OCCUPATIONAL DISEASE IN THE BRITISH CONSTRUCTION INDUSTRY, 1996-2000

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The health of workers in the construction industry requires control of the many and varied hazards to which they are exposed. The pattern of occupational disease for this and other industries has been recorded in the UK since 1996 by some 3000 specialist physicians who report monthly to the Occupational Disease Intelligence Network (ODIN). During this 5 year period, from an estimated 69,186 new cases of work-related disease in men, 6385 were in construction and 62,801 were in other industries, distributed as follows:

<table>
<thead>
<tr>
<th>Industry (n)</th>
<th>Respiratory</th>
<th>Skin</th>
<th>Musculoskeletal</th>
<th>Mental</th>
<th>Auditory</th>
<th>Infectious</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction (6385)</td>
<td>47%</td>
<td>17%</td>
<td>21%</td>
<td>11%</td>
<td>4%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Other (62,801)</td>
<td>22%</td>
<td>19%</td>
<td>19%</td>
<td>30%</td>
<td>4%</td>
<td>7%</td>
</tr>
</tbody>
</table>

Thus there has been far more respiratory illness in construction workers, but fewer cases of mental illness than in other industries, explained mainly by the high frequency of malignant and non-malignant asbestos-related diseases in the former, and of stress disorders in teachers, health professionals and police in the latter. In contrast to this general picture, the distribution of selected diagnoses by specific occupation, in the same period, has been far more variable:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Respiratory Asthma</th>
<th>Cancer</th>
<th>Skin Dermatitis</th>
<th>Cancer</th>
<th>Musculoskeletal</th>
<th>Mental</th>
<th>Auditory</th>
<th>Total cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Painters/Decorators</td>
<td>1%</td>
<td>25%</td>
<td>21%</td>
<td>9%</td>
<td>43%</td>
<td>-</td>
<td>1%</td>
<td>215</td>
</tr>
<tr>
<td>Fitters</td>
<td>-</td>
<td>55%</td>
<td>34%</td>
<td>-</td>
<td>-</td>
<td>11%</td>
<td>4%</td>
<td>47</td>
</tr>
<tr>
<td>Electricians</td>
<td>-</td>
<td>51%</td>
<td>11%</td>
<td>-</td>
<td>13%</td>
<td>21%</td>
<td>4%</td>
<td>141</td>
</tr>
<tr>
<td>Plumbers/Plumbers/Heating</td>
<td>&lt;1%</td>
<td>53%</td>
<td>8%</td>
<td>-</td>
<td>19%</td>
<td>16%</td>
<td>4%</td>
<td>382</td>
</tr>
<tr>
<td>Carpenters/Joiners</td>
<td>9%</td>
<td>34%</td>
<td>20%</td>
<td>-</td>
<td>23%</td>
<td>5%</td>
<td>9%</td>
<td>556</td>
</tr>
<tr>
<td>Miscellaneous trades</td>
<td>3%</td>
<td>15%</td>
<td>31%</td>
<td>20%</td>
<td>11%</td>
<td>18%</td>
<td>3%</td>
<td>1164</td>
</tr>
<tr>
<td>Labourers etc.</td>
<td>-</td>
<td>16%</td>
<td>4%</td>
<td>2%</td>
<td>57%</td>
<td>3%</td>
<td>9%</td>
<td>1181</td>
</tr>
<tr>
<td>All</td>
<td>2%</td>
<td>28%</td>
<td>17%</td>
<td>7%</td>
<td>30%</td>
<td>10%</td>
<td>6%</td>
<td>3692 (100%)</td>
</tr>
</tbody>
</table>

In construction, musculoskeletal disorders and respiratory tract cancers (almost all the result of asbestos exposure) are the major health problems, followed by a substantial incidence of dermatitis, but the detailed occupational distribution is importantly different. Electricians and plumbers/heating engineers have been most at risk from mesothelioma and lung cancer, and musculoskeletal disorders have mainly affected labourers and painters/decorators. In contrast to the general pattern, asthma has been important for carpenters/joiners, and dermatitis, skin cancer and stress illnesses in certain trades but not others.

