scans per day was reduced by up to one third. They were now expected to complete 12 scans in the morning and 8 scans in the afternoon. This was in line with the national average of 20 scans per day. To compensate for the reduced number carried out by the sonographers, it was calculated from the recorded statistics that two midwives could make up the difference; and they were trained to carry out antenatal sonography. They only carried out the scans that related to their midwifery duties – such as umbilical artery doppler examinations, and they still practiced midwifery. One midwife carried out sonography for about two days, and the other for about four days per week (average 2.3 days per week between them).

As a result of the interventions, in the six months since the saddle seats were used there have been no reports or complaints of upper limb discomfort. In addition, as a direct result of the changes made the sonographer at Hospital 1 returned to normal duties after eight months of being on restricted duties.

**Costs and benefits**

Table 11.1  Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complaints of upper limb discomfort ceased</td>
<td>60-70% of the sonographers had previously complained</td>
</tr>
<tr>
<td>One sonographer who was on significantly reduced duties returned to normal duties</td>
<td>She had previously only carried out five scans per day and was now able to undertake 20</td>
</tr>
<tr>
<td>Better use of existing workstation equipment</td>
<td>Saddle seats that had been purchased are now used</td>
</tr>
<tr>
<td>The sonographers are able to self-manage their workload</td>
<td>New booking system introduced means that they are in control and not overloaded.</td>
</tr>
</tbody>
</table>

The costs of some of the elements of the intervention are calculated as follows:
<table>
<thead>
<tr>
<th>Intervention</th>
<th>Time / unit cost</th>
<th>Total cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ergonomist’s time to carry out the study, manage the training sessions and</td>
<td>10 hours @ £22/hr.</td>
<td>220</td>
</tr>
<tr>
<td>investigate the additional monitor arm.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management time for meetings</td>
<td>0.33 day @ £300 x /day average</td>
<td>100</td>
</tr>
<tr>
<td>Cost of physiotherapist for training in exercises.</td>
<td>2 hours @ £22 /hr</td>
<td>44</td>
</tr>
<tr>
<td>Cost of training two midwives in antenatal sonography*</td>
<td>Two courses:</td>
<td>2,200</td>
</tr>
<tr>
<td>1 short course for 2 midwives = £1,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 long course for 1 midwife = £1,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Three midwives entered training but only two completed the course.

Staff costs are calculated at salary plus overhead costs.

Although complaints of upper limb discomfort stopped at Hospital 1 it is not possible to determine whether this had an effect on the sonographers’ productivity. As the number of appointments booked was not affected, it is assumed not. However one sonographer was on reduced working prior to the intervention. Instead of being able to complete 30 scans per day she was only able to complete five. Following the intervention she was able to return to full scanning tasks; even with the reduced number of scans of 20 per day this represents a 400% increase in her productivity.

The sonographer on reduced duties was deployed on management duties and on quality assurance whereby she observed the student sonographers and provided additional on-the-job training. Her time has been costed as ‘lost’ for 5/6ths of her working time because her role was not essential for the running of the sonography department and did not contribute to its productivity. An agency sonographer was brought in to cover for the employed sonographer on restricted duties. This sonographer cost £25 per hour. The hourly cost for running a staffed sonography suite or room in 2005 was £296.
Economic analysis

Costs and Benefits.

Direct intervention costs:  
Investigation of problem by ergonomist, carry out the study and manage the training: 10 hours @ £22 per hour  
Sonographers meetings: 22 hours @ £27 per hour  
Sonographers training with physiotherapist at hospital  
1: 6 hours @ £23 per hour  
Cost of physiotherapist for training: 2 hours @£22 per hour  
Cost of training 3 midwives in antenatal sonography  
0.33 management days at a day cost of £300 per day  
Total cost  
£3,296

Annual pre-intervention costs  
8 months of reduced scanning by one sonographer (see note 1)  
Cost of agency sonographer (see note 2)  
Total cost  
£67,875

Annual post intervention costs  
Peer review process:  
Sonographers - 11 hours @ £27 per hour  
Ergonomist - 2 hours @ £22 per hour  
Total cost  
£341

Extra staff  
2 midwives carrying out antenatal sonography to compensate for reduced number carried out by sonographers (see note 3)  
Total costs  
£53,922

Annual post-intervention benefits  
£13,953

Conclusion  
The equipment lifecycle is 3 years from the date of intervention.

Total cost of intervention  
£3,296

Net present value of post intervention benefits over the process lifecycle at a 8% discount rate  
£10,834 per annum for 3 years  
£38,835

Net intervention benefit  
£35,539

Payback period  
39 months

Base price year is 2004
### Note 1
One sonographer on reduced working: 5 scans per day instead of 30.
Sonographer's hourly cost = £27
Thus lost productivity = £27x9 (hours/day)x150 (days of reduced productivity)x0.833 (reduced number of scans - 25 out of 30) = £33,750

### Note 2
One sonographer at £25 per hour for 8 months
Cost = £25x10 (hours/day) x150 (days cover) = £37,500

### Note 3
Midwife's hourly cost = £28
2 midwives working 2.3 days per week (average)
Cost = £53,581
12. Changes to reduce risk in a hospital laundry

- Washing, drying and pressing linen was manually intensive.
- There was high musculoskeletal sickness absence for the laundry workers.
- Changes to the design of the workstations, laundry equipment and to the pattern of work were made, resulting in increased productivity and reduced sickness absence.
- Payback period was approximately 19 weeks.

The task

Workers in the laundry of a large general hospital handled dirty linen from the hospital and then throughout the sorting, washing, drying and pressing process. These tasks involve:

- collecting dirty linen and placing into large linen bags
- emptying the linen bags into washers
- transferring wet laundry from washer to cart
- sorting the wet laundry
- placing the wet laundry into the driers
- removing dry laundry from the driers and passing through the presses.

The workers were mostly female.

Musculoskeletal risks

The lower back and shoulders were most likely to be injured by these work activities. This was due to a combination of excessive forward bending to lift dry and wet linen, forceful exertion, and awkward postures. The tasks were carried out on a regular basis and there was little light work to which workers can be assigned in order to provide an element of recuperation from these physical activities. The tasks of collecting, placing in the linen bags and into the washers and sorting laundry involved all of these risk factors and therefore posed the greatest risk of injury.

Identifying the problem

Of the 42 workers in the laundry 12 had suffered lost time musculoskeletal injuries in the year prior to the study being carried out. In addition there had been an average of 16 first aid instances per month for musculoskeletal injuries prior to the intervention. This prompted the laundry management to investigate and take remedial action, with particular emphasis on reducing the manual handling of laundry bags.

What was done?

The management commissioned an ergonomics assessment of the operations. This assessment included the interviewing and observation of laundry workers. The assessment led to recommendations for tackling the manual handling issues being developed. These were derived through focus groups and discussions involving the ergonomist, and the laundry manager and workers.

In total 35 recommendations were made for 10 of the 13 tasks carried out in the laundry. These included modifications to workstations, the way that the work was organised e.g. introducing a pattern of job rotation so that the physical effort was more
equally distributed between the workers, and psychosocial issues such as providing feedback on performance to workers and others ways of improving morale.

The more major changes are listed below:

<table>
<thead>
<tr>
<th>Change introduced</th>
<th>Reason for the change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing the number of laundry carts.</td>
<td>So that the carts did not need to be loaded so full (maximum of 220kg for a loaded cart) and pushing and pulling was made easier.</td>
</tr>
<tr>
<td>Using spring loaded carts (these present the load at a constant height relative to the handler irrespective of the weight of the load contained in the cart like a dinner plate dispenser in a canteen).</td>
<td>So that manual handling of linen from the bins was always close to waist height, thereby avoiding lifting when in a stooped posture.</td>
</tr>
<tr>
<td>Extend the feed conveyor (see figure 12.2) and extend the sides of the conveyors to prevent bags from falling off.</td>
<td>Brings the bags closer to the worker and avoids unnecessary additional manual handling when laundry falls from the conveyor.</td>
</tr>
<tr>
<td>Replaced linen bag with plastic bags.</td>
<td>To allow easier handling of the bags from the feed conveyor (see Figures 12.1 and 12.2).</td>
</tr>
<tr>
<td>Using assistive devices, such as long-handled clothes rakes.</td>
<td>Reduces the reach into the washer to pull out wet laundry.</td>
</tr>
<tr>
<td>Sort laundry when dry rather than wet.</td>
<td>Dry linen is lighter to handle than wet linen. This reduces manual handling.</td>
</tr>
<tr>
<td>Purchased a new drier.</td>
<td>Necessary in order to maintain throughput because of other changes made in terms of job rotation.</td>
</tr>
</tbody>
</table>

Figure 12.1. Feed conveyor before modification showing the awkward posture and long reach
Figure 12.2. Feed conveyor after modification showing an extended conveyor and the use of plastic linen bags

**Costs and benefits**

Table 12.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced costs due to staff sickness absence due to musculoskeletal disorders.</td>
<td>In the years following the intervention there was a 62% decrease in musculoskeletal disorder sickness absence.</td>
</tr>
<tr>
<td>Increase in productivity and decrease in overtime payments.</td>
<td>Productivity increased by 12% and overtime payments decreased by an estimated 20% in the full year after the intervention.</td>
</tr>
<tr>
<td>Staff morale was improved.</td>
<td>A post-intervention survey showed staff thought there were good levels of interest and variety in the work.</td>
</tr>
</tbody>
</table>

The main item of capital expenditure was the new drier at £20,000. Other modifications to equipment were less expensive and totalled £9,200. The laundry was able to sell the drier that the new model replaced, thereby offsetting 40% of the purchase and installation cost. The consultancy fee for the work was £6,000 and the staff time involved in consultations and focus groups was estimated to be £304. Post-intervention staff training was carried to reinforce good working practice. This cost £1,100.

In the year before the interventions, the number of days of sickness absence due to musculoskeletal disorders for all 42 workers was estimated to be 378. There was a 14% decrease in this value in year 1 and a further 48% decrease in year 2. The benefit that this creates has been calculated at a daily wage and on-cost rate of £104 per day. There was a marked decrease in first aid incidents from an average of 16 per month to 4 per month. The benefit from this decrease was calculated by using the cost of a first-aid incident from the HSE Ready Reckoner (£35 per incident).
The management reported a 12% increase in productivity in the first year after the intervention. This benefit has been calculated on the basis of a charge of about £0.96/kg and a throughput of 245.5 tonnes of laundry per annum.

A part of the post intervention analysis was to include a survey of worker satisfaction and quality of work life. This was carried out independently by the consultant eight months after the interventions were put into place. The results showed the following:

- 88% of workers feel the job is better
- 70% report the job requires less physical effort
- 75% say the work is more varied
- 75% say the work is more interesting
- 69% feel they are less tired
- 75% feel they are less sore.

The above is based on a 57% response rate.
Economic analysis

Costs and Benefits

Direct intervention costs:
- Purchase of new drier: £20,000
- Sale of old drier: -£8,000
- Equipment - minor modifications: £9,220
- Staff training: £1,100
- Ergonomics consultancy fees: £6,000
- Estimate for staff time for consultation and focus group meetings: £710
- Laundry manager: 1 day @ £200 per day
- Laundry staff: 5 days @ £104 per day

Total cost: £29,030

Annual pre-intervention costs
- Sickness absence due to MSD: £39,312
- First aid treatment costs: 16 reports per month @ £35 each: £6,720
- Overtime payments: £20,000

Total cost: £66,032

Annual post-intervention costs
Year 1
- First aid treatment costs: 4 reports per month @ £35 each: £1,680
- Sickness absence due to MSD: £33,808

Total: £35,488

Year 2
- First aid treatment costs: 4 reports per month @ £35 each: £1,680
- Sickness absence due to MSD: £17,580

Total: £19,260

Annual post-intervention cost savings
- 12% increase in productivity (note 1): £28,281
- 20% reduction against pre-intervention annual overtime costs: £16,000
- Projected saving in personnel costs associated with an estimated reduction in staff turnover: £565

Total: £44,846

Yearly cost savings:
- Year 1: £75,390
- Year 2: £91,618
- Year 3 (note 2): £91,618

Conclusion
The process lifecycle is assumed to be 3 years from the date of intervention.

Total cost of intervention: £29,030

Net present value of post intervention benefits over the process lifecycle at an 8% discount rate:
- £75,390, £91,618, and £91,618 over 3 years: £238,769

Net intervention benefit: £209,739

Payback period: 4.38 months

Base price year is 2001
**Note 1**
Productivity gain was achieved by the utilisation of existing staff on other tasks during standard hours.

**Note 2**
No data yet available for year 3 - assumption is that sickness absence and incidences of first aid treatment will be in line with year 2.
13. Better aids cut risks in estate maintenance work

- Estate maintenance was physically demanding work and involved risks to the back and knees from manual handling items over long distances, often uphill
- Work efficiency and safety was improved by investing in better clothing and increased use of vehicles for carrying loads
- Direct intervention costs of just over £3,600; payback from the combined initiatives in under 10 months

The tasks

Footpath and estate maintenance involved labour intensive work. Erecting fencing or maintaining paths often meant carrying equipment long distances to the point of use. The work was conducted outdoors in all but the worst weather, on rough and often remote terrain.

