Promotion of sustainable employability
van Holland, Breunis Johannes

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Chapter 2

PREVENTIVE OCCUPATIONAL HEALTH INTERVENTIONS IN THE MEAT PROCESSING INDUSTRY IN UPPER-MIDDLE AND HIGH-INCOME COUNTRIES: A SYSTEMATIC REVIEW ON THEIR EFFECTIVENESS


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R. Soer
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ABSTRACT

Objective: To investigate the effectiveness of occupational health interventions in the meat processing industry on work and health-related outcomes.

Methods: A systematic literature review was performed. PubMed, Embase, and The Cochrane Library were searched. Studies were included when they reported on an intervention among employees in the meat processing industry and with outcomes related to work or health. Studies were assessed on risk of bias and data were synthesized by type of intervention.

Results: A total of 13 articles reporting on two randomized controlled trials and nine non-randomized intervention studies were retrieved. Studies were categorized into three topics: ergonomics programs, skin protection, and Q fever vaccination. All studies had high risk of bias. Based on four studies, there was limited evidence for workplace health and safety programs showing reductions in musculoskeletal injury severity, reduction of lost work days, and reduction of costs and claims for several musculoskeletal disorders. There was limited evidence for added rest breaks resulting in improved productivity at the end of a workday and in reductions of perceived discomfort in various body regions at the end of the workday. One study on skin protection showed reductions of eczema prevalence, although evidence was moderate. Based on four studies, there was high quality evidence for strong effectiveness of Q fever vaccination.

Conclusion: This review presents evidence for the effectiveness of a variety of workplace interventions. There was limited evidence for effectiveness of ergonomic interventions, moderate evidence of a skin protection intervention, and strong evidence for Q fever vaccination.

Key words: meat-packing industry, absenteeism, Q fever, contact dermatitis, occupational health, workplace, musculoskeletal disorders
INTRODUCTION

Health promotion programs are a part of occupational health care that addresses safety, health and well-being of workers. They can serve as a means to detect and treat workers with health loss, but they can also act in a preventive fashion for workers at risk of health loss in order to improve employee health and to reduce absenteeism. Moreover, they address, among others, physical activity, nutrition, mental health, ergonomics, and safety issues. Due to the aging workforce and a rising retirement age, employers have become aware of the importance of investing in their workforce and have spent large amounts of money on such programs. However, their effectiveness seems to vary, which may be caused by the program characteristics, the implementation process, the study population, and several other factors. In a meta-analysis study of Rongen et al. it was concluded that workplace interventions were more effective when there were more frequent contacts, but programs with a counseling component were less effective. Furthermore, interventions were more effective in smaller populations. Studies among younger (<40 years) workers reported larger effects. Among white-collar workers, the effects of workplace interventions were larger compared to studies among blue-collar workers. Little explanation was provided for the difference between white-collar and blue-collar workers. In those studies, the effects of workplace interventions among blue-collar workers were tested in construction industry, aluminum industry, and laundry services.

Another very specific blue-collar population which might benefit from workplace interventions are meat processing workers. They perform monotonous and physically demanding work and are a vulnerable group in the way that they are exposed to several occupational health hazards simultaneously. Several common occupational injuries and illnesses have been reported. Among them are musculoskeletal disorders (MSDs), skin disorders, hearing disorders, and infectious diseases. Prevalence rates of MSDs of over 90% have been reported. According to the US Bureau of Labor Statistics, slaughterers and meat packers have to stand the majority of their workday. They typically work on an assembly line performing one specific function, although they may rotate duties during and between workdays. Strenuous activities are performed, floors are often slippery, and workers are exposed to animal waste. Furthermore, work is performed near dangerous equipment, such as knives and saws. Slaughtering and deboning call for specific skills to be
executed repeatedly, precisely and fast. Pork shoulder deboners execute almost 50 cuts and saws during one deboning operation of 50 seconds\textsuperscript{12}. If knives are not optimally sharp, higher force applications are necessary\textsuperscript{12}, leading to more operator exertion and increased risk for upper extremity MSDs\textsuperscript{13}. In addition, employees may be exposed to airborne substances. For instance, one study showed a prevalence of 5.6\% of Methicillin-Resistant Staphylococcus Aureus (MRSA) in slaughterhouse workers when live pigs were involved\textsuperscript{14}. There is also evidence of zoonotic influenza among poultry and swine workers\textsuperscript{15}. Few studies have reported on psychological consequences of work in the meat processing industry. When studied, no associations between psychosocial job characteristics and depressive symptoms among poultry processors were observed\textsuperscript{16}.