**Implications** Ergonomic principles, and the control of mineral fibres and siliceous dusts warrant priority, but the prevention in certain trades of dermatitis, skin cancer, asthma and stress will require the identification of causal factors.
DUST CONTROL MEASURES IN THE CONSTRUCTION INDUSTRY

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Introduction
Considerable emphasis is put on improvement of exposure control in the construction industry, because of potentially high respirable quartz levels. Dust exposure can be reduced by (local) exhaust systems, use of (cooling) water or other wet techniques, or by the use of personal protective equipment. The nature of the work makes it difficult to use exposure control technology in an effective way, and available technologies might not be sufficiently effective to reduce the exposure to a desired level. Knowledge on the effectiveness of control measures is essential to achieve sufficient dust reduction for compliance with the TLV value for quartz (0.075 mg/m³).

The effectiveness of exposure control technology, such as exhaust systems or wet techniques can be evaluated by the amount of dust reduction achieved on the basis of short-term measurements. More realistic results can be achieved by measuring the amount of dust reduction, using full-shift measurements. These allow calculation of the degree of dust level reduction when different conditions are being compared.

Methods
Dust reduction measures were evaluated during certain tasks using short term exposure measurements with a MiniRam. All factors, except the control measure, were kept constant. Full shift respirable quartz dust exposure measurements (n=61) were performed on 30 subjects using Dewell-Higgins cyclones. During full shift measurements all factors that potentially determine exposure (materials used, presence of exposure control technology and climate) were recorded. Regression coefficients were calculated with multiple regression analysis (proc mixed), to evaluate the influence of different characteristics on exposure.

Questionnaires (n=1335) from quartz dust exposed construction workers who participated in a health effects study, gave information on the use of control measures and protective equipment.

Results
Short term (1 to 3 minutes) measurements of respirable dust shows that the use of water or local exhaust systems can reduce dust exposure by 80 to over 95%. During the dull shift measurement program, exposure control technology was not used extensively. The materials worked on mainly determined the level of exposure. When the material worked on was wet, the respirable dust level was reduced by 62 % (t-test, p<0.05), but the quartz levels did not differ significantly. Local exhaust techniques were not used. The health effects study showed that control measures most frequently used consist of personal respiratory protection.

Conclusion
Although short-term measurements prove to reduce respirable dust levels significantly, the full shift measurements suggest that the effect on the full shift exposure is smaller. A full shift measurement program where construction workers work under normal conditions, but where all factors, except the use of exposure control technology, are kept constant, is necessary for a more accurate evaluation of the actual level of dust reduction during a full working day.
DETERMINANTS OF DUST EXPOSURE IN TUNNEL CONSTRUCTION WORK

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Introduction
In tunnel construction work, dust is generated from rock drilling, rock bolting, grinding, scaling, and transport operations. Other important dust generating activities are blasting rock, and spraying wet concrete on tunnel walls for strength and finishing work. The aim of this study was to identify determinants of dust exposure in tunnel construction work and to propose control measures.

Methods
Personal exposures to total dust, respirable dust, and a-quartz in respirable dust were measured among 209 construction workers who were divided into 8 job groups performing similar tasks: drill and blast workers, shaft drilling workers, tunnel boring machine (TBM) workers, shotcreting operators, support workers, concrete workers, outdoor concrete workers, and electricians. Information on determinants was obtained from interviewing the workers, observation by the industrial hygienist responsible for the sampling, and the job site superintendent. Multivariate regression models were used to identify determinants associated with the dust exposures within the job groups.

Results
Approximately 400 personal samples of total dust and respirable dust were collected. Exposures to total dust, respirable dust and a-quartz differed substantially between job groups. TBM workers and shaft drilling workers were highly exposed to a-quartz, whereas shotcreting operators, TBM workers, and shaft drilling workers were highly exposed to total dust and respirable dust. The exposure measurements of shaft drilling workers, shotcreting operators and TBM workers most frequently exceeded the Norwegian OELs of total dust (22-57% above 10 mg/m3) and respirable dust (7-57% above 5 mg/m3), whereas the exposure of TBM workers, shaft drilling workers and tunnel concrete workers most frequently exceeded the Norwegian OEL of a-quartz (21-91% above 0.1 mg/m3). Important determinants of exposure were job group, job site, certain tasks (e.g. drilling and scaling), the presence of a cab, and breakthrough of the tunnel.