Musculoskeletal risks

There was a risk of musculoskeletal disorders because of the frequent lifting and carrying that was required. Working on the land meant that many of the activities were carried out at or around ground level which put strain on the lower back and knees.

Heavy weights involved in many of the jobs increased the risk of manual handling injuries. Gates, for example, could weigh between 50 and 150 kg and would have to be lifted by three or more strong people. Training in manual handling techniques was provided but did not remove the risks present in the tasks.

Identifying the problem

Manual handling injuries were high. The management noticed that sickness absence was increasing and motivation was known to be quite low in some areas. This was believed to be because of the disruption caused by sickness absence to remaining members of the team, and the hard physical work required.

What was done?

A series of risk assessments were carried out for each of the major work activities. The risk assessments considered the physical hazards involved in each type of job, the health hazards, and the people or groups at risk. Physical and organisational precautionary measures were then identified during regular health and safety meetings attended by management and workers.

The Health and Safety Advisor observed that the risk assessment process “…got us thinking in the right way. When we listed what our clothing needed to achieve: dryness, warmth, to be breathable – this became the specification which made it easier to go out with confidence to source the kind of equipment we needed. The long list of high priority risks associated with some jobs also made us realise that getting mechanical help was sometimes the only effective way to way to deal with them all. This had not been obvious until the risks had been recorded methodically”.

A number of methods of reducing the musculoskeletal risks were implemented, including:

- Better personal protective equipment and outdoor clothing. To save money, walking boots costing between £25-50 had been issued, but it emerged that these were being replaced after only around two months of daily use. Boots that
had been ruled out on the basis of cost were found to last one to two years before needing to be replaced. At £80 - £100 these boots were more expensive to buy but saved at least £100 per year per pair. The more expensive boots were reported to be more comfortable to wear and offered better support for hill climbing and descending.

- Use of a tractor with a mechanical attachment for putting in fence poles and strainer posts. This avoided the musculoskeletal disorder and acute injury risks associated with using heavy hammers and handling the poles and fence wires manually. Where a fencing job previously took two staff a week to complete, it is now typically finished in one day. The savings are approximately £180 a week for fencing jobs. This is based on the daily cost of hiring the tractor and mechanical fencing equipment, plus the day’s wages for two workers, and comparing this to the weekly wages costs of two workers.

- Material such as loose chippings for footpaths is now delivered to the point of use by small sized dumper trucks (of 1, 2 or 3 tonnes capacity) which are able to manoeuvre over rough terrains. These are hired as required. Prior to this, material was mechanically transported on a trailer, but often could not be brought close to the point of use, so staff shovelled material from it and into wheelbarrows. The wheelbarrows typically had to be moved across uneven ground for long distances to the point of use, and several trips typically had to be made. The wheelbarrows were heavy when filled and the force required to propel them over rough ground resulted in a high risk of musculoskeletal disorders. The dumper trucks made delivery of materials much quicker and easier, with greatly reduced risk of musculoskeletal injury. Ideally the dumper trucks stay at the delivery point so that the shovelling can be done from waist height (rather than emptying the load onto the ground), though this depends on other jobs that need to be done using the trucks.

![Material left by dumper truck where it is needed](image)

Figure 13.1. Material left by dumper truck where it is needed

- Garden-style huts have been installed in remote locations where people may be working so that heavy equipment and soiled outdoor clothing can be left there rather than carried every day from the base. As well as reducing the lifting and carrying required, this facility means that equipment and clothing for several teams of workers do not need to be stored and sorted every day at the base, thereby avoiding unnecessary manual handling.
Figure 13.2. Hut installed on hillside to store clothing and equipment

Costs and benefits

Table 13.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased efficiency and decreased musculoskeletal disorder risk.</td>
<td>Many jobs are now done more quickly and with musculoskeletal risks greatly reduced or avoided altogether.</td>
</tr>
<tr>
<td>High levels of morale have been reported.</td>
<td>Manual handling accidents and sickness absence rates are down. Personnel feel that their wellbeing is considered to be important – this has positive implications for retaining staff.</td>
</tr>
<tr>
<td>Personal protective equipment and clothing meets user requirements better.</td>
<td>Since clothing has been specified through the risk assessment process, meaning that there is a better fit for the type of work carried out, MSD rates have reduced overall.</td>
</tr>
</tbody>
</table>

The costs associated with some of these risk reduction measures (provision of footwear where appropriate, and use of tractor for installing fences) are outlined below. Other interventions were reported to reduce risk, but it has not been possible to quantify these benefits.
**Economic analysis**

**Costs and Benefits**

### Direct intervention costs:

<table>
<thead>
<tr>
<th>Cost</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Health and safety meetings:</td>
<td></td>
</tr>
<tr>
<td>Management time: estimated to be 2 days @ £500 /day</td>
<td>£1,000</td>
</tr>
<tr>
<td>Staff time: estimated to be 3 days @ £112 /day</td>
<td>£336</td>
</tr>
<tr>
<td>Three garden huts at £275 each</td>
<td>£825</td>
</tr>
<tr>
<td>100 days hire of 3 ton dumper truck @ £105 per week</td>
<td>£1,500</td>
</tr>
</tbody>
</table>

**Direct intervention costs** £3,661

### Post-intervention benefits

<table>
<thead>
<tr>
<th>Saving</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual saving by purchasing higher quality boots:</td>
<td></td>
</tr>
<tr>
<td>Original cost - 26 pairs every 2 months at £35</td>
<td>£ 5,460</td>
</tr>
<tr>
<td>Revised cost - 26 pairs every 1 ½ years at £90</td>
<td>£ 1,560</td>
</tr>
<tr>
<td></td>
<td>£3,900</td>
</tr>
<tr>
<td>Annual saving by mechanising fencing work:</td>
<td></td>
</tr>
<tr>
<td>Original cost - Five day's staff costs for two personnel</td>
<td>£1,120</td>
</tr>
<tr>
<td>Revised cost - Tractor, equipment hire and two staff for one day</td>
<td>£ 940</td>
</tr>
<tr>
<td></td>
<td>£ 180</td>
</tr>
<tr>
<td>Assuming 5 fencing jobs per year</td>
<td></td>
</tr>
<tr>
<td>= 5 x £180</td>
<td>£900</td>
</tr>
</tbody>
</table>

**Total annual post intervention benefits** £4,800

### Conclusion

The lifecycle of the estate management procedures is assumed to be 3 years from the date of intervention.

**Total cost of interventions** £3,661

**Net present value of direct intervention costs over the process lifecycle at an 8% discount rate** £4,800 per annum for 3 years £13,360

**Net intervention benefit** £9,699

**Payback period** 9.87 months
14. Work organisational changes in maintenance activities

- Estate management involved physically demanding work
- To reduce musculoskeletal risks, tasks were planned so that unnecessary lifting and carrying was avoided. Specialist work was subcontracted to specialists and efforts were made to match staff skills with job demands
- Better organisation meant that risks of musculoskeletal injury were reduced and efficient working was promoted, with a payback period of just over 8 months

The tasks

The Organisation had responsibility for a large area of land, and employed approximately 100 people at eight bases to undertake a variety of estate maintenance work. This work was physically demanding (see for example Figure 14.1). In addition to the physical demands of the individual tasks, the work was carried out in rugged and often remote locations, and could involve working in adverse weather (see Fig 14.2). More workers were provided for the more difficult or time consuming tasks. This way of working was not always efficient, and having large numbers of people undertaking a job meant that communication and site management were important in ensuring that work was carried out safely and effectively.

![Figure 14.1. Preparing the ground for building a dry stone wall, pre-training.](image-url)
Musculoskeletal risks

- Manual handling accidents were increasing and musculoskeletal disorders were beginning to emerge.
- There was a high level of sickness absence.

Identifying the problem

Management were aware that accidents and sickness absence were high and that one of the reasons for sickness absence was operators experiencing musculoskeletal disorders.

What was done?

A series of risk assessments was carried out for each of the major work activities. The outcomes of the assessments included the provision of better work equipment and mechanical aids. Also, certain organisational changes were made that improved safety, health and efficiency.

An active policy to share ideas and information about good working practices was set up among the eight bases on the estate. To make the best use of resources, labour intensive ways of working were changed to make more effective use of workers’ skills and competencies.

The organisational changes included:

- Regular team talks to determine ways in which workplace risks could be managed. Getting together to discuss ways in which jobs could be improved resulted in better understanding and coordination between different groups of workers. For example, chippings to be distributed on footpaths were dropped off by a dumper truck or tipping trailer. Estate workers would then shovel chips from the ground. Following a review of procedures, wherever possible, small dumpers are now left at the point of use so that workers can shovel from waist height. Shovelling jobs are now done more quickly and are much less fatiguing. Reports of back pain have reduced. The estimated cost of implementing a range of such changes in practice was £910.

- Dry stone walling cost £40-50 labour costs per metre using estate staff. Specialist contractors are now brought in to repair and build walls at a cost of
approximately £25-30 per metre. Bringing in specialist firms for dry stone walling enabled estate staff to do other work. Previously, repairs to a typical length of wall (150 m) could occupy several estate staff members for several weeks.

- Although most of the dry stone walling was contracted out some of it was still done by estate workers. Under this new system the estate workers had less practice of the task, and could therefore potentially be at increased risk of musculoskeletal injury for the times when they do undertake it. However, this increased risk is outweighed by reduced exposure to the hazard.

- Prior to the initiatives, this work was organised among the estate workers so that one person would be responsible for digging out the footings, another for fetching stones and a third person would be responsible for laying them. The risk assessment showed that there was a risk of injury due to overuse of the same muscle groups. After the intervention, the work was reorganised so that each person had responsibility for all the jobs along a 20m section of wall; this job rotation helped to reduce risk. Apart from the time taken to assess the risks and discuss risk reduction strategies during the health and safety meeting (2 days management time), there was no cost for these changes.

- A review of training needs was carried out during weekly group health and safety meetings. They listed the skills and competencies that workers needed and compared these with existing training to establish if there were training gaps. It was found that the manual handling training being provided was more suited to an office environment than to working outdoors on rough terrain. More appropriate training was sought and then integrated into the probationary period for new staff. This training was mostly carried out at the work site rather than being based in the office, which was felt to be of more practical benefit. The extra training was estimated to have cost approximately £4,000 per year.

Costs and benefits

Time off through musculoskeletal disorder related absence has fallen by 20% following these interventions. This has provided an estimated additional £6,720 per year of labour time. It is not known how much of the reduction in injuries and absence is due to improved training and how much due to changed work practices. The training also helped improve morale as workers feel that they have learned useful skills and have been able to choose areas in which to specialise.

Table 14.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced MSD risks.</td>
<td>Several alternative ways of working have been developed which have reduced MSD risks and made jobs more efficient without cost. Sickness absence has been reduced by 20%.</td>
</tr>
<tr>
<td>Use of specialist contracting firms</td>
<td>The cost of using in-house resources and contractors for different jobs has been calculated which has allowed the most cost-beneficial way of working to be established.</td>
</tr>
<tr>
<td>reduces the risk of injury in cases where jobs are done infrequently but require skill and knowledge to carry them out safely.</td>
<td></td>
</tr>
</tbody>
</table>
Morale has improved.  
Training and jobs are better matched.  
Personnel feel better equipped to do different jobs.

**Economic analysis**

**Costs and Benefits**

**Direct intervention costs:**
- Estimated cost of additional training: £4,000
- Management time to complete risk assessments estimated to be 2 days at £350 per day: £700
- Estimated cost of changes in practice: 56 hours of estate staff time @ £10 per hour + wage oncosts @ 30%: £784
- 1 day of management time @ £350 per day: £350
- **Direct intervention costs**: £5,834

**Post-intervention benefits**
- Replacing estate personnel with subcontract labour for dry stone walling: £17.50 per metre ( £45 for own labour - £27.5 for subcontract labour) for 150 metres: £2,625
- Labour costs available through reduced sickness absence: 360 days absence prior to the change compared with 300 days in the following year @ £112 per day: £6,720
- **Total benefits per year**: £9,345

**Conclusion**

The lifecycle of the estate management procedures is assumed to be 3 years from the date of intervention.

- **Total cost of interventions**: £5,834
- **Net present value of post-intervention benefits over the process lifecycle at an 8% discount rate**: £9,345 per annum for 3 years = £26,010
- **Net intervention benefit**: £20,176

**Payback period**: 8.07 months

Base price year is 2002
15. Avoiding manual handling in estate maintenance

- Moving stone by hand was difficult and often involved a high risk of injury to the lower back, knees and muscles of the upper body
- Use of mechanical means to move stones means constructing paths from stone is done more quickly and with significantly less risk of injury
- Better quality stone is available because it can be chosen from a wider area
- Direct intervention costs of £132,400; payback period of just over 4.5 months

The tasks
Building and maintaining pathways on a very large countryside estate is a relatively frequent occurrence, requiring the use of local stone for conservation reasons. It was difficult to use vehicles around boulders and on loose scree which meant that almost all stone moving was done by hand. Moving the stone typically involved several workers lifting the heavy loads, which was hazardous and fatiguing (see Figure 15.1). The amount of stone that needed to be moved varied according to need and the priorities of the work.