MSDs, skin disorders, hearing disorders, and infectious diseases increase the chance for sickness absence and reduced work ability\textsuperscript{17}. If injuries or illnesses are severe enough, they may lead to early retirement or disability pension\textsuperscript{18} and thus have considerable economic consequences\textsuperscript{19}. High direct and indirect costs due to occupational injuries and illnesses (industry wide) amounted to approximately $250 billion in the United States in 2007\textsuperscript{20}.

It is therefore relevant to learn from effective (preventive) interventions in the meat processing industry. Some interventions have been deployed to enhance work and health outcomes, but a systematic overview on their effectiveness is missing. Therefore, we performed a systematic literature review to investigate the effectiveness of occupational health interventions in the meat processing industry on work-related and health-related outcomes including perceived health, quality of life, productivity, or sickness absence. The findings might give directions to employers and occupational health professionals on which interventions to deploy.
METHODS

This report was written according to the guidelines of the PRISMA statement\textsuperscript{21,22}.

Search strategy

Key terms were identified and combined to systematically search PubMed, Embase, and The Cochrane Library from January 1990 until January 2013. We searched for “meat processing industry”, including synonyms, and interventions and outcomes related to work and health (e.g., “health promotion”, “work ability”, “sickness absence”, “health status”). In 1988 the Occupational Safety and Health Administration (OSHA) published a guideline in the United States entitled “Safety and Health Guide for the Meatpacking Industry”\textsuperscript{23}. Assuming that it takes some time for such guidelines to be incorporated, or even investigated, we chose to include articles published from January 1990 onwards. The final search was performed on January 8, 2013. Furthermore, reference lists of the eligible full-text articles were searched. If applicable, unpublished studies and gray literature were included.

Selection of studies

Selection of studies was performed by two reviewers independently (BvH, RS). The reviewers were not blinded for study authors, journal names, etc. A first selection was performed on titles. When in doubt of eligibility, articles were included for further assessment using the abstract. All potentially eligible articles were further screened on abstracts and when still deemed eligible on the full text. When the reviewers did not reach consensus or were unsure whether the articles should be included, a third reviewer (SB) was consulted.

Inclusion and exclusion criteria

Studies were included when they reported on work- and health-related interventions among workers in the meat processing industry. The meat processing industry was defined as the process starting at slaughterhouses and ending at the transport to retailers and supermarkets. Studies in animal farmers, retail butchers, and supermarket meat departments were excluded. Only studies performed in upper-middle and high-income countries, according to 2012 World Bank statistics\textsuperscript{24}, were included in this review.
Furthermore, interventions had to address work or health, and be organized at the workplace. Studies had to contain within- or between-group comparisons. Only randomized controlled trials (RCTs) and non-randomized intervention studies written in English, Dutch, German, or French were included in the review. Letters to the editor, guidelines, editorials, book chapters, dissertations, conference proceedings, design papers, and case reports were excluded.

**Methodological quality**

The risk of bias of the included studies was independently assessed by three reviewers. BvH assessed all articles, RS and SB each assessed half of the studies. For the risk of bias assessment, we used the checklist for RCTs recommended by the Cochrane Handbook for Systematic Reviews of Interventions\(^{25}\) and the checklist for observational studies recommended by the Cochrane Bias Methods Group\(^{26}\), both adapted for our purposes.

RCTs and non-randomized intervention studies were assessed on the basis of selection bias, performance bias, detection bias, attrition bias, reporting bias, and evaluation of co-interventions. The evaluation of co-interventions was added to the assessment of RCTs; the evaluation of selective reporting was added to the assessment of non-randomized intervention studies. This was done in order to keep both assessments as identical as possible.