Conclusions
The exposure of tunnel workers to dust and a-quartz differed substantially between job groups. Shotcreting operators, tunnel boring machine operators and shaft drilling workers were highest exposed tunnel construction workers and measurements often exceeded Norwegian OELs. The use of ventilated, closed cabs appeared to be the single most important control measure for lowering exposures.
EXPOSURE AND ACCIDENT SCENARIO’S DURING TUNNEL CONSTRUCTION

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Introduction
Drilling big tunnels in soft soil is an activity, which has started only recently in The Netherlands. Accident and exposure scenario’s, that can be expected during construction of these tunnels, are largely unknown. The aim of the study is to develop a technique to predict these scenario’s.

Method
A design analysis spit up the activities of underground drilling into relevant production functions. Per production function a hazard evaluation technique was developed, focussing on relevant disturbances of the material flow. The focus on process disturbances is highly relevant for accident scenarios in case of remote controlled or automated operations. Exposure scenarios do occur during process disturbances as well as during normal process conditions. The technique was adopted to include these conditions as well.

Results
The hazard evaluation technique was applied during multidisciplinary group sessions of experts and workers and generated a list of accident and exposure scenario’s during various production functions. A ranking technique provided a shortlist of the most dominant scenarios.

Conclusions
The application of techniques from the domain of safety science into the domain of occupational hygiene is promising and needs further development. The scenario’s can become a relevant input during early stages of design of the tunnel drilling operations, an area of influence, which is hardly explored by occupational hygienists.
SOURCES OF VARIATION IN NOISE EXPOSURE DURING TYPICAL CONSTRUCTION ACTIVITIES

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Noise exposures in construction work are known to be highly variable; however, the components of this variability have not been comprehensively detailed. Sources of variation include simple determinants such as trade and building site which are constant over work shifts; detailed determinants such as task, tool, and number of co-workers in the work area which vary within a shift; and the highly time-variable noise exposure associated with the intermittent use of specific tools and the impact-type noise profile of many construction tools. In addition, exposure levels vary between workers, even after controlling for these other determinants. We have used our large noise exposure dataset to explore these components of variability during commercial construction activities.

Five hundred and twelve full-shift measurements were obtained on 5 different construction trades at a total of 11 building sites using datalogging dosimeters that recorded average and peak noise levels at one minute intervals and 8-hr TWAs using both 3 and 5 dB exchange rates (ER). Task, tool, and number of nearby workers were recorded by subjects during the monitoring period. Only small differences were seen in mean TWA exposure levels by trade; however, exposure variability and peak levels differed substantially between trades. Thirty-five percent of all 5 dB ER TWAs measured exceeded 85 dBA, while 75% of all 3 dB ER samples exceeded 85 dBA. Task, tool, and stage and method of construction were found to be good predictors of exposure level.

Sources of variability are explored using multivariate models with mean levels, peak levels, and variability (expressed by the ratio of the 3 and 5 dB ER) as the dependent variables. A mixed model structure is used to explore the relative contributions of the potential determinants, simultaneously accounting for the variation between subjects and the residual within-subject variation. The modeling results provide a comprehensive description of the many sources of variability in noise exposure during typical construction activities.
EXAMPLE OF SUCCESSFUL NOISE ABATEMENT: COMPACTING MACHINES FOR THE PRODUCTION OF PREFABRICATED CONCRETE PARTS

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Looking at occupational diseases in Germany the highest number of approved cases is found for occupational hearing impairment. 6197 cases were reported in the year 2000 by the German gewerblichen Berufsgenossenschaften (Institutions for statutory accident insurance and prevention for industry). These Berufsgenossenschaften are responsible for more than 43 million insured persons and reported in total about 16 thousand approved occupational diseases in 2000. About 8.5 % of persons insured are employed in the construction industry but about 23 % of the approved cases of occupational hearing impairment were found in construction industry. By that it is obvious that construction industry is still today one main focus of hearing impairment caused by occupational exposure to noise.