Musculoskeletal risks
Moving stone often required several workers handling it together. Team handling was risky because if one or more people lose their grip or fail to take sufficient weight, the weight supported by other members of the team could far exceed their capability suddenly and without warning. Furthermore, the shape and size of the stones meant that it was difficult for workers to always get a good hold on them, and to be able to adopt good postures (see Figure 15.1). Depending on the nature of the load, it was likely that some members of the team were unable to see where their feet were being placed, or where they were going. On the estate, uneven ground made carrying more risky.

There was a risk of injuries to the knees, back and shoulders, as well as the muscles of the upper body. Additionally, the loads themselves could cause injury if they came into contact with the body when dropped or rolled.

Figure 15.1. Manually moving stone
Identifying the problem

Accident rates related to manual handling were high. Individuals that sustained injuries through their work were unable to work as productively as before.

What was done?

To address a broad range of health and safety issues weekly team meetings had been set up, involving the whole workforce, to discuss ways of improving the work. One suggestion was to use a helicopter to transport stone from its original location to its point of use. The stone could be placed in large sacks and moved using the helicopter; this would mean large quantities could be delivered at once which could save hours of work. The cost of hiring a helicopter and crew, and the procedures required for its safe use were investigated. The helicopter company was able to supply information on safe procedures for use of the helicopter. The organisation set up a half day training course to take place during a scheduled training session which was also provided free of charge.

Using a helicopter to move stone weighing ½ tonne or more was found to be more cost effective than other forms of handling, if the distance was greater than 10m. Using the helicopter significantly reduced the musculoskeletal disorder risks; it removed the need for teams of people to carry stone over long distances. The sacks were placed near the stone to minimise manual handling. A degree of handling was however inevitable in loading the sacks, which were placed close to the stone; the sacks were loaded by rolling stones onto them. The edges of the sack were then gathered and attached to the helicopter winch (see Figure 15.2).

Use of lifting sacks avoided the need to take winches and barrows into the hills for lifting stone. The lifting sacks were also found to be useful for dragging other material manually, rather than lifting and carrying the items. Wheelbarrows were awkward to use when the ground was sloping and uneven and could hold less than a lifting sack.

Figure 15.2. Helicopter lifting a sack of stone. Additional bags can be seen on the ground.
Stone for creating paths can now be taken from sites where there will be least disruption to the landscape and better stone can be sourced. Prior to use of the helicopter, it was only feasible to gather stone close to the place where it would be needed because of the time and effort required to transport it over the terrain. Four personnel would be expected to move a tonne of stone over the course of a day (this includes half of the day being spent getting to the site and back). The helicopter can move 100 – 120 bags in a day, with each bag containing a tonne of stone. Although hiring a helicopter is expensive, the amount of work that can be done with the helicopter far outweighs the cost of shifting stone manually. Much of the stone was taken down or across the hill with approximately a five minute turnaround. The labour time saved can be used on more skilled operations.

The helicopter was typically used for four sessions in a year. Each session would typically be 5 days of 6-8 hours per day. The extent to which the helicopter was used depended on the weather and the amount of stone that needed to be moved at the time.

The helicopter company required that the lifting sacks only be used once for safety reasons. An estimated 2000 were used each year, with each costing approximately £5.00.

Fluorescent vests, hard hats and ear defenders for staff working near the helicopter lift and drop off sites were used. Goggles were also occasionally required as the helicopter could raise a lot of dust in dry weather. This equipment was already available from the organisation as it is used routinely on other jobs.
### Costs and benefits

**Table 15.1 Summary of benefits**

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of a helicopter for moving heavy stone in remote locations was found be very cost effective.</td>
<td>Although it is expensive to hire, there are very few problems with access and it can carry over 100 times more in a day than a team of workers.</td>
</tr>
<tr>
<td>Musculoskeletal risks are significantly lower.</td>
<td>Stone is rolled into nearby sacks and the helicopter lifts the sacks.</td>
</tr>
<tr>
<td>Sacks can be used without the helicopter.</td>
<td>The sacks have been found to be a successful way of reducing the manual handling risk, by dragging other relatively light or small materials such as earth, fence posts and tools.</td>
</tr>
<tr>
<td>More appropriate stone can be sourced, with minimal environmental impact.</td>
<td>Stone can be more easily transported longer distances.</td>
</tr>
</tbody>
</table>

A helicopter is hired on a routine basis and so the cost savings have been accrued into one financial year. It has not been possible to isolate the savings made in terms of reduced sickness absence due to musculoskeletal disorders because other interventions have been made involving the same staff over the same period which may have led to reduced musculoskeletal disorder related sickness absence.
### Economic analysis

#### Costs and Benefits

**Direct intervention costs:**

<table>
<thead>
<tr>
<th>Cost</th>
<th>£</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual helicopter hire (20 days at £650 per hour)</td>
<td>91,000.00</td>
</tr>
<tr>
<td>Annual wage costs for workers to fill bags for helicopter</td>
<td>22,400.00</td>
</tr>
<tr>
<td>Annual cost of lifting sacks (2000 @ £5.00 each)</td>
<td>10,000.00</td>
</tr>
</tbody>
</table>

**Post-intervention benefits**

<table>
<thead>
<tr>
<th>Saving</th>
<th>£</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saved labour cost of shifting 110 tonnes manually:</td>
<td>985,600.00</td>
</tr>
</tbody>
</table>

**Conclusion**

The lifecycle of the estate management procedures is assumed to be 3 years from the date of intervention.

- Net present value of annual direct intervention costs over the process lifecycle at an 8% discount rate: £113,400 per annum for 3 years = £343,455.00
- Net present value of direct intervention costs over the process lifecycle at an 8% discount rate: £985,600 per annum for 3 years = £2,743,186.00

**Net intervention benefit**

| £2,399,731.00 |

**Payback period**

4.51 months

Base price year is 2002
16. Improving postures in vegetable harvesting

- Vegetable harvesting was fatiguing and associated with risk of injury to the knees, hamstrings, back and upper body
- A cart was provided which allowed workers to support the harvest container and their body weight and remain mobile while working at ground level
- This resulted in harvesting being completed in 60% of the time and a decreased risk of musculoskeletal disorders
- The cost of the cart was £775; the payback period was 7 months

The task

Harvesting salad vegetables was labour intensive. The job required operators to stoop, kneel and crawl, and took considerable time and energy. The harvest container (a plastic crate) also had to be lifted and moved frequently as the picker worked along the rows. In addition to harvesting, the job involved transplanting vegetables and weeding which also required working at ground level.

Musculoskeletal risks

The work was tiring for the knees, hamstrings, back and upper body. Small scale growers are consistently among the highest risk groups for occupational injuries. These health problems contribute to industry costs through sickness absence and reduced productivity. Compensation claims and high staff turnover in some areas add to the potential costs.

Identifying the problem

Researchers working in agriculture used accident and ill health statistics to gauge the extent of the problem. Their experience of working with large and small scale growers provided them with information on the level of the musculoskeletal risks. Also kneeling for prolonged periods on a regular basis is known from research to be associated with chronic knee conditions.

What was done?

A cart was designed and built by engineers working in agricultural research that allowed labourers to sit while they harvested (see Figure 16.2). It had wheels that allowed the user to move forward by pushing with the hands, in the manner of a
wheelchair, or by using the feet. The cart was designed to be easy to construct. It was not released as a commercial design. The aim instead was for growers to be able to build one themselves from parts commonly found in a hardware store, requiring only a local welder. An example cart is shown in Figure 16.2.

Figure 16.2. Harvest cart

The basket into which the harvested salad vegetables were placed was supported on a frame just above the steering wheel at the front of the cart.

The cart provided the following practical benefits:

- Low mounted seat allowed work directly over the bed allowing a variety of postures to be adopted; changing posture regularly helps to avoid discomfort.
- The seat swivelled which allowed harvesting from all parts of the bed without twisting. Although stooping is still required (Figure 16.2 shows what was regarded as the worst posture likely to be adopted using the cart), the amount of stooping required is less than with the conventional harvesting method.
- Kneeling for long periods was avoided, so the risk of knee discomfort is reduced.
- The harvest container was positioned on the front corner of the frame, within easy reach of the operator. Manual handling of the container was eliminated as the operator moved along the bed.
- Use of the cart resulted in the same amount of vegetables being harvested 40% more quickly. Faster harvesting allows the product to be delivered to the cooler more quickly, which maintains crop quality.
- Front wheel swivelled for easy steering
- Less soil compaction than walking or kneeling on the crop or bed – the weight bearing wheels lie in the paths between the crops. This helped reduce the amount of product waste.

The engineers who designed the cart conducted a harvest speed and postural analysis to assess its efficiency. The same worker performed the same task for the study. Postural analysis was conducted using a recognised technique.
Harvest speed and posture analysis

<table>
<thead>
<tr>
<th></th>
<th>Without cart</th>
<th>With cart</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. minutes taken to fill a crate of size 400 x 500 x 700 mm (approx)</td>
<td>7.8</td>
<td>4.6</td>
</tr>
<tr>
<td>% time spent in hazardous postures</td>
<td>46</td>
<td>0</td>
</tr>
<tr>
<td>% time spent in marginally hazardous postures</td>
<td>48</td>
<td>93</td>
</tr>
<tr>
<td>% time spent in acceptable postures</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

It should be noted that the cart does not eliminate all ergonomic risks. As mentioned above, use of the cart reduces stooping and eliminates kneeling. However posture and movement is fairly restricted and cannot therefore be described as ‘good practice’.

Costs and benefits

Reducing the harvest time saved labour costs, and improved product quality and potentially therefore the sale price achieved.

Reducing the risk of musculoskeletal disorders significantly reduced the likelihood of sickness absence, claims, and costs associated with dealing with an incident. As labourers generally carry out a variety of tasks it has not been possible to isolate accident and sickness data specifically related to the harvesting operations. It is assumed for the purposes of calculation that:

- Labour costs are £5.70 per hour.
- Harvesting takes place for 20 weeks per year.
- Each worker works 37.5 hours per harvest week.

The cost of producing each cart is estimated at between £250 and £400, costs varying depending upon location and quality of materials used.

Table 16.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less fatigue and discomfort</td>
<td>Sitting is better than prolonged kneeling or stooping</td>
</tr>
<tr>
<td>Faster harvest time</td>
<td>The same amount of vegetables were harvested 40% more quickly using the cart</td>
</tr>
<tr>
<td>Less soil compaction</td>
<td>Worker does not tread on crop row or bed as their weight is transferred through the cart’s wheels to the paths</td>
</tr>
</tbody>
</table>
Economic analysis

Costs and Benefits.

Direct intervention costs:  
- Manufacture of harvesting cart, average cost: £325
- Product design costs, averaged: £450
  
  **Total cost of intervention:** £775

Post-intervention benefits  
- Productivity gain per worker:  
  - 40% on 20 weeks at 37.5 hours and £5.70 per hour: £1,710

No data was available to allow for the quantification of cost savings associated with reducing the incidence of MSDs

Conclusion  
The process lifecycle is assumed to be 3 years from the date of intervention.

Total cost of intervention: £775

Net present value of direct intervention costs over the process lifecycle at an 8% discount rate:  
- £1,710 per annum for 3 years: £4,759

**Net intervention cost benefit:** £3,984

Payback period: 7.00 months

Base price year is 2000
17. Improved manual handling in the maintenance of drilling equipment

| • Testing and maintenance of offshore drilling equipment involved connecting heavy duty pipework together |
| • Manually handling the pipework meant that personnel were at risk of developing back and shoulder pain |
| • Changes to layout and equipment avoided unnecessary handling and improved working postures |
| • Direct intervention costs of £3,555; payback period of less than one month |

The task

Oil drilling tools were tested by the Company, prior to being used offshore. Each tool could be between 6 m and 15 m long and could vary in diameter from approximately 120 mm to 150 mm.

The tool was connected to a high pressure water supply (see Figure 17.1) to test mechanical properties and flow rates. To get it into position, the tool was lowered onto stands in the testing area by an overhead crane. Operators then attached the tool to the inlet and outlet of the water supply. Attaching it to the inlet required manual fitting a bypass adaptor and manifold. At the outlet end, a long flexible hose was attached between the tool and an outlet pipe running along the length of the wall of the test area.

The employees were mostly male. They carried out a range of engineering and maintenance tasks on offshore drilling equipment in the Company’s workshop and test areas.

The musculoskeletal risks

A risk assessment was completed as there were concerns over the risk of musculoskeletal disorders associated with this task. This showed that there were a number of ergonomics issues associated with testing the tools that were identified as posing a high risk of musculoskeletal injury:

• Attaching the bypass adaptor at the inlet end of the tool was a physically demanding task because of the adaptor’s weight. The adaptor had to be fitted by two operators each time a tool was tested (approximately six times a day). The job took two operators 20 minutes.