Risk of bias was considered low if all criteria were unlikely to influence study outcomes. Moderate risk of bias was established if no criteria were highly biased, and if one or more criteria were unclear. High risk of bias was established if one or more criteria seriously weakened the results. Consensus between the reviewers was reached by discussion, and if necessary by consultation with a fourth reviewer (MdB).

**Data extraction**

One reviewer (BvH) extracted the data from the final set of eligible articles. Accuracy was verified by the reviewers who also assessed the risk of bias of the respective articles (RS, SB). The following study characteristics were extracted and described: research question / study aim, study design and setting, inclusion and exclusion criteria, intervention characteristics (nature, frequency, duration), sample characteristics at baseline (job titles,
Systematic review

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Grading of evidence

If possible, the quality of evidence for single outcomes was assessed by two reviewers (BvH, SB) following the GRADE Working Group guideline (Grading of Recommendations Assessment, Development and Evaluation). The quality of evidence was graded on the basis of study design, risk of bias, inconsistency, indirectness, imprecision, publication bias, effect size, dose-response gradient, and confounding. If possible, only RCTs were used for the grading of the evidence, otherwise multiple observational studies were graded. The design of the studies prescribed the initial quality of evidence: RCTs started with high-quality evidence (++++) and observational studies with low-quality evidence (++). Evidence was qualified as high, moderate, low, or very low.

Data synthesis

The results of the data extraction were synthesized according to type of intervention. We planned to conduct meta-analyses when two or more studies were retrieved per outcome within a certain comparison. This criterion was not met and thus data synthesis was done descriptively.

RESULTS

Selection of studies

The results of the literature search are presented in Figure 1. The search resulted in 1,200 hits which were screened on title for eligibility. This yielded 94 articles that possibly met the inclusion criteria. The agreement of the two reviewers on screening was high ($K=0.86$). Next, abstracts were screened for eligibility, which left 38 articles for full-text evaluation. At this stage, articles were mainly excluded based on the criteria for population and intervention. The reference check yielded no additional potentially eligible articles. After full-text
screening, 13 articles (reporting on 11 studies) remained for data extraction, risk of bias assessment, and evidence grading. During full-text evaluation articles were mainly excluded because interventions did not adhere to our inclusion criteria or studies did not contain a control situation, either within or between subjects.

**Study characteristics**

Four articles reporting on randomized controlled trials were identified\(^ {29-32} \), of which three articles reported on the same study\(^ {29-31} \). Furthermore, nine longitudinal non-randomized intervention studies were identified\(^ {33-41} \).

Six articles addressed various ergonomics programs\(^ {34-37,40,41} \). Three articles addressed the prevention of skin problems\(^ {29-31} \) which were all on the same study, and four studies addressed Q fever vaccination\(^ {32,33,38,39} \). The studies on Q fever were partially performed within the same population. The authors did not mention which parts of the study populations overlapped, nor could they be reached for consultation on this matter. Therefore, we did not perform a meta-analysis for this type of intervention. Detailed information on all studies is presented in Table 1. Statistical analyses, reviewed protocol / ethics approval, competing interests, and funding are not presented.

**Risk of bias analysis**

The results of the risk of bias assessments for the included studies are presented in Tables 2 and 3. All studies displayed a high overall risk of bias. In non-randomized intervention studies, not all bias criteria could be assessed due to their respective study designs (e.g., whether the study matched exposed and unexposed persons for all variables that were associated with the outcome of interest or whether the statistical analysis adjusted for these prognostic variables). After consultation with the fourth reviewer (MdB), it was decided that these items were marked as ‘not applicable’.