Noise abatement in construction industry is often a difficult job: In many situations productive procedures cannot be substituted by noise reduced techniques; frequently the noise cannot be decreased at the source; furthermore the noise propagation cannot be reduced; and even in case there is a new noise reduced technology available it has to be successful under the severe conditions to be found in construction industry.

An example for very successful noise abatement as described here is rare in construction industry. A main component of noise exposure in the production of prefabricated concrete parts is the sound emission generated by the vibrating unbalanced metal form for concrete. In general it is found to be in the range of 100 to 120 dB(A). Although the time of compacting concrete is short the rating level frequently exceeds 90 dB(A). Those rating levels indicate the risk of hearing impairment.

By application of noise abatement measures to conventional vibrating machinery in use for compacting prefabricated concrete parts the sound generation and emission can be reduced evidently. In general those measures do not result in the total avoidance of noise exposure. Replacement of the conventional machinery by noise reduced vibrating forms for concrete or low noise shaking forms for concrete the sound emission may be reduced up to unbelievable 40 dB(A).

The principles of the noise reduced vibrating machinery and the low noise shaking technique are described. The sound emissions obtained using various techniques for compacting concrete are compared by corresponding measurement results.
Noise is a major occupational hazard in the construction industry. It is estimated that half of all Dutch construction workers are exposed to hazardous noise levels. Research shows that 38% of the workers in the Dutch construction industry complains about noise and that 17% of the workers complains about their hearing ability. Because of these figures and the considerable impact of deafness (from a safety point of view as well as from a social point of view), Arbouw, an expertise centre on working conditions in the Dutch construction industry, has started a project on noise. The goal of this project is to reduce the amount of people exposed to hazardous noise levels with 10%. For this project, five priority groups were selected: pile drivers, demolition workers, road works machinists, operators of wood working machines, and road markers. These groups were chosen because of their seize, the amount of complaints about noise and the level of exposure. The project has started in 2000 and will end in 2002.

The project consists of several phases. First of all, a picture of the current situation is created by means of a literature survey, measuring noise exposures and a survey among employers about their knowledge of the problem.

Apparently, the relationship between complaints about noise and the level of exposure is poor. Among the road markers, 67% complains about noise. Levels of exposure from 78 to 90 dB(A) were found (AM = 84) and 4 out of 11 measurements were below 80 dB(A). Among the demolition workers, 65% complains about noise and the level of exposure varied between 81 and 109 dB(A) (AM = 96) and 11 out of 13 measurements were above 90 dB(A).

Generally, employers have the idea that the noise problem is under control. However, they hardly report to have taken noise reduction measures. Distribution of hearing protectors is by far the most popular measure.

Very remarkably, machine dealers were hardly interested in the project. Out of 29 dealers inquired for noise reduction measures, only three have answered to have taken these.

The second part of the project consists of a plan for the reduction of noise exposure. The result of the first phase shows that several information gaps are to be bridged. The challenge of the project will be to convince employers to take other measures than providing hearing protection. But even more, to promote that machine dealers will produce more silent machines. And last but not least, the difference in the level of complaints about noise among workers and the actual exposure data shows that complaints may be more a measure for the awareness of the consequences of hearing loss than of the actual risk.
CHEMICAL USE AND SELF REPORTED HEALTH EFFECTS AMONG FINNISH HOUSE PAINTERS

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Introduction
Solvent-based paints have been mainly replaced by water-based paints in the construction industry. There is increasing concern, whether water-based paints do cause irritation or allergic symptoms in the workers. In addition to paints and solvents, house painters use also many other chemicals, such as putties, plasters, paint removers and wood preservatives in their work. This paper was focused on current chemical use and symptoms experienced by the painters.

Material and methods
Working conditions, chemical use and health status of 1000 Finnish house painters and 1000 carpenters as their referents were studied by a posted questionnaire. The painters and carpenters living in southern Finland were picked from the member register of the Finnish Construction Trade Union. The comprehensive questionnaire had questions on the work history, present and past use of chemicals, use of personal protection, health status and experienced symptoms (cough, asthma, rhinitis, eye and skin irritation, dermatitis and neurological symptoms). Clinical investigation was focused on the painters reporting skin, respiratory and neurological symptoms. After the clinical investigation the correlation between the symptoms and the painting work was estimated with the help of work diaries.