• The tool sloped down from about waist height at the inlet end to between 400 – 600 mm off the ground at the outlet end (the exact height depended on the length of the tool). Attaching the flexible hose to the outlet end involved stooping and had been identified as posing a risk of injury to the back and shoulders. To minimise stooping, a jack had been provided to raise the height of the tool. Although this improved the working posture, using the jack required repeated forceful effort, again in a stooped posture. Attaching the flexible hose to the tool and drainage piping required three or four operators to expend moderate to high effort for an hour, two or three times a week.
Couplings for connecting the tool to inlet or outlet pipes weighed around 20 kg and were stored on the floor, usually at the place where they had last been used. The couplings were picked up and carried to where they were needed, several times a day. The risk assessment identified that this involved a risk of injury.

**Identifying the problem**

Based on the findings of the risk assessment, the company was concerned that musculoskeletal injuries were likely to develop, particularly in the back and shoulders. The risks included high forces required for some jobs and applying force in awkward postures. There had also been reports of pain and discomfort.

**What was done?**

The management commissioned an ergonomics consultant to give advice on work layout and organisation with a view to reducing risks and finding more efficient ways of working.

The recommendations were delivered in a report which the management used to draw up an action plan of changes. Good relations existed between the management and the workforce which allowed concerns and ideas to be communicated in both directions easily. As the recommendations were implemented, operators undertaking this task contributed ideas of their own to the action plan. The company reviewed progress on an ongoing basis.

The following changes were made:

- The bypass adaptor at the inlet end of the tool was relocated to an earlier part of the line. This avoided the need for fitting it to every new tool; this had previously taken 20 hours per week.

- The slope of the tool was eliminated by using stands which supported the tool horizontally, so the outlet point was always at the same height. The stand height was set so that the top of the tool would be slightly below elbow height for most operators, avoiding the need for awkward postures. The stands were
adjustable in height, but in practice the compromise height was suitable for all the tools of different diameters.

- The 20kg couplings were machined down to remove excess weight. A wheeled stand was bought that held the couplings at a convenient height for storage. All of the couplings were now housed in one unit which was easily moveable. The stand with some couplings on it is shown in Figure 17.2.

![Figure 17.2. Wheeled couplings stand](image)

- Additional manifolds were fitted along the wall-mounted outlet pipe which meant that a shorter hose could be used to connect the tool to the outlet pipe. The shorter hose was lighter which reduced the associated manual handling risks. Fig 17.1 shows the long hose which had originally been used; figure 17.3 shows the newer short hose attached to a manifold. The job of fitting the flexible hose was reduced from requiring three or four operators for one hour to one or two operators requiring only half an hour. This task was carried out two or three times a week, making a time saving of five hours per week.
Figure 17.3. Short flexible hose and manifolds along the wall. The hose can be connected to the nearest manifold, depending on the length of the tool.

**Costs and benefits**

The time saved through avoiding unnecessary handling was converted into a financial value by using the wages costs for the time saved.

The following costs were incurred in assessing and modifying the area:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ergonomics consultant, proportion of one week$^5$</td>
<td>£310</td>
</tr>
<tr>
<td>Machining the couplings (in-house)</td>
<td>£45</td>
</tr>
<tr>
<td>Purchase of wheeled couplings stand</td>
<td>£400</td>
</tr>
<tr>
<td>Refitting the bypass adaptor</td>
<td>£100</td>
</tr>
<tr>
<td>Fitting additional manifolds</td>
<td>£2,000</td>
</tr>
<tr>
<td>Purchase of shorter flexible hose</td>
<td>£700</td>
</tr>
<tr>
<td>Total costs</td>
<td>£3,555</td>
</tr>
</tbody>
</table>

$^5$ About 10% of an ergonomist’s week was spent assessing and providing advice on this work area.
The labour time saved per week was converted into a cost saving as shown:

<table>
<thead>
<tr>
<th>JOB</th>
<th>TIME TAKEN BEFORE</th>
<th>TIME TAKEN AFTER</th>
<th>MONEY SAVED PER WEEK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fitting bypass adaptor to pipe</td>
<td>2 operators for 20 minutes, 30 times per week = 20 hours / week</td>
<td>0 minutes</td>
<td>20 hours at £48 per hour = £960</td>
</tr>
<tr>
<td>Fitting hose to tool and outlet pipe</td>
<td>3 operators x 1 hr, 2.5 x per week = 7.5 hours / week</td>
<td>2 operators x 30 min, 2.5 x per week = 2.5 hours / week</td>
<td>5 hours x £48 per hour = £240</td>
</tr>
<tr>
<td>Total saved per week</td>
<td></td>
<td></td>
<td>£1,200</td>
</tr>
</tbody>
</table>

The savings do not take into account:

- Reduced overtime costs at time and a half or double time
- Savings from potential sickness absence due to musculoskeletal disorders
- Enhanced productivity because staff were released to do other jobs
- Reduced likelihood of claims due to musculoskeletal injuries

The intervention was reviewed at regular team meetings which considered health and safety and efficient ways of working.

Table 17.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short payback period of around 3 weeks.</td>
<td>Time saved by reduced manual handling has allowed other work to be completed.</td>
</tr>
<tr>
<td>The risk of shoulder and back pain was reduced</td>
<td>Reducing the amount of manual handling reduced the risks.</td>
</tr>
<tr>
<td>Feedback from operators was very positive</td>
<td>Working procedures have been improved and operators have continued to contribute ideas to reduce risks further</td>
</tr>
</tbody>
</table>
**Economic analysis**

**Costs and benefits**

**Direct intervention costs**
- Adaption of manifold systems: £3,245
- Ergonomics Consultant's costs: £310
- **Total**: £3,555

**Post Intervention Benefits**
- 2 men at 12.5 hours per week each, for 45.5 weeks per year at £48 per hour (includes oncosts): £54,600

**Conclusion**
The process lifecycle is assumed to be 5 years from the date of intervention.

- **Total cost of intervention**: £3,555
- **Net present value of post-intervention costs over the process lifecycle at an 8% discount rate**: £54,600 per annum for 5 years = £235,442
- **Net intervention benefit**: £231,887
- **Payback period**: 0.91 months

Base price year is 2003
18. Controlling handling risks for offshore equipment

- Manual effort in handling heavy canisters involved awkward postures and heavy weights, resulting in a risk of lower back injury
- Fitting a jib crane to the transport container (overpack) reduced risks, with a payback period of 3 months based on previous accident data
- After direct intervention costs of £14,875 no further injuries have occurred in three years of monitoring the outcome. Payback period of 3 months.

The task

In the oil and gas industry, radioactive sources are used to investigate the density of rock formations. The radioactive material is stored in source containers of various sizes (see Figure 18.1).

![Figure 18.1. Three radioactive source containers](image)

The source containers varied in weight; the largest weighed 75kg, the medium weighed 45kg and the lightest container weighed 10kg. These containers were transported on and offshore in an overpack (see Figure 18.2). Onshore they were handled into the overpack manually; offshore, cranes and other handling aids were more likely to be available, which avoided the need for manual effort.

All handling was carried out by contractors to the Company. Usually their job was sedentary, with manual handling activities carried out only occasionally.
Musculoskeletal risks

The containers were loaded into the overpack manually. This would happen between a maximum of twice in 24 hours to once every ten days. The risks of back injury were high, even with this low frequency. In addition to the heavy unit weight, constraints on posture increased the risk:

- The operator was required to stoop to fit the container into the overpack which placed high loading on the lower back.
- There was only space for one operator to reach into the overpack at a time, so assistance could not easily be provided.

Identifying the problem

A back injury had occurred when an operator was loading the heavier of the containers; this resulted in six months sickness absence. Specialised personnel, such as the injured man, were in short supply. The Company relied upon a good reputation to ensure that their offshore contracts were renewed and that they retained staff to hire out as contractors.

What was done?

It was not possible to make the source containers lighter or to change the dimensions of the overpack which would have improved the postures that could be adopted. Instead, a jib crane was fitted permanently to the top of the overpack which would take the weight of the containers (see Figure 18.3). In addition, a trolley was fitted to the interior of the overpack (see Figure 18.4) which would allow containers to be handled without the operator having to reach into the storage space.

A chain strap was fitted round the 75 kg keg-shaped container to provide a lifting point. At the onshore depot, this was used to raise and lower the containers between the ground and the overpack storage space. Figure 18.5 shows a smaller container being lifted using a ratchet lever hoist. The jib crane would be pushed back by hand and the source container guided into place.
Figure 18.3. Using the crane jib to lift the keg-shaped container

Figure 18.4. Loading the container using the trolley system
Figure 18.5 Use of the jib crane and ratchet lever hoist to lift the 45 kg source container

*The costs and benefits*

One day’s consultancy time of £500 was expended to assist the company to identify the required solution. The cost of the jib crane and trolley system was £2,000 for the first overpack. The design was modified in the light of experience and further overpacks were fitted with the lifting aids at a cost of £750 per installation. In total fifteen overpacks were modified at a total cost of £12,500.

The intervention was monitored by obtaining feedback from operators and by reviewing accident statistics.

Like all of the Company’s personnel who carry out this job, the injured operator was a contractor. For six months after his injury, he was only able to undertake light work onshore. The Company had been charging out his time at £350 a day but could only charge £175 for the onshore work he was able to do during his period of rehabilitation. In this case the cost of the injury to the Company on lost revenue alone was therefore £21,000, assuming 20 working days a month. This cost does not include the costs of the investigation into the accident or the potential expense of losing customer confidence.

Another onshore injury, sustained in the same way a few months earlier resulted in 10 days revenue lost at a cost of £4,655.

Revenue generated from employing a temporary replacement contractor was estimated to be 65% of that which could be achieved from a permanent contractor because of the difference in wage charge-out rates.

Based on the known accident rate, and the high level of ergonomic risk associated with the original handling methods, it has been assumed that without the modifications, accident rates would have continued to be at the level of two per year. The savings
from preventing similar accidents more than offsets the costs of modifying all of the containers.

Table 18.1 Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs of injuries (both personal and to company) avoided.</td>
<td>No operators have sustained musculoskeletal injuries while carrying out this job since the overpacks were modified.</td>
</tr>
<tr>
<td>Short payback period.</td>
<td>Sickness absence was very costly – avoiding it has resulted in significant cost savings.</td>
</tr>
<tr>
<td>Job reported to be less fatiguing.</td>
<td>As heavy handling is avoided, operators are less likely to develop aches and pains or to sustain an injury through cumulative damage.</td>
</tr>
</tbody>
</table>
**Economic analysis**

**Costs and Benefits**

**Direct intervention costs:**
- Investigation of problem, consultation and implementation of proposals, 3 management days at a day cost of £625: £1,875
- External expert consultation and proposal: £500
- 15 overpacks modified: £12,500
- **Total cost:** £14,875

**Pre-intervention costs**
Based upon 2 incidents arising within a 12 month review period

<table>
<thead>
<tr>
<th>Immediate incident intervention:</th>
<th>Hours</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management time</td>
<td>4</td>
<td>£360</td>
</tr>
<tr>
<td>Work stopped</td>
<td>4</td>
<td>£188</td>
</tr>
<tr>
<td>Investigation, report and follow up</td>
<td>4</td>
<td>£360</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>£908</strong></td>
</tr>
</tbody>
</table>

**Replacement personnel**

| Contractor 1 - lost production: 10 days | 4,655 | £3,026 |
| Contractor 2 - lost production: 120 days | 42,000 | £27,300 |
| Contractor 2 - reduced production: 120 days | 21,000 | £13,650 |
| **Total** |       | **£43,976** |

Cost of temporary replacement contractors estimated to be 65% of revenue

| Annual pre-intervention costs | **£44,884** |

**Conclusion**

The process lifecycle is assumed to be 5 years from the date of intervention.

- Total cost of intervention: £14,875
- Net present value of pre-intervention costs over the process lifecycle at an 8% discount rate:
  - £44,884 per annum for 5 years: £193,546
- **Net intervention benefit:** £178,671
- **Payback period:** 3.00 months

Base price year is 2002
### 19. Improving the work environment in a newspaper office

| • Office workers on different shifts shared desks |
| • Prolonged computer work was associated with sickness absence due to upper limb disorders |
| • Better display screen equipment was installed and a schedule of regular breaks was set up |
| • Direct intervention cost of just under £47,000 but reduced sickness due to musculoskeletal absence since the changes mean that the payback period was just over 27 months |

#### The task

Around 170 staff were employed in the Free Ads department of a newspaper. Most of these staff were involved in copytaking i.e. inputting adverts received via the post, fax, email or telephone. Space restrictions meant that desks were shared between personnel working on different shifts.

#### Musculoskeletal risks

The copytaking work involved repetitive keying for prolonged periods at the workstations (which constrained posture, see Figures 19.1 and 19.2), with little chance to vary posture; this posed a risk of musculoskeletal disorders. Staff often had to work to production deadlines, which further increases the risk of musculoskeletal disorders and stress.

![Figure 19.1 Typical original desk](image1)

![Figure 19.2 Typical original desk](image2)

- The workstation in Figure 19.1 is poorly set up – the screen is too low, and the user is sitting too low relative to the keyboard. The desk thickness means that the user would not be able to sit higher because of difficulties with thigh clearance.
- The screen in the workstation in Figure 19.2 is much too low for this user and there is little room available on the desk top for the necessary papers.