**Data synthesis**

*Ergonomic interventions*

Four studies reported on ergonomics programs which focused on the improvement of workplace health and safety. Mainly, they aimed at reducing injuries and musculoskeletal
disorders. One longitudinal cohort study showed a 90% reduction in injury severity rate between 1992 and 1996\textsuperscript{34}, which was measured as the number of days off work due to lost time injuries per hours worked. Another longitudinal cohort study showed a reduction in lost work days after the introduction of cut-resistant gloves\textsuperscript{35}. At one study site the number of lost work days reduced from 16 to 1 days, while at the other study site the number of lost work days was reduced from 32 to zero. Similar results were demonstrated in a third study on a corporate ergonomics program\textsuperscript{40}. Over a 10 year period a significant downward trend was found in lost time incidence rates as a result of a corporate ergonomics program (-89%; \( p < 0.05 \)). In the fourth study, a corporate ergonomics program as well, significant reductions in new claim rates were observed, both in severity and costs\textsuperscript{41}.

Two experimental studies investigated the effect of added rest breaks\textsuperscript{36,37}. The introduction of added rest breaks showed positive effects for maintenance of production rates at the end of a workday, which was significantly higher than the control condition with no added rest breaks\textsuperscript{36}. With added rest breaks, productivity remained at 90% of the production level of the beginning of a workday, whereas without added breaks, it dropped to 60% of that level. When accounting for the added rest time, total production did not change. Added rest breaks also resulted in lower ratings of perceived discomfort at the end of the workday\textsuperscript{36,37}. Stress ratings did not change with the addition of rest breaks\textsuperscript{36}. 

Systematic review
Chapter 2

Figure 1 Flow diagram of the search process.

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<thead>
<tr>
<th>Author, year, country</th>
<th>Design, period</th>
<th>Aim of study</th>
<th>Intervention content</th>
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Table 1 Characteristics of included studies.