Results
Both worker groups were similar in response rate (61 %), alcohol and tobacco consumption and the duration of construction work. Alkyd paints were used frequently, (almost) daily by 20 %, other solvent paints by 9 % and putties by 69 % of the painters. Surprisingly, the painters experienced putty dust and construction dust as the most hazardous chemical exposure (putty dust very harmful to 42 % and somewhat harmful to 49 % of the painters). Solvent-containing products were considered as very harmful by 17 % and somewhat harmful by 49 % of the painters, whereas water-based paints were named as very harmful to only 2 % and somewhat harmful to 17 % of the painters. Respiratory, eye and skin symptoms were experienced by 14-45 % (depending on the symptom) of the painters. Sanding of putty was the most often named occupational cause for symptoms among the painters suffering from cough (67 % of those with symptoms), asthma (50 %), rhinitis (65 %), throat irritation (57 %), eye irritation (66 %) and dermatitis (56 %). Symptoms were linked to solvent-based products in 20-30 % (depending on the symptom) of the cases and to water-based paints only in 4-12 % of the cases. Similar trend was discovered in the work diaries.

Discussion
Our study shows that house painters’ work includes many different work tasks and chemicals. In addition to solvent-based and water-based paints, the work with putties and plasters seems to cause various respiratory, eye and skin symptoms. Work methods and personal protection should be re-evaluated and better prevention should be applied.
SKIN DISEASE IN RELATION TO THE USE OF WATERBORNE PAINTS BY HOUSEPAINTERS

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Introduction
From 1/1/2000 on, the use of paints with a solvent content of less than 10% for indoor applications is compulsory in the Dutch regulations. The reason for this was to reduce exposure to VOC and thus to eliminate the occupational risk on Chronic Toxic Encephalopathy (CTE). In practice, only waterborne paints are allowed now. However, these paints have a more complex composition than the traditional alkyd resin solvent-borne paints, and may contain several components that are skin irritants or skin sensitizers. Thus, the main question to be answered in this study was: is there a potential for an increase in skin allergy among house painters as a result of the increased use of the new generation of waterborne paints?

A complicating factor is, that solvents are strong irritants for the skin. This means that skin irritation may be decreasing due to the use of waterborne paints and this might hide or blur an increasing sensitising effect from the use of waterborne paints.

Methods
The composition of modern waterborne paints was investigated, as former investigations were more than 10 years old. ‘Average recipes’ for a number of commonly used product types were defined, and a survey was made of paint additives used in waterborne paints.

The potential health effects of the paint components were investigated by a literature study and classified by means of recording the respective ‘R-phrases’ (‘risk-phrases’). For each type of paint the potential sensitizers and skin irritants were recorded.

Furthermore, the prevalence of skin disease among painters was studied in literature, as well as exposure of house painters to paint components and relations between product use and skin disease.

Finally, a questionnaire study was performed. Firstly, the data from a continuously running ‘Painter’s Questionnaire’, which is filled in by 3600 painters each year and focuses on health complaints, were analysed for prevalence of skin complaints, use of waterborne paints, skin protection etc. Secondly, an additional questionnaire was sent to 200 painters who reported skin complaints in the first questionnaire and to 200 painters who reported no skin complaints. The second questionnaire contained more detailed questions on product use, tasks performed and skin disease during childhood.

Results
The first results of the investigation indicate that the composition of waterborne wall paints has not changed much over the past decade, but that new varieties of waterborne trim paints have come up. In particular, polyurethane-acrylate dispersions and alkyd emulsions have gained popularity among professional painters. In both waterborne wall and trim paints, the use of a number of irritant or toxic substances - such as ammonium, nitrite and some specific (di)ethylene glycol ethers - has ceased, while concentrations of sensitising preservatives have dropped considerably. It appears that alkyd resin paints – conventional solventborne, high solids and waterborne emulsions – contain much higher concentrations of sensitising components than latex wall paints or (polyurethane-)acrylate-dispersion trim paints. This is due to the use of sensitising dryers and anti-skinning agents in alkyds. On the other hand, (polyurethane-)acrylate dispersions for trim may contain higher amounts of skin-irritants than the other types of waterborne paints, caused by the use of cosolvents such as propyleneglycol.