#### Identifying the problem

A number of staff had been diagnosed with musculoskeletal disorders. The company realised that there was a significant risk of these problems developing as a result of the work and the workstations provided.
**What was done?**

A consultant ergonomist was brought in to assess the work environment and suggest changes that would reduce the risk of musculoskeletal and stress-related problems.

Recommended changes included some specific, focussed interventions to tackle particular risks to more general improvements to create a more acceptable working environment. Changes included:

Table 19.1 Summary of benefits

<table>
<thead>
<tr>
<th>Change made</th>
<th>Benefit of the change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reorganisation of schedules meant that tight working deadlines could be relaxed to a degree</td>
<td>This helped to reduce pressure on staff and enabled them to take breaks from intensive keyboard work.</td>
</tr>
<tr>
<td>Line managers were given responsibility for keeping note of the amount of time staff spent working continuously at the computer</td>
<td>This helped to ensure that workers took their breaks rather than working continuously for long periods.</td>
</tr>
<tr>
<td>Provision of new split level, height adjustable desks.</td>
<td>This allowed shift workers of different heights who shared the desks to adjust the furniture to suit their needs, and find a more comfortable working position. The desks allowed independent height adjustment of the screen and the height of the keyboard and mouse. The document holder could also be placed on the screen shelf, further helping to improve neck posture. The new workstations provided more working space.</td>
</tr>
<tr>
<td>New chairs were purchased.</td>
<td>These provided better postural support and more closely matched the job requirements of the seated staff.</td>
</tr>
<tr>
<td>Improved the level and type of lighting.</td>
<td>This made it easier to read copy, reduced glare and reflections on the screens.</td>
</tr>
<tr>
<td>Privacy screens were introduced between staff facing each other.</td>
<td>This gave staff some privacy at their workstation and reduced the likelihood of distractions from colleagues.</td>
</tr>
<tr>
<td>A rest room was set up.</td>
<td>This provided staff with somewhere to take breaks away from the workstation.</td>
</tr>
</tbody>
</table>

There was no reported sickness absence due to musculoskeletal disorders in the 3 years following the intervention. The changes were beneficial but costly to make, so health and safety staff were keen to carry out a cost benefit analysis. A comprehensive list was compiled of the possible costs of an employee leaving their job or taking sickness absence due to work related musculoskeletal disorders.
Figures 19.3 and 19.4. New layouts allow better working postures and provide more space at the workstation

**Costs and benefits**

Based on information from the company, the typical cost of one copytaker developing a musculoskeletal disorder was estimated, assuming an average wage cost/employee/productive hour of £8.14 per hour (related to year 2000).

It was estimated that an injured copytaker was absent from work for 2 weeks on full pay. If the injury required more extensive rehabilitation then the Company paid extended sick pay in full for a further 6 weeks. Before the interventions there was an average of 3 new cases of upper limb disorder, amongst copytakers, leading to sick leave. Following the intervention there were no reported musculoskeletal disorders. Prior to the intervention the number of copytakers leaving their jobs due to work related upper limb disorders was between 2 to 5 per year. It was reported that the number of copytakers leaving since the intervention had reduced.
Table 19.2. The cost of one worker developing a work related upper limb disorder

<table>
<thead>
<tr>
<th>Cost item</th>
<th>Cost in employee hours</th>
<th>Cost (£) Internal labour</th>
<th>Cost (£) External services</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal sick pay</td>
<td>40</td>
<td>326</td>
<td>0</td>
<td>2 weeks (part time staff worked 20 hours / week)</td>
</tr>
<tr>
<td>Extended sick pay</td>
<td>120</td>
<td>977</td>
<td>0</td>
<td>6 weeks</td>
</tr>
<tr>
<td>Cost of temporary cover for sick leave</td>
<td>160</td>
<td>1302</td>
<td>0</td>
<td>8 weeks</td>
</tr>
<tr>
<td>Decreased productivity due to injury</td>
<td>60</td>
<td>488</td>
<td>0</td>
<td>Estimated at 25% reduced productivity for 3 months prior to sick leave</td>
</tr>
<tr>
<td>Visits to doctor / therapist</td>
<td>6</td>
<td>49</td>
<td>0</td>
<td>Estimated at 2 hours away from work, x 3</td>
</tr>
<tr>
<td>Doctors’ report fees</td>
<td>0</td>
<td>0</td>
<td>90</td>
<td>2 letters @ £45 each</td>
</tr>
<tr>
<td>Cost of physiotherapy</td>
<td>0</td>
<td>0</td>
<td>180</td>
<td>4 sessions @ £45 each</td>
</tr>
<tr>
<td>Cost of recruiting new staff member</td>
<td>125</td>
<td>1018</td>
<td>0</td>
<td>Advertisements, interviews, administration and 25% lowered productivity in first 3 months due to inexperience</td>
</tr>
<tr>
<td>Cost of training new staff</td>
<td>85</td>
<td>692</td>
<td>0</td>
<td>Induction and on the job training for three months</td>
</tr>
<tr>
<td>Discussions with Health and Safety staff or Personnel</td>
<td>8</td>
<td>65</td>
<td>0</td>
<td>Estimated @ 1 hour of employee’s time and 2 other staff (paid 3.5 times injured staff salary)</td>
</tr>
<tr>
<td>Counselling</td>
<td>0</td>
<td>0</td>
<td>120</td>
<td>4 sessions @ £30 each</td>
</tr>
<tr>
<td>Retraining programme for injured staff member</td>
<td>300</td>
<td>2442</td>
<td>0</td>
<td>Estimated wages of another staff member training plus injured staff member on full pay</td>
</tr>
</tbody>
</table>

Total: 904 hours 7359 390

The cost to the company for sick pay involves three elements. Firstly there is the cost of sick leave. Additionally, temporary replacement staff had to be brought in from an agency. The worker off sick might later resign and have to be replaced with a permanent member of staff, which also cost the company money.
It was not possible to estimate costs for the following:

- Loss of skills and knowledge
- Impact on other staff, morale and motivation
- Potential costs of compensation plus cost of negative publicity for the Company

Assuming that each episode of lost time due to a work related upper limb disorder cost 904 employee hours, and with other costs added, the cost of productivity losses and fees was £7,749 per year (see Table 19.3).

<table>
<thead>
<tr>
<th>Cost to the Company</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>904 lost employee hours at £8.14/hour</td>
<td>7,359</td>
</tr>
<tr>
<td>2 doctor’s letters at £45 each</td>
<td>90</td>
</tr>
<tr>
<td>4 physiotherapy sessions (at £45 each)</td>
<td>180</td>
</tr>
<tr>
<td>4 counselling sessions (at £30 each)</td>
<td>120</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7,749</strong></td>
</tr>
</tbody>
</table>

With three incidents over the course of a year, the cost was 3 x £7,749 = £23,247.

Table 19.4. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced risk of musculoskeletal disorders.</td>
<td>The incidence of musculoskeletal disorders was reduced to zero following the intervention.</td>
</tr>
<tr>
<td>Morale is higher in the company.</td>
<td>Musculoskeletal disorders cases can often be damaging for team morale. The reasons may include healthy workers having to cover for those off sick; increased worry over health and a perceived lack of control over the causes and symptoms of pain and discomfort.</td>
</tr>
</tbody>
</table>
Economic analysis
Costs and Benefits

Direct intervention costs:
- Ergonomics consultant: £5,000
- Furniture and equipment: £38,270
- Staff time to assist with the intervention, estimated to be 15 hours @ £8.14/hour: £122
- Management time, estimated to be 7 days @ £500 per day: £3,500

Direct intervention costs: £46,892

Post-intervention benefits
- Saving from 3 workers not developing upper limb disorders (Table 2): £7,749 ea x 3 workers = £23,247

Total post-intervention benefits per year: £23,247

Conclusion
The process lifecycle is assumed to be 4 years from the date of intervention.

Total cost of intervention: £46,892

Net present value of post-intervention cost savings over the process lifecycle at an 8% discount rate:
- £23,247 per annum for 4 years: £83,157

Net intervention benefit: £36,265

Payback period: 27.07 months

Base price year is 2000
20. Better storage in delivery operations

- Loading of containers with rolls of material required awkward postures and handling above shoulder height
- Positioning a platform on the lower layer of rolls allowed workers to stand on it and load the upper section of the container more easily
- Direct intervention costs was just over £1,500: payback period was just over 1 month

The task

The Company delivered 1.5m long rolls of material in 12m long containers to their customers. The rolls were ‘handballed’ (manually placed into position) by one warehouse worker standing inside the container and positioning the rolls as best as he could to fill the container. The height of the container from its base was just over 3 metres. As the Company was relatively small it was not financially viable for them to purchase or lease a height adjustable conveyor, but ramps (such as dock levellers) were used so that product could be delivered easily to the container for loading.

The Company had a long-term contract to deliver this particular product and, on an average day, ten containers of this product would be loaded for delivery to the various customers.

Musculoskeletal risks

This process required the workers to lift and position the rolls using a variety of postures. The rolls were:

- soft and flexible
- quite heavy, weighing between 8 to 10 kg
- 1.5m long and 0.4 m in diameter, and
- wrapped in a slippery plastic with no handles.

As a result the rolls were awkward to handle. The activity of loading was also repetitive. The three workers would load 10 containers per day, so each worker would load one container about every 2.5 hours.

The containers needed to be fully filled with the rolls, so workers had to handle some rolls up to a height of 3m.

The task posed a high risk of back and upper limb injury.

Identifying the problem

The warehouse/transport manager became concerned when a number of his warehouse staff began reporting neck and shoulder pain. When the management team carried out a risk assessment they identified the source of the shoulder and neck pains as arising from loading the rolls into the delivery containers and loading them at above shoulder height in particular. The weight of the rolls combined with their difficult handling properties made the task of pushing them in the uppermost rows in the container particularly difficult (see Figure 20.1).
What was done?

The drivers and management team set up a focus group to consider several solutions that had been proposed. The Company had no control over the way the product was packaged by the manufacturer, so a solution had to be made concerning how it was packed. The solution chosen was to load two rows of product to shoulder height at the far end of the container and then to load a layer along the floor at just above knee height in front of these rows. A layer of boards was placed on these rows and one man stepped up and stood on the boards. Individual rolls were then passed up to him by another warehouse worker and he could then pack the top rows of the container from this raised platform (see Figure 20.2). The platform that was created was wide and stable and enabled the workers to eliminate most of the loading above head height, thereby significantly reducing the risk of musculoskeletal injury.

The load allowed a stable base for the platform to be achieved. If the base was made of different material, it might not have been possible to provide a safe and stable platform, which would have made this solution unviable. The new packing strategy
proved successful; the warehouse staff found the method more comfortable and they no longer suffered neck and shoulder pains.

**Costs and benefits**

Over the following few months the warehouse/transport manager noticed that the warehouse staff were consistently loading more product per container. He observed that because they were now packing the top layers of the container from the platform, the warehouse staff were able to better fill the whole container. It was found that using the original loading system meant that each container was packed to 89% capacity by volume but, with the new system, the capacity was increased to 95%. This made such a difference that the drivers were able to load the entire day’s deliveries of product into one fewer container – 9 containers instead of 10. As a result the new packing strategy meant that the Company was able to operate with 9 containers instead of 10. It has been calculated that the annual cost to operate one container and tractor unit in terms of repairs, licence fee, insurance, depreciation and running costs was £48,586. It has been assumed that the Company was able to use the additional tractor unit elsewhere in their operation, for example in shunting containers within the depot. If the Company could have disposed of this unit then an additional post-intervention benefit would have been realised.

Although the time taken to load each container increased from 35 to 45 minutes, this was more than compensated by the increase in delivery volume. So although the full-time equivalent resource required to load the entire fleet per week increased from 2.2 to 2.5 workers, the costs to run 9 containers instead of 10 was less. There was a net saving of over £48,000 per annum.
**Economic analysis**

**Costs and benefits**

**Direct intervention costs:**
- Management time estimated to be 0.75 day @ £500 per day = £375
- Warehouse staff time estimated to be 3 days @ £77 per day (includes overhead costs @ 30%) = £231
- Estimated cost of platforms for 10 trucks = £900

**Direct intervention costs:** £1,506

**Pre-intervention costs**
- Cost in worker's hours to load the entire fleet (29 hours @ £9.69 per hour to include overhead costs) = £281
- Total cost of running the fleet (10 trucks) for one year = £485,857

**Pre-intervention costs** £486,138

**Post-intervention costs**
- Cost in worker's hours to load the entire fleet (34 hours @ £9.69 per hour to include overhead costs) = £329
- Total cost of running the fleet (9 trucks) for one year = £437,271

**Post-intervention costs** £437,600

**Annual post-intervention benefits** £48,538

**Conclusion**
The equipment lifecycle is assumed to be 5 years from the date of intervention.

**Total cost of intervention** £1,506

**Net present value of annual post-intervention benefit over the process lifecycle at an 8% discount rate** £209,300

**Net intervention benefit** £47,032

**Payback period** 1.2 months

Base price year is 2003
21. Redesign of a cask processing operation

- Preparing beer casks for reuse involved repetitive use of hand tools, often when the operator was in a stooped posture
- Waste from the handling process caused conveyor breakdowns
- New hand tools and a relatively simple change to conveyor design cost just over £8,800 but made a significant difference
- Payback period of just under 3 months

The task

When empty aluminium beer casks are received from pubs and clubs they are washed prior to re-use. In preparation for washing, the top caps in each barrel are removed by levering out with a chisel. The wooden bung on the side of the barrel is removed with a hammer and chisel.