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[^1]: Refers to the reference number in the cited work.
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<tr>
<td>Jones(^\text{a}), 1997, USA</td>
<td>NRI '90-'95</td>
<td>To evaluate a program that was created to reduce the risk of musculoskeletal disorders in poultry processing facilities.</td>
<td>Corporate ergonomics program started in 1990. Creation of ergonomic committee at each processing facility which addressed / solved problems associated to workplace / task design. Site-specific ergonomic training to supervisors, management, and ergonomic committee. Medical management procedure from 1994 onwards. Yearly program evaluation.</td>
<td>The intervention was applied on an on demand basis.</td>
<td>Employees of 13 poultry processing plants from one company in the Southeast of the USA, N = 12,000</td>
<td>1.1: Compensation claims and costs for upper extremity musculoskeletal disorders 1.2: Compensation claims and costs for lifting.</td>
<td>1.1: (Severity) rates of new claims decreased significantly after an initial increase. 1.2: (Severity) rates of new claims decreased significantly after an initial increase.</td>
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<td>Moore &amp; Garg, 1998, USA</td>
<td>NRI '84-'93</td>
<td>To evaluate the effectiveness of a corporate ergonomics program that used a participatory approach to solving problems related to musculoskeletal hazards.</td>
<td>In 1986 a Corporate Ergonomics Program was introduced with the goal to 1) reduce the amount of physical stress in the workplace, 2) prevent internal damage to the body, 3) reduce cost of work-related injuries and illnesses. Elements of the program are: workplace analysis; hazard correction, prevention, and control; medical management; training and education.</td>
<td>The program was implemented in 1986 and became part of company policy.</td>
<td>Employees of one meat packing company headquartered in the USA, with plants in the Philippines, Japan, Korea, England and other European countries* N = 11,000</td>
<td>1: Lost time incidence rates (as a percentage of the 1984 rate)</td>
<td>1: 1985: 87% 1986: 50% 1987: 48% 1988: 34% 1989: 30% 1990: 21% 1991: 23% 1992: 14% 1993: 11% Significant decreasing trend (p&lt;0.05)</td>
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<tr>
<td>Dababneh et al., 2001, USA</td>
<td>NRI --</td>
<td>To examine the comparative effect of two differing short rest break schedules on workers' comfort, stress and productivity. The objective was to determine the impact of added short rest breaks on productivity and workers' well-being.</td>
<td>The intervention consisted of added rest breaks during a work shift of 4 x 9 minutes and 12 x 3 minutes. The entire intervention lasted 6 weeks in which the 1st and 4th week served as controls. During the 2nd and 3rd week the 4 x 9 minutes schedule was implemented, during the 5th and 6th week the 12 x 3 minutes schedule was implemented. During all conditions a normal rest break of 30 minutes and 2 x 15 minutes were included.</td>
<td>I1: 2 weeks, 4 x 9 minutes added rest. I2: 2 weeks, 12 x 3 minutes added rest.</td>
<td>Production line workers of a meat processing plant in Ohio, USA N = 35 Mean age 39 (SD 10.8) years 19% male, 81% female</td>
<td>1.1: Production rate 1.2: Rate of perceived discomfort 1.3: Stress ratings</td>
<td>1.1: Productivity in I1 and I2 was significantly higher (25-30%) at the end of the day than control (F(3,12) = 22.49; p=0.0). 1.2: Significant interactions between time of day and rest break condition → Favoring added rest breaks. Upper legs F(3,264) = 3.73; p=0.01 Knees F(3,264) = 5.16; p&lt;0.01 Lower legs F(3,264) = 5.16; p&lt;0.01 1.3: No difference</td>
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<td>Genaidy et al.37, 1995, USA</td>
<td>NRI --</td>
<td>To test whether or not a system of active microbreaks can reduce significantly the discomfort experiences on the job by employees engaged in meatpacking operations. Additional objectives of this research were to examine the relationship between the discomfort perceived by employees on the job and their anthropometric, strength, and endurance attributes, and whether these variables differ for Hispanic and Caucasian employees in the meatpacking industry.</td>
<td>Active microbreaks with stretching exercises.</td>
<td>Total duration per day could be no more than 24 minutes. Frequency and length of microbreaks were based on perceived discomfort.</td>
<td>Employees of one meatpacking company in the USA N = 28 12 Hispanic, 16 Caucasian Mean age 26 (SD 5) 100% male</td>
<td>1: Ratings of perceived discomfort (RPD) for several body regions 2.1: Microbreak frequency 2.2: Microbreak length</td>
<td>1: Significant main effect of microbreak at p-level of 0.05. RPD for upper extremities was significantly lower when microbreaks were introduced (p&lt;NA). No significant effects for other body regions. 2.1: Mean 2.1 (SD 1.2) breaks per day 2.2: Mean 48 (SD 46) seconds per break</td>
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<td>Ackland et al.33, 1994, Australia</td>
<td>NRI '85-'90</td>
<td>To examine the efficacy of various batches of a formalin-inactivated whole cell Coxella burnetii vaccine (Henzerling strain, Phase 1 [Q-Vax, CSL]) in the prevention of Q fever among abattoir workers.</td>
<td>Q fever vaccination: administration of Q-Vax (30μg C. burnetii cells per dose of 0.5ml)</td>
<td>1 time 1 vaccination</td>