When the abstract was written (Sept., 2001) the analysis of the questionnaires was still in progress. On the basis of the results it will be decided whether medical examination and allergic skin diagnosis is indicated.
A DATABASE OF EXPOSURE TO SOLVENTS AMONG COMMERCIAL PAINTERS IN THE NETHERLANDS, AIMED TO SUPPORT RETROSPECTIVE EXPOSURE ASSESSMENT

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In 1995, ARBOUW has put in place a health surveillance programme designed to prospectively follow the health of commercial painters in the Netherlands. In particular, the goal of the program is to investigate the relationship between long-term exposure to organic solvents and chronic encephalopathy. An integral part of reaching this objective is the reconstruction of past solvent exposures among painters. We set out to develop a database of exposure measurements that can be used as a tool for exposure assessment among commercial painters in the Netherlands.

After consulting the peer-reviewed scientific literature and internal reports from leading institutions in the field of occupational hygiene in the Netherlands, eight studies were identified that had sufficiently detailed information to allow their inclusion in the database. A database management system was created as a Microsoft Access 97 application to allow collection, storage and retrieval of data from these studies. At present, data from all eight surveys have been added to the database. These were conducted in 1980, 1982/1983, 1984, 1991, 1989, 1994, 1998 and 1999, providing data from approximately 150 measurement days. In excess of 300 personal samples were collected, resulting in measurements of more than 4000 concentrations of individual chemicals. Comprehensive contextual information was recovered, which facilitated interpretation of patterns in the data, although the amount, type and quality of the information varied considerably among the surveys. The data collected comprises most, if not all, exposure measurements among commercial painters still available in the Netherlands.

Toluene appeared to have been measured most commonly among Dutch commercial painters and was consequently used as a marker for solvent exposure of these workers. The result of preliminary statistical analyses indicated distinct differences between house (maintenance) and shipyard painters. Furthermore, statistical models detected a historical downward trend in solvent exposures that could be attributed to both increased use of water-based paints since the 1980 and decrease in solvent content of the solvent-based paints. Application methods (brush vs. spray painting) and environmental conditions (indoors vs. outdoors, confined spaces) also appeared to be highly influential. In addition, measurement strategies applied (e.g. worst-case sampling) appeared to be of great influence on the measured concentrations. Validation of the findings with exposure data from neighbouring countries and paint producers’ information is ongoing.

In conclusion, most of the data present in the database originated from large studies performed for research purposes during the last 20 years. The coverage of the data allows estimation of trends and determinants of solvent exposure level, which will aid in exposure assessment within the mandate of the ARBOUW surveillance program. However, considerable limitations exist due to (a) uncontrollable confounding of time-trends by measurement strategies and (b) the relatively limited number of workplace where measurements were collected.

The lessons learned from this project have important implications for creation of similar databases for either retrospective or prospective occupational exposure data collection, such as the proposed National Occupational Exposure Database project.
Cost effectiveness has become an important aspect in evaluating health care interventions. This will also become true for typical occupational hygiene control measures. Specific problems arise in measuring and valuing the costs and health benefits of interventions. A cost-effectiveness analysis requires that the gain in health status (e.g. less low-back pain, less hearing loss, less occupational cancer) due to the interventions is related to the costs to achieve these health benefits. A cost-effective intervention will result in substantial health gains for moderate costs.

A first principle of economic evaluation is that all consequences of an intervention should be considered and not only those of interest. In general, a distinction is being made between direct and indirect costs. Direct costs are recognisable ‘out of pocket’ costs which include the costs of the introduction and implementation of control measures and the costs of health care due to associated illnesses. Indirect costs are primarily costs due to production loss because of morbidity and mortality. These costs include absence from work (short / long term), reduced productivity at work, disability or premature death, and production loss of those with unpaid work. Although these costs may be difficult to estimate, the indirect costs as a consequence of productivity losses are far greater than direct costs. Some examples from the literature will be presented to illustrate different estimates of sources of indirect costs. The cost-effectiveness analysis will be illustrated in a case study on the introduction of ergonomic work techniques in construction industry.