The casks were mostly 11 and 22 gallon capacity, with occasional 36 gallon casks (50, 100 and 164 litres respectively); the weights of the empty casks were 9, 16 and 28 kg respectively. The wooden bungs were about halfway down the sides of the casks, which was at or below knee height even for the smallest operators.

The casks were presented to the operator on a floor-level conveyor belt; they were lifted or slid from the conveyor belt to the floor and a chisel was used to lever off the top cap. The chisel was then inserted into the side of the bung and hit with a hammer. Normally after several blows the bung would either be levered off or disintegrate and fall out.

When the bungs were removed the wooden pieces fell to the floor, forming a tripping hazard as well as getting trapped in the conveyor belt and causing damage to the belt. When the belt was damaged it had to be stopped while a mechanic fixed it. This took about 15 minutes for each stoppage; on average, a belt stoppage occurred three times each day.

Musculoskeletal risks

The force and repetitive movements needed to break and remove the wooden bungs using the hammer and chisel led to musculoskeletal injuries. The 2 staff members (both
males aged around 40) carrying out this operation had taken sick leave for shoulder and back injuries in the previous year. Back injuries were caused by the repetitive manual handling of the casks off the conveyor and having to bend to strike the bungs. As the platform was at floor level all the operators had to bend their backs.

Figure 21.2  Removing the wooden bungs from the side of the casks

**Identifying the problem**

The Company's occupational health and safety advisers had inspected the wash area and had determined that the work activities and consequent injuries to the shoulders and backs were not acceptable and that the risks had to be reduced. Job rotation, although practised, was not effective in reducing back injuries as other work tasks included bending. There were no environmental conditions identified that would be likely to affect injury rates, such as cold conditions, draughts, etc. Although the task was known to be difficult, there was no indication that the staff were predisposed towards suffering from musculoskeletal problems.

At about the same time as the occupational health and safety advisers' visit, management had decided to increase the line's output but realised that the injury rate would almost certainly increase as a result. It is known that if the speed of work is driven by the process rather than the human operator it is likely to result in increased stress and risk of developing musculoskeletal disorders. It was realised that the increase in output would be likely to reduce the amount of flexibility operators had to rotate to other jobs, and may cause them to speed up their work, with an accompanying increased risk of musculoskeletal problems.

**What was done?**

Through workplace meetings, management involved both engineers and the operators in finding a solution to prevent injuries and to increase output. Although many suggestions were made, it was realised that there was not enough experience within the group to reduce the injury rates and, at the same time, increase production. The Company's ergonomist was asked to advise and assist. It was found that the task needed to be re-organised so as to reduce the extent of bending, and of manual handling in general, as well as to reduce the effort required to remove the bungs.

The most suitable solution for reducing the bending would be an inclined conveyor belt so that the operators could position themselves at the most suitable place along it. The slope of the belt would have to be slight so that the casks remained stable, and thus a
long belt was needed. There was a shortage of space which made this solution impractical.

Instead, the ergonomist determined the average elbow height of the men working there and, after allowing for the heights of the casks, determined the most suitable conveyor belt height. The conveyor belt height had to be such that the top cap could be removed without forcing the operator to adopt an awkward posture. The first section of the conveyor (placed at right angles to the main conveyor section) took barrels from floor height up to the required height using a short incline.

To address the force required to remove the bungs, which was leading to shoulder injuries, a two step approach was adopted. In the very short term it was agreed that the chisels would be kept sharp and chisels with a rubber grip would be used to reduce shock loading on the upper limbs when the hammer stuck the chisel. The cost of doing this was negligible and has not been included in the cost benefit analysis. In the short/medium term the chisels were replaced with a power tool.

**Costs and benefits**

During the course of the year prior to the intervention the two operators had taken a total of 54 days sickness absence due to musculoskeletal injury (432 hours). The hourly rate of pay was £9.62, but other employment costs added a further £3,873 each per annum. Thus the cost to the Company as a result of the sickness absence for the two operators was £4,155.84 for wage costs plus £402.20 as the pro-rata contribution for other employment costs. This totals £4,558.04. In the year following the intervention there was no lost time due to musculoskeletal injury.

The Company calculated that the costs of the intervention in terms of changes to the conveyor line, and the management, ergonomist and staff time totalled £8,830.

In the year prior to the intervention the two operators had worked overtime on the task in order to meet production requirements; this had cost the company £8,680. In the year after the intervention the overtime cost for these two operators was reduced to £2,630.

The cost of the conveyor breakdowns attributed to the task before the intervention could also be calculated. During belt breakdowns, not only were the two operators idle, but so was the entire wash line of another nine operators. The productive employment cost of the eleven operators on the wash line and the mechanic to repair the conveyor belt was £43.05 per breakdown for 15 minutes. This is derived from a productive employment cost of £14.35 per hour (£3.59 per 15 minutes) for the 12 operators (including the mechanic). By extrapolation to the full year, at a rate of three breakdowns per day and taking into account factory outage, the total employment cost of breakdowns was approximately £32,000.

There were some breakdowns of the conveyor belt after the changes; about 15 per year. On the same costing basis these breakdowns cost about £650.

Table 21.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significantly reduced musculoskeletal related sickness absence.</td>
<td>No lost time due to musculoskeletal disorders or injuries in the year following the intervention.</td>
</tr>
<tr>
<td>Lowered equipment downtime.</td>
<td>Significant improvement in conveyor running time and in wasted employment time.</td>
</tr>
</tbody>
</table>
**Economic analysis**

**Costs and benefits**

**Direct Intervention Costs**
- Changes to conveyor line and new power chisels: £6,580
- Estimated management, ergonomist and staff time: £2,250

**Direct Intervention Costs Total**: £8,830

**Annual post intervention benefits**
- Reduced marginal labour costs (note 1): £41,958

**Total annual post intervention benefits**: £41,958

**Conclusion**

The process lifecycle is assumed to be 3 years from the date of intervention.

Total intervention costs: £8,830

Net present value of annual post intervention benefits over the process lifecycle at an 8% discount rate:
- £41,958 per annum for 3 years: £116,780

**Net intervention benefit**: £107,950

**Payback period**: 2.72 months

Base price year is 1999

---

**Note 1 - Comparison of pre and post intervention labour marginal costs**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (pre)</th>
<th>Cost (post)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sickness absence (432 hours @ £9.62)</td>
<td>£4,156</td>
<td>£0</td>
</tr>
<tr>
<td>Other employment costs</td>
<td>£402</td>
<td>£0</td>
</tr>
<tr>
<td>Overtime costs</td>
<td>£8,680</td>
<td>£2,630</td>
</tr>
<tr>
<td>Total employment costs of breakdowns of the conveyor lines</td>
<td>£32,000</td>
<td>£650</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>£45,238</strong></td>
<td><strong>£3,280</strong></td>
</tr>
</tbody>
</table>

**Annual post intervention marginal labour cost savings**: £41,958
22. Use of elbow pads to ease discomfort

- Fine detailed work required the hands to be held close to the eyes – this meant long periods leaning on the elbows
- Elbow pads that met clean room requirements were sourced
- The Company’s assessment shows that elbow discomfort and upper limb risk has been greatly reduced at low cost. Operators were able to better concentrate on the job.

The task

Operators working on a production line manufacturing operating theatre equipment conducted fine detailed work. The equipment was held in a jig under the microscope and because the jig had to be moved around for inspection purposes this meant that the operator’s hands were held in an elevated position close to the eyes (see Figure 22.1). To avoid bending over the desk, operators tended to work with the elbows resting on the work surface for long periods.

Musculoskeletal risks

Over the course of a shift, operators were experiencing discomfort in the elbows due to bruising or swelling. The discomfort caused some operators to carry out the work with their elbows raised off the work surface, which resulted in shoulder discomfort after a short period of time. The discomfort was also distracting, which could have an impact on the quality of their work.

Identifying the problem

A risk assessment, which was carried out on a routine basis to maintain health and safety standards, identified that there was a risk of upper limb problems associated with this task.

What was done?

Elbow pads, such as those used by skateboarders, were first trialled but found to be too bulky and the straps did not hold the pads properly over the elbows. Elbow pad suppliers were identified via the internet and a suitable UK distributor was contacted to supply different types of elbow pads. The Company were looking for loose fitting pads.
that allowed unimpeded elbow movement, which was required for the other tasks being undertaken.

The pads also had to meet bio-burden tests (that is, no degradation of product leading to fibre or particle release was permitted) as they were to be used in a clean room environment. One of the operators on the line realised that if the elbow pads were worn inside the smock instead of outside, there would be an enhanced level of protection from contamination due to wear and tear.

Following the trials of a few models, a preferred type of elbow pad was selected. The new elbow pads were controlled and distributed according to the clean room procedures. Instruction sheets were provided for all users informing them of correct fitting, washing instructions and minimal replacement times.

**Costs and benefits**

An assessment conducted after the introduction of elbow pads showed that take-up of the pads was 100% and most operators found the pads very comfortable, and effective in reducing elbow discomfort. Re-assessments using the Company’s upper limb disorders checklist showed that risk scores were reduced due to removal of direct pressure at the elbow and improved shoulder postures. The elbow pads cost £4.00 per pair.

The cost of running the trial was around £170. This cost was incurred because four types of pads were trialled, with six operators taking part (4 x elbow pads at around £4.00 per pair x 6 operators = £96). The trial was run in ‘real time’ which meant that the operators’ jobs were not disrupted. The remaining cost of the trial is an estimate of the wages cost for the administration and planning of the trial. The results were discussed during weekly team talks which did not incur additional costs.

<table>
<thead>
<tr>
<th><strong>Benefit</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Discomfort reduced resulting in improved concentration and potentially improved quality</td>
<td>It is easier to maintain concentration for long periods</td>
</tr>
<tr>
<td>Reduced risk score for upper limb disorders</td>
<td>Less stress on the elbow joint and improved shoulder postures</td>
</tr>
<tr>
<td>Operators embraced the change</td>
<td>Operators were involved in the sourcing and trialling of the elbow pads and took ownership for storing and washing the additional clean room equipment</td>
</tr>
</tbody>
</table>
23. Better drum handling aid

- Drum handling was heavy work and required awkward postures
- A previously identified handling solution was revisited to reduce risks further
- Risks of injury to back, upper body, arms and legs were all reduced

**The task**

A lifting aid had been installed in a drum store to assist operators in moving and turning drums from a vertical to a horizontal orientation for storage.

**Musculoskeletal risks**

Although drum handling was quicker and safer when using the lifting equipment compared with previous procedures, a risk assessment showed that relatively high forces and awkward postures were nevertheless required to handle the drums. In particular, raised arms, excessive flexion of the back and hip and a forceful downward leg movement was observed to overcome the momentum of the load and lifting aid. These actions are known risk factors that can contribute to the onset of musculoskeletal injury.

![Figure 23.1. Drum handling using the original system](image)

**Identifying the problem**

Although drum handling had been improved by providing lifting equipment following a previous risk assessment, during a subsequent review of risks, the Company identified that a better solution could still be found.

**What was done?**

The Company decided to look again at the method of drum handling and identified a better drum trolley from a different supplier. The new drum trolley was trialled with the warehouse staff before it was permanently installed. The new equipment has made drum handling safer because the operator does not have to apply as much force to initiate the movement, and the postures adopted are more neutral which puts less strain on the body. The drum trolley also had the advantage of fitting a wider range of types and sizes of drums.
The operators provided feedback to the manufacturer suggesting improvements to the design. The modifications, such as providing stowage for the drum-holding chain and repositioning of cross bar on handles to allow unimpeded walking were adopted by the manufacturer. Based on the success of the design, three additional drum trolleys have since been bought by other sites belonging to the Company.

![Image](image.png)

**Figure 23.2. Improved posture with the new drum trolley**

**Costs and benefits**

The new drum trolley cost £800 and two operators use the drum handling equipment about 25 times a week. More types and sizes of drums can be used with the new drum-handling device. Chemical service operator Stephen Thomson says ‘the new drum handling device is effortless during use compared with the older handling device which means you can move a lot of drums with minimal effort’.

Table 23.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risks of musculoskeletal disorders reduced</td>
<td>The company recognised that although risks were adequately controlled with existing equipment, improvements in lifting equipment meant that the drum handling task could be improved further, and risks further reduced.</td>
</tr>
<tr>
<td>Less fatigue experienced</td>
<td>The job is less fatiguing and since the intervention there have been no reports of aches and pains.</td>
</tr>
<tr>
<td>Solution recommended to other sites</td>
<td>The new drum handling system has been recommended to three other UK facilities belonging to the same Company.</td>
</tr>
<tr>
<td>Feedback to equipment suppliers</td>
<td>Company operators using the equipment provided feedback to the supplier on further design improvements.</td>
</tr>
</tbody>
</table>

The new equipment makes drum handling much less fatiguing and provides the opportunity for a greater range of drums to be handled safely.
24. Re-designed foot control for a manufacturing press

- Bending and moulding the heads of needles involved repeated activation of a foot pedal
- The pedal size, angle and activation force were redesigned to improve the operator’s lower limb position
- With the lower limb position improved, posture in the rest of the body was also improved.