<td>Employees of three meat processing companies in South Australia, Australia I: N = 2,553 Mean age 28 (SE 8.6) years 75.5% male, 24.5% female C: N = 1,365 Mean age 35 (SE 11.8) years 77.6% male, 22.4% female</td>
<td>1: Q fever prevalence (incidence) → total number (cases / 1,000 exposure months)</td>
<td>1: I: no Q fever cases (2 cases vaccinated during incubation period of natural attack); incidence of 0.05 cases / 1,000 exposure months C: 55 Q fever cases; incidence of 1.3 cases / 1,000 exposure months. Difference in incidence of 1.25 (95%CI 1.2497 – 1.2535), p&lt;0.0001 100% vaccine efficacy</td>
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<td>Gilroy et al.38, 2001, Australia</td>
<td>This investigation aimed to describe the outbreak of Q fever in time and to determine the safety and effectiveness of Q fever vaccination when given before and after the likely period of Q fever exposure.</td>
<td>Q-Vax vaccination (whole-cell formalin inactivated Henzerling strain of Coxiella burnetii Phase 1).</td>
<td>1 time 1 vaccination</td>
<td>Employees of one abattoir in New South Wales, Australia N = 103 82 males, 21 females Median age 33.5 years (range 17-62) I: N = 35 C: N = 68</td>
<td>1: Q fever incidence 2: Sick days</td>
<td>1: I: no Q fever cases 2: C: 29 confirmed Q fever cases, 8 suspected Q fever cases 2: I: 0 days C: Median 7 days (range 1-23)</td>
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<td>Marmion et al.39, 1990, Australia</td>
<td>To establish whether or not vaccine could be given without hazard to abattoir workers. Secondary objectives of the trial were to calibrate immune response to vaccine, to obtain evidence of vaccine-induced protection, and to monitor for vaccine-enhanced disease.</td>
<td>Q-Vax administration (one subcutaneous dose of 30μg of a formalin-inactivated, highly purified Coxiella burnetii cells Henzerling strain, Phase 1 antigenic stat, in a volume of 0.5ml)</td>
<td>1 time 1 vaccination</td>
<td>Abattoir workers in South Australia Baseline I: N = 3,521 vaccinated C: N = 2,453 unvaccinated</td>
<td>1: Q fever prevalence</td>
<td>1: I: no Q fever cases (8 cases vaccinated during incubation period of natural attack) C: 97 Q fever cases 100% protection</td>
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<td>Shapiro et al.32, 1990, Australia</td>
<td>No study aim was described in the paper.</td>
<td>The intervention group received 0.5 ml of Q-Vax vaccine. The control group received 0.5 ml of influenza vaccine. After the trial they also received Q-Vax vaccine.</td>
<td>1 time 1 vaccination</td>
<td>Employees of three abattoirs in Queensland, Australia I: N = 98 C: N = 102</td>
<td>1: Q fever incidence 2: Sick days</td>
<td>1: I: no Q fever cases 2: C: 7 Q fever cases Trial was terminated after 7 Q fever cases</td>
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<td>Flyvholm et al.29, 2005, Denmark</td>
<td>RCT 02-03</td>
<td>To describe the characteristics of the study population and the results, with focus on changes in eczema and use of preventive measures.</td>
<td>The preventive strategy consisted of a two part concept, with an evidence-based prevention program giving recommendations for prevention of work-related skin problems in wet work occupation, and a documented method for implementation. The prevention program included both recommendations aimed at the management and recommendations on work routines aimed at the employees.</td>
<td>1 educational session in May 2002, 1 educational session in June 2002, 1 follow-up meeting in October 2002.</td>
<td>Gut-cleaning departments of 18 swine slaughterhouses in Denmark</td>
<td>1: Eczema prevalence in past 3 months</td>
<td>1: -27.0% (p&lt;0.005)</td>
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<tr>
<td></td>
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<td>2.1: Preventive measures – use of gloves</td>
<td>C: +9.4% (NS)</td>
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<td>2.2: Preventive measures – use of skin care</td>
<td>2.1: +20.8% (NS)</td>
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<td>2.3: Preventive measures – reception of information on prevention</td>
<td>C: -13.2% (NS)</td>
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<td>C: +17.8% (p&lt;0.005)</td>
</tr>
<tr>
<td>Mygind et al.30, 2006, Denmark</td>
<td>RCT 02-03</td>
<td>To investigate the hypothesis, that the better the combination of the top-down and the bottom-up strategy implemented, the better the prevention of work-related skin problems.</td>
<td>See Flyvholm et al.29, 2005</td>
<td>Baseline I: N = 204 Baseline C: N = 494 Follow-up I: N = 170</td>
<td>See Flyvholm et al.29, 2005</td>
<td>1: Eczema prevalence (per intervention location)</td>
<td>1: Baseline – Follow-up</td>
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<td></td>
<td>Plant1: 60.4%-21.6%</td>
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<td>Plant2: 37.5%-34.8%</td>
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<td></td>
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<td>Plant3: 50.0%-50.0%</td>
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<td>Plant4: 68.6%-52.4%</td>
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<td>Plant5: 67.6%-46.2%</td>
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<td>Plant6: 57.9%-38.9%</td>
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<td></td>
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<td>Total: 59.8%-40.6%</td>
</tr>
</tbody>
</table>