The task

A pedal operated pneumatic machine was used to swage (that is, bend and mould) the head of a needle onto suture material to form a surgical suture, which is used for various wound closure procedures. Personnel using the swaging press rested their right foot on the pedal and activated it when necessary with a single push. Different designs of needles required multiple swage hits, which involved a number of pedal activations. The pedal was fixed in height to the right under the workstation (see Figure 24.1)

![Figure 24.1. Lower limb position before modifications](image)

Musculoskeletal risks

Keeping the foot on the pedal compromised other body postures and limited the operator’s ability to vary their posture. Operators with shorter legs tended to sit forwards in their seat to reach the pedal, which meant that they were not obtaining adequate support from the chair’s backrest. The requirement to reach the pedal also resulted in some staff sitting relatively low, meaning that awkward shoulder postures were adopted and elbows were raised when undertaking the task on the worksurface. These awkward upper limb postures were fatiguing when maintained for a period of time, and led to discomfort in the neck and shoulder regions.

Only the right foot was placed on the pedal so the operator’s legs were held at different positions (see Figure 24.1). Different thigh angles can lead to uneven muscle loading on the pelvis and lower back. The angle of the uncompressed pedal was steep, at 30° to the horizontal, also resulting in awkward lower limb postures.
**Identifying the problem**

The problem was identified by the Company ergonomist who thought the foot pedal arrangement could be improved. Rather surprisingly, few operators complained about the foot pedal position, most probably as the operators had got used to the arrangement which had been in place for many years. Some of the taller operators did complain of lack of legroom and the pedal location when further alterations were carried out to the underside of the work surface.

**What was done?**

The Company ergonomist investigated ways of reducing the risks of musculoskeletal disorders through improving lower limb position. A larger and height adjustable footrest incorporating a slim footswitch was provided which allowed the operator to rest both feet at the same height when the swage unit was being operated.

The Company investigated the force needed to activate the original footswitch. With the footswitch being relatively easy to push (1.5 kg of force), operators tended to ‘hover’ the foot over the switch to avoid inadvertent activation of the foot control. Supporting the foot in an awkward, fixed position could lead to fatigue and discomfort in the ankle and lower leg. It was decided to increase the force required to operate the pedal to ensure that a definite action was required and avoid the foot being held hovering over the pedal. The manufacturer was contacted and agreed to install a stiffer spring in the footswitch.

![Figure 24.2. Lower limb position after modifications](image-url)

The angle of the footswitch was also changed. Placing the pedal on the footrest allowed it to be tilted at about 15° from the horizontal, which improved the angle at the ankle. The footrests were adjusted in height and angle using foot operated controls which allowed the operator to choose the most comfortable working position without kneeling down on the floor to adjust. This was an important consideration as the hands had to be cleaned before entering the clean room area.

When it was first proposed, operators working on the line did not think there would be any benefit in the proposed change to the angle and type of pedal, as there had only been a few complaints. However, when staff had a chance to try a mock-up of the new footrest / foot switch arrangement, they found that they were able to adopt more comfortable postures as they did not have to continually reach to the fixed height pedal.

The new footswitches cost £15 each and the adjustable footrests £65. Altogether 120 pedals and footrests were bought. Including the labour costs to fit the equipment to the
attaching machines, the total cost was £10,000. This represents £67 per person involved in the operating the swagers.

Table 24.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is now possible to adjust the pedal to suit a range of users.</td>
<td>The old pedal lacked adjustment in height and angle. The new pedal adjustment offers sufficient adjustment to suit the range of users. Observations of the selected footrest heights now used by the operators demonstrate how much working postures were compromised with the fixed pedal arrangement.</td>
</tr>
<tr>
<td>Reduced loading on the lower back.</td>
<td>The larger footrest and slim footswitch allow both feet to be supported at the same height, and the operator to sit back in the chair and use the backrest.</td>
</tr>
<tr>
<td>Better foot and ankle posture encouraged.</td>
<td>The force required to activate the pedal has been increased so that it becomes a definite and discrete action. This avoids the tendency for the foot to be hovered over the pedal during the majority of the task cycle, which could contribute to discomfort.</td>
</tr>
<tr>
<td>The risk of lower limb disorders has been greatly reduced</td>
<td>Operators can now adjust the equipment to suit themselves, rather than have to compromise their posture due to the non-adjustability of the equipment.</td>
</tr>
</tbody>
</table>

Dr Kevin Tesh, Head of Safety and Ergonomics at the Company, said ‘Allowing flexible postures both under and above the workstation allows the full range of adjustment to be utilised by operators. Observations of various footrest positions adopted along the production line now demonstrate how much the working postures must have been compromised before the intervention. Staff feedback has been very positive and this modification will allow more optimal working postures to be adopted leading to reduced sickness absence and higher productivity’.
25. Better shelf heights for self-service chemicals store

- A storage area was in use 24 hours a day for operators to collect powdered and liquid chemicals
- Manual handling in the store posed a risk of injury to the back, shoulders and arms
- The problem was solved by relocating some shelves and providing guidance on safe storage and lifting techniques

The task

Powdered and liquid chemicals were stored at floor level in tubs and tins. The weight was clearly marked on the container. Some of these loads were heavy, weighing 20 – 25kg. Although the loads were heavy, the turnover of product was low. Trained production staff were able to collect the chemicals from the self-service area as and when they needed as 24/7 production was employed. Staff were provided with trolleys to transfer the loads from the self-service to the production area. All staff had received manual handling training, but when heavier tubs were placed on the floor or on the higher shelves (shoulder height or above), they were difficult to lift. There was no formal system in place for deciding which loads were stored where in the self-service area.

Figure 25.1 The store before the shelving was rearranged

Musculoskeletal risks

The risk associated with handling loads increases the further away the load is handled from waist height as operators have to bend or stretch to reach them. The risk becomes significant when loads of 20-25kg are handled outside this ‘ideal’ position.

The main risk of injury from awkward lifting would be damage to the lower back (the lumbar region). Injury can also occur to the upper body, shoulders, neck and upper limbs.
Identifying the problem

The potential risks associated with storing heavy items on the floor were identified during routine risk assessments.

What was done?

Guidelines based on good manual handling practices were draw up for personnel replenishing the chemical store and for operators who came to collect tubs and tins from the shelves. This included:

- Guidance on storing heavier and more frequently used items on the middle shelves, lighter items and less frequently used items on the other shelves. This guidance was issued and discussed in team meetings;
- Chemical service staff were given the responsibility of ensuring that heavier tubs in particular were being stored appropriately;
- Refresher manual handling training was also provided to chemical service operators and operators using the self-service area.

There was no need to buy shelving – the shelves were simply relocated at a higher level so that the loads could be handled at a more comfortable working height (above knee height).

Good handling practice indicates that loads should be handled around waist height. In Figure 25.2 the shelf is slightly lower than optimal – this was because room had to be made for larger loads that were occasionally stored there. Bringing loads nearer to waist height helps keep the load close to the body during handling; this reduces the effort required to handle the load and lowers the risk of injury to the lower back.
Costs and benefits
Table 25.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced risk of manual handling injury.</td>
<td>Handling of heavier tubs now poses much less risk of injury as awkward postures (extreme bending) are avoided.</td>
</tr>
<tr>
<td>Chemicals are easier to find.</td>
<td>The revised layout has meant that identifying the correct chemical container is easier and quicker because each has a dedicated place in the store room.</td>
</tr>
</tbody>
</table>

Dr Kevin Tesh, Head of Safety and Ergonomics at the plant, said ‘The costs of reorganisation required no capital spending and minimal staff time to change layout. The immediate benefits are reduced chances of self-service staff developing manual handling problems’. 
26. Better design of wax moulds

- The work involved reaching and bending while supporting a load, with the risk of burns from hot water or steam; the load was lowered into hot water.
- There was a risk of injury to the back and shoulders from manual handling the load and from awkward postures adopted to avoid scalding.
- The problem was solved by using lighter materials and providing better handholds.
- The costs were minimal and the risks inherent in the job significantly reduced.

The task

The production of a medical device involved use of wax moulds, which subsequently had to be cleaned. This was done by using a steam bath. Four moulds were held in a frame, which was lifted in and out of the steam bath (see Figure 26.1). The filled moulds and the frame weighed about 23 kg. This job was done approximately once a month depending on product demand, with a number of moulds being cleaned each time.

Figure 26.1  Frame being lifted out of the steam bath (moulds not shown)

Musculoskeletal risks

The load was heavy and bulky and exceeded HSE guideline figures for weights to be lifted in these circumstances without a detailed risk assessment, particularly as most of the staff were female. There was also the risk of scald injury from the hot water if the frame were dropped, as steam was used to clean the wax moulds. Steam also rose from the steam bath and could be uncomfortable for the operators as they leaned over the bath. Avoiding the steam may have encouraged operators to work in awkward postures.

The design of the bath meant that operators had to reach into it; those of shorter stature or shorter arm length had to lean further than taller operators. The frame had to be held for a short period of time above the bath to allow the water to drain off the
moulds; this increased the loading on the back and upper limbs. Supporting a weight away from the body is considerably fatiguing.

**Identifying the problem**

Operators complained of pain and discomfort in the arms, shoulders and neck associated with this task. Some operators also felt discomfort in the upper and lower back. The symptoms were consistent with static loading in the arms and bending forward to reach into the sink.

**What was done?**

Smaller frames using lighter material were made to hold the moulds – each of the new frames held one mould (the original frames held four). They were significantly easier to lift because of the reduced weight. The new frames (plus a filled mould) weighed 5 kg. Rubber sleeves were also fitted on the handles to provide a better grip. To reduce the need to hold the frames over the bath, a draining board was fitted to the end of the bath. In the longer term, the company is planning to transfer this operation to another site where the wax moulds will be cleaned using ultrasound techniques which will avoid the need for operators to be exposed to the risk of scalding water.

The manufacturing cost of the racks was £50 and the labour costs estimated to be £100. The cost of the assessment was negligible.

![Figure 26.2 Using the smaller, lighter frame (moulds not shown)](image)

**Costs and benefits**

<table>
<thead>
<tr>
<th>BENEFITS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced risk of musculoskeletal injury.</td>
<td>This was achieved by lightening the load, making the frames easier to hold, and providing an area for draining the moulds.</td>
</tr>
<tr>
<td>Reduced risk of accident.</td>
<td>Design modification reduced potential for splashes of hot water.</td>
</tr>
</tbody>
</table>
Operator feedback was very positive. The job is less awkward to do, and better postures can be adopted.

The Head of Safety and Ergonomics at the plant, Dr Kevin Tesh, said ‘This initiative was low cost, straightforward and simple. By spending £150 we have made a huge reduction to the risks of injury through awkward lifting. The job is now easier and safer to do. Operator feedback on the new frames has been very positive’.
27. Modifications to a medical film examination workstation

- Viewing mammograms at machines caused poor postures to be adopted, with associated reports of discomfort in key personnel
- Concern that key staff may suffer sickness absence which would have a negative affect upon service delivery
- Relatively straightforward modification to the machines meant that the risk of musculoskeletal disorders related sick leave was reduced

The task

As part of a breast screening service, images of tissue, presented on photographic films (mammograms), were viewed by specialist medical staff – the radiologists. This was a highly demanding task, requiring careful and very attentive viewing, and comparison of the films with previous examinations.

A new style of machine was bought as it offered a greater capacity; this met the employer’s requirement to extend the service and increase the number of films viewed. Twelve new machines were purchased.

The viewed area (frame) of the new machine was about 1.4m and wide 0.5m high. This frame held 16 films, arranged 8 across and 2 down. Radiologists sat to view the films across this area. The controls to advance the films and to control the lights were positioned at the far left of the machine and were not easy to reach. The chairs provided originally were not selected specifically for this task, and their compatibility with the machine was not considered. Radiologists could spend a few hours viewing films in one session, and this is done at least 3 times per week.

Radiologists had to get close to the films (approximately 300mm viewing distance) in order to examine the images in sufficient detail. The design of the new machine (see Fig 27.1) was such that there was very limited legroom when sitting, and radiologists had to lean forwards to view the films. A shelf extended forwards from the machine by 300mm; this was used for paperwork, but also limited how close radiologists could get to the films. Because of this and the limited legroom, radiologists sat twisted in the seat, and/or leant forwards in the seat with their knees touching the underside of the machine. The size of the viewed area meant that extreme neck postures had to be adopted to view the films (looking up and down), and these postures were compounded by the forward lean posture. Radiologists also had to move along the width of the frame in order to examine all the films, and this was awkward with conventional chairs.

Musculoskeletal risks

Shortly after purchasing the new machines it became clear that their use was causing discomfort to the radiologists. There was concern that staff would be unable to continue to work at the machines, with a significant implication for the service delivery, as well as costs to the service.
What was done?

An ergonomic assessment was requested from external consultants to identify ways to reduce the risk of discomfort and any potential for musculoskeletal disorders.