NRI = non-randomized intervention study; RCT = randomized controlled trial; I = intervention; C = control; NS = Not significant; NA = Not available; CI = Confidence interval.

* The results seem to be derived from OSHA 200 logs. Since these logs are required to be maintained by the US Department of Labor, it is assumed that data were only available for US employees. Furthermore, results were compared with US figures, which strengthened this assumption. Hence, the population is presented as being from US production plants only. From the original paper it does not become clear whether this is actually the case. The size and origin of the population may therefore not be correct.
<table>
<thead>
<tr>
<th>Author, year, country</th>
<th>Design, period</th>
<th>Aim of study</th>
<th>Intervention content</th>
<th>Duration and frequency</th>
<th>Subjects</th>
<th>Outcomes</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flyvholm et al.39, 2005, Denmark</td>
<td>RCT '02-'03</td>
<td>To describe the characteristics of the study population and the results, with focus on changes in eczema and use of preventive measures.</td>
<td>The preventive strategy consisted of a two part concept, with an evidence-based prevention program giving recommendations for prevention of work-related skin problems in wet work occupation, and a documented method for implementation. The prevention program included both recommendations aimed at the management and recommendations on work routines aimed at the employees.</td>
<td>1 educational session in May 2002, 1 educational session in June 2002, 1 follow-up meeting in October 2002.</td>
<td>Gut-cleaning departments of 18 swine slaughterhouses in Denmark Baseline I: N = 242 C: N = 494 Follow-up I: N = 172 C: N = 348</td>
<td>1: Eczema prevalence in past 3 months 2: Preventive measures – use of gloves 2: Preventive measures – use of skin care 2: Preventive measures – reception of information on prevention</td>
<td>I: -27.0% (p&lt;0.005) C: +9.4% (NS) Significant difference between I and C at baseline (p&lt;0.05) and follow-up (p&lt;0.01) 2.1: I: +20.8% (NS) C: -13.2% (NS) Significant difference between I and C at follow-up (p&lt;0.05) 2.2: I: +4.3% (p=NA) C: +9.5% (p=NA) 2.3: I: +26.2% (p&lt;0.005) C: +17.8% (p&lt;0.005) Significant difference between I and C at follow-up (p&lt;0.01)</td>
</tr>
<tr>
<td>Mygind et al.31, 2006, Denmark</td>
<td>RCT '02-'03</td>
<td>To test the hypothesis that a high-fat petroleum-based moisturizer can be an alternative to protective gloves in wet-work occupations.</td>
<td>See Flyholm et al. 2005</td>
<td>See Flyholm et al. 2005</td>
<td>I: N = 136 C: N = 280</td>
<td>1.1: Risk of eczema – gloves 1.2: Risk of eczema – skin care</td>
<td>No results to add to Flyholm et al. 2005. The study does not give evidence to the hypothesis that a high-fat petroleum-based moisturizer can be an alternative to protective gloves in general, but the study does give evidence to the fact that a high-fat moisturizer is a crucial supplement to protective gloves.</td>
</tr>
</tbody>
</table>

NR1 = non-randomized intervention study; RCT = randomized controlled trial; I = intervention; C = control; NS = Not significant; NA = Not available; CI = Confidence interval.

* The results seem to be derived from OSHA 200 logs. Since these logs are required to be maintained by the US Department of Labor, it is assumed that data were only available for US employees. Furthermore, results were compared with US figures, which strengthened this assumption. Hence, the population is presented as being from US production plants only. From the original paper it does not become clear whether this is actually the case. The size and origin of the population may therefore not be correct.
### Table 2 Risk of bias analysis for included randomized controlled trials.