An outcome of the assessment identified that there was a need to increase the legroom under the machine; to shorten the shelf that extended from the front of the machine (see Figure 27.2); and to provide a second set of controls to move the films. These second set were positioned so that they could be operated while seated at the machine. It was also recommended that appropriate seating be provided.

The manufacturer recognised the benefits of making modifications to the machine, and bore the costs. The legroom available was increased by 160mm (the maximum possible with the design of the machine) meaning that radiologists could now sit in a much improved posture.

The Trust provided suitable seating for the radiologists which matched the radiologist’s needs with the demands of the job. Some users found a saddle chair to be most suitable as it facilitated movement along the length of the frame, and prevented the knees extending as far forwards as with a conventional chair. Because legroom was limited, this helped radiologists get closer to the machine (see Figure 27.3). Where individuals did not find a saddle chair comfortable, an alternative, suitable ‘office style’ seat was provided.

An ergonomic review was carried out after the modifications had been made. This indicated that the modifications had reduced the risk of MSDs to an acceptable level. The radiologists commented that they found it much more comfortable to work with.
Figure 27.2: Radiologist sitting on a saddle seat to view the mammograms after the modification to the viewer. The second set of controls is shown at the right hand end of the shelf.

Figure 27.3: Showing a cross section of the viewer to illustrate changes made.
Costs and benefits

Table 27.1  Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced risk of MSDs.</td>
<td>Moderately straightforward redesign of the viewing machine has been shown by expert risk assessment to give rise to a reduced risk of MSDs.</td>
</tr>
<tr>
<td>Reduced risk of delays in diagnosis and associated concerns from members of the public.</td>
<td>No MSD related sickness absence for radiologists using the redesigned machine since its introduction.</td>
</tr>
<tr>
<td>Improved comfort of radiologists.</td>
<td>This may lead to improved quality of service, although this is not measurable.</td>
</tr>
</tbody>
</table>

The costs associated with the intervention have been estimated to be as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ergonomic advice on</td>
<td>£3,000</td>
</tr>
<tr>
<td>New chairs/saddle seats purchased for the 12 new machines</td>
<td>£4,000</td>
</tr>
<tr>
<td>Management time including overhead costs</td>
<td>£4,000</td>
</tr>
</tbody>
</table>

The potential cost of a radiologist’s absence due to MSDs would be approximately £1,950 / week (including overhead costs). Due to a shortage of radiologists with appropriate expertise it would not be possible to contract radiologists to cover sick leave, and any absence would have a negative effect on service delivery and would increase pressure on other colleagues.

“This initiative was excellent value for money. The staff were fully involved and were reassured by the professional advice they received. In addition, the supplier acted on the recommendations and made significant improvements to the equipment design so that users across the country also benefited.” Dr Hilary Fielder, Director of Screening Services, Breast Test Wales.
28. Rationalising oven and hob assembly

- The manufacture of domestic ovens and hobs was associated with a significant musculoskeletal disorder sickness absence
- Investment in modifications to workstations and the production line over time produced very beneficial results
- Sickness absence was reduced and productivity was increased.

The task

The manufacture of ovens and hobs for the domestic market was carried out at individual workstations located along an assembly line. At each workstation an element of the manufacturing process was completed by one worker. The units were moved between the workstations by conveyors. Tasks carried out at the workstations include chassis assembly, installing insulation wrapping, inserting wiring looms, pipe assembly and door assembly. Staff always worked at the same workstation for extended periods of time without any change in activity. The workstations were of a fixed height and were not necessarily matched to the best height for working on the unit.

Musculoskeletal risks

The tasks required quite repetitive and forceful movements of the upper and lower limbs, and for some tasks there was stooping of the back for long durations. The frequent use of torque tools (e.g. nut runners) and other hand-held tools added to the risk of upper limb disorders.

Identifying the problem

It was identified in the late 1990’s that work related upper limb disorder injuries were becoming a significant issue in the factory. The Occupational Health department reported that about 20% of all sickness absence was found to be due to musculoskeletal disorders (MSDs). Up to 75% of the workforce was on restricted duties of some kind and of that number, as many as 25% were off sick with MSDs.

What was done?

The production manager in conjunction with the health and safety team initiated a monitoring scheme that included the use of self reported body discomfort charts. They also compiled information on the risk of musculoskeletal disorders caused by production line activities. Data were collated and analysed on the range and severity of reported MSDs that contributed to production staff being on restricted duties and sickness absences. An ergonomics team, consisting of a consultant ergonomist, physiotherapist, occupational health nurse advisor, and engineers from the Company’s maintenance department was assembled to tackle the issues. The first step was to make a full and detailed analysis of all equipment used in each production area. Thereafter many assessments of the workstations were carried out using the Quick Exposure Assessment Check tool (QEC). The assessments and feedback from staff was instrumental in identifying the ergonomics problems at each type of workstation.

The main risk control measures identified and carried out were to:

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6 Available from Health and Safety Executive website [www.hse.gov.uk/msd/risk.htm](http://www.hse.gov.uk/msd/risk.htm)
• Angle the workstations so that workers were able to hold their wrists in a more neutral position (see Figures 28.1, 28.2 and 28.3).
• Make the workstations height adjustable so that assembly / sub assembly work could be carried out at the most appropriate height for each worker (see Figures 28.1, 28.2, and 28.3).

Figure 28.1. Ergonomically designed workstation showing all items within easy reach and at the appropriate height

Figure 28.2. Ergonomically designed workstation showing an angled work position and the conveyor positioned for a level transfer

Figure 28.3. Angled workbench for pipe assembly

Figure 28.4. Rotating workstation to allow work to be carried out on all faces of the work piece

Figure 28.5. Height adjustable workstation (up)

Figure 28.6. Height adjustable workstation (down)
Figure 28.7. Fully adjustable workstations shown linking to fixed height conveyors

Figure 28.8. Fully adjustable workstation – both in height, rotation and in the angle of presentation of the work piece

Figure 28.9. Conveyor fitted with rubber ‘lifters’ on the rollers to prevent hand trapping injuries

Figure 28.10. Scissor lift trolley for level transfers between workstations

Figure 28.11. Vacuum lift device

Figure 28.12. Roller toolboxes for maintenance staff avoiding the need to carry the boxes
• Make the workstations so that they can be rotated to allow ease of access to the work piece (see Figures 28.4 and 28.8).
• Use lifting devices to avoid the need to manually lift items (see Figures 28.9 – 28.12).
• Reduce exposure to hand arm vibration by introducing new, or modifying existing, hand tools.

In addition the following actions were taken to support the changes in workstation design:

• Instigating a training programme to multi-skill all workers in a particular production area. This permitted a much wider use of job rotation thereby allowing workers to change their activities on a frequent basis during each shift. This training took over 2.5 years. It was carried out by the Company’s Training Officer.
• Body discomfort charts were used to monitor and encourage early reporting of musculoskeletal problems.
• Physiotherapy treatment was commenced at the early stages of a worker reporting musculoskeletal discomfort
• Tracking an individual’s progress with an existing MSD problem against workstation improvements.

In 1995, before any interventions were made, there were 90 staff working on the production lines on a mean salary of £15,000 pa (excluding overhead costs: £19,500 including overhead costs). With these staff the following applied:

• 75% of workers were on restricted duties at any one time due to MSDs.
• 25% of the above workers were on sick leave at any one time with MSDs.
• 8 – 10 agency staff had to be taken on at any given day (costs similar to workers’ salaries – excluding on-costs).
• Up to 8 personal injury claims pending.
• 6 different workstations in the production line.
• Average of 50 ovens completed per team per day.

Post intervention there were only 52 staff working on the production lines on a mean salary of £20,000 pa (excluding on-costs: £26,000 including on-costs). With these staff the following applied:

• Very little sickness absence due to MSDs. The impact of this on overall sickness absence for the site was a reduction of 6%.
• Most injuries are minor (e.g. cuts); MSDs are managed from very early on by the occupational health team to ensure that the injury does not become chronic.
• Agency staff not routinely required.
• 5 workstations in the production line instead of 6.
• An average of 75 ovens completed per team per day.
• Production targets are never missed.
The costs for the consultant ergonomist were about £30,000. This work was completed in the first year of the intervention. A site engineer was recruited to provide engineering support for the project and he was involved for 1-2 days per week over one year at a cost of about £10,600 (excluding overhead costs: £13,750 including overhead costs).

Table 28.1. Summary of benefits

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substantial reduction in MSD related sickness absence.</td>
<td>This has contributed to improved productivity because there is less down time requiring agency staff</td>
</tr>
<tr>
<td>Increased multi-skilled capacity of workers.</td>
<td>Enables job rotation and therefore reduces the risk of MSDs; also provides greater variety of work for workers.</td>
</tr>
<tr>
<td>The resource required to manufacture an oven or hob was reduced compared to before the intervention.</td>
<td>Productivity has increased per worker.</td>
</tr>
</tbody>
</table>
29. Laying bricks and blocks using mast climbers

- Laying bricks and blocks from traditional scaffolding involved bricklayers bending and stretching to the appropriate height, and posed a high risk of injury to the lower back, knees and muscles of the upper body.
- Use of a mast climber allows the working platform to be set at an appropriate height, and adjusted incrementally as the wall is built.
- This reduces bending and stretching when laying bricks, and has been well received by bricklayers.

The task

Laying bricks / blocks for the exterior of a building traditionally required scaffolding to be erected to provide a safe working platform. Erecting the scaffolding was manually intensive and required a considerable amount of time to carry out.

Musculoskeletal risks

Erecting and dismantling scaffolding involved the handling of quite heavy, awkward-shaped loads. Laying bricks or blocks from scaffolding requires bending and stretching to position the bricks on some parts of the wall as the scaffolding platforms are 2m apart. The task is repetitive; repeated handling in these awkward postures can lead to discomfort.

Identifying the problem

Complaints of discomfort in the back from brick and block layers were very common. It was known that this is due to the frequent cycle of bending and standing in order to lift and place bricks / blocks at the height of the wall / fabrication.

What was done?

In planning the construction and refurbishment of large tower blocks, the opportunity arose to consider other means of providing access for the bricklayers. Mast climbers (see Figures 29.1-29.4) were identified as a viable alternative.

These form a series of powered platforms that can be moved independently of each other. The platforms move relatively quickly up and down the masts which makes the task of replenishing the materials quite straightforward. The platform is lowered to the ground and packs of shrink-wrapped bricks or blocks are placed onto the platform by a fork lift truck. The mast is then raised again for the materials to be laid see for example figure 29.2).
Figure 29.1. Showing the mast climber being used for laying brickwork

Figure 29.2. Showing a series of mast climbers being used for laying brickwork
Figure 29.3. Showing how the working platform can be set so that the bricklayers can work at a comfortable height without excessive bending and stretching.

Figure 29.4. Showing bricklayers working from the mast climber. It allows them to work at about waist height and adopt a good posture.

**Costs and benefits**

- The adjustable working height allows bricklayers to avoid excessive bending and reaching when laying bricks. This reduces the risk of back pain.
- The manufacturer reports that three times the volume of bricks can be laid as from normal access.
• Power tools sockets, lighting and canopies can be provided on the mast climber to protect against adverse weather.

There are limitations to use that should be taken into account:
• Use of the mast climber can be expensive. The system becomes cost effective compared with scaffolding costs for buildings over 2 or 3 stories high.
• One contractor commented that smaller loads had to be loaded compared to what they could put in using a loading bay (used with scaffolding).
• The operatives may still have to bend to pick up bricks from the brick stack.
• Power failure renders the system inoperable.

Mast climbers are best used on medium / large construction sites and new builds. They can also be used on buildings that have relatively long straight walls where the use of a mast climber is feasible.

Two companies who had used the mast climber for laying bricks were asked about its performance and to rate their impressions on a scale out of five (five being good).

How does the Mast Climber Working Platform (MCWP) affect productivity of the workforce?
(This received scores of 4 and 5)
• ‘Much improved productivity of the workforce compared to scaffolding. A bonus.’
• ‘It is better than scaffold – much more efficient. Once the workforce were used to working with a new system, and got the planning side of things right (i.e. by thinking ahead), they were more than happy to use it. We think this is the way forward.’

What was the reaction of your operatives/tradesmen to the ease of operating at a consistent working height?
(Both companies scored this as 5)
• ‘They were very happy. You couldn’t get a better platform for this type of work.’
• ‘It is great because you can adjust it to whatever height you want – so there is no stretching up or down all the time.’
• ‘There’s nothing worse than having to bend down to lay bricks at your feet [and the mast climber eliminates this need]’
• ‘Workforce would use it every time if they could.’
• ‘All very happy with the system – no bending down all the time. Top marks.’

What are its advantages?
• ‘A much better quality of brickwork is possible with MCWPs – less damage done to freshly laid sections than when using scaffolding.’
• ‘Once you have planned your labour properly, it’s very easy to use.’
• ‘Not having to stop and start work when an area of scaffold is left free by other trades.’
• ‘Biggest advantage would be the comfort factor of the system.’
REFERENCES

6. Ready reckoners for accidents, ill health and incidents can be found via www.hse.gov.uk/costs
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