<table>
<thead>
<tr>
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<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Overall risk of bias</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skin disorders</strong></td>
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</tr>
<tr>
<td>Flyvholm et al.²⁹</td>
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<td></td>
<td></td>
<td></td>
<td>High</td>
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<tr>
<td>Mygind et al.³⁰</td>
<td>+</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>?</td>
<td>-</td>
<td>+</td>
<td>?</td>
<td>High</td>
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<tr>
<td>Mygind et al.³¹</td>
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<tr>
<td><strong>Q Fever</strong></td>
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<tr>
<td>Shapiro et al.³²</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>High</td>
</tr>
</tbody>
</table>

1. Was the randomization sequence adequately generated?
2. Was participant allocation adequately concealed?
3. Were participants blinded to their allocation?
4. Was personnel blinded to the allocation of participants?
5. Were the outcome assessors blinded to the allocation of participants?
6. Was loss to follow-up or response rate acceptable?
7. Were all the outcomes of interest described in pre-specified ways?
8. Were co-interventions similar between groups?

+ = low risk of bias; - = high risk of bias; ? = unclear risk of bias; n.a. = not applicable.

### Prevention of skin problems

Three articles on one RCT described the results of an intervention program aimed at reducing eczema among gut-cleaning workers. The intervention consisted of educational activities and evidence based recommendations (e.g., protective gloves, skin care). A 27% reduction (from 56.2 to 41.0%; p < 0.005) of eczema was observed in intervention groups compared to control groups which demonstrated an increase of 9.4% (from 45.9 to 50.2%; p = not significant)²⁹. The reduction in the intervention groups was not equally distributed between factories. Of the six factories in the interventions group, four factories showed significant reductions in eczema prevalence of 24-64%, while two factories showed no significant changes (0 and 7% reduction)³⁰.
Table 3 Risk of bias analysis for included non-randomized intervention studies.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Overall risk of bias</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ergonomics programs</strong></td>
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<tr>
<td>Blewden &amp; Wyllie³⁴</td>
<td>n.a.</td>
<td>-</td>
<td>-</td>
<td>n.a.</td>
<td>-</td>
<td>-</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>High</td>
</tr>
<tr>
<td>Caple &amp; Moody³⁵</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>n.a.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>High</td>
</tr>
<tr>
<td>Dababneh et al.³⁶</td>
<td>n.a.</td>
<td>+</td>
<td>+</td>
<td>n.a.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>High</td>
</tr>
<tr>
<td>Genaidy et al.³⁷</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>n.a.</td>
<td>+</td>
<td>-</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>High</td>
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<tr>
<td>Jones⁴¹</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>n.a.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>High</td>
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<tr>
<td>Moore &amp; Garg⁴⁰</td>
<td>-</td>
<td>-</td>
<td>?</td>
<td>-</td>
<td>n.a.</td>
<td>+</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>High</td>
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<tr>
<td><strong>Q fever</strong></td>
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<tr>
<td>Ackland et al.³³</td>
<td>?</td>
<td>+</td>
<td>-</td>
<td>n.a.</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>-</td>
<td>+</td>
<td>High</td>
</tr>
<tr>
<td>Gilroy et al.³⁸</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>?</td>
<td>?</td>
<td>-</td>
<td>High</td>
</tr>
<tr>
<td>Marmion et al.³⁹</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>High</td>
</tr>
</tbody>
</table>

1. Was selection of exposed and non-exposed cohorts drawn from the same population?  
2. Can we be confident in the assessment of exposure?  
3. Can we be confident that the outcome of interest was not present at the start of the study?  
4. Did the study match exposed and unexposed persons for all variables that are associated with the outcome of interest or did the statistical analysis adjust for these prognostic variables?  
5. Can we be confident in the assessment of the presence or absence of prognostic factors?  
6. Can we be confident in the assessment of the outcome?  
7. Was the follow-up of cohorts adequate?  
8. Were co-interventions similar between groups?  
9. Were all the outcomes of interest described in pre-specified ways?  
+ = low risk of bias; - = high risk of bias; ? = unclear risk of bias; n.a. = not applicable.

**Q fever vaccination**

Four studies reported on the effectiveness of Q fever vaccination by means of Q-Vax administration³²,³³,³⁸,³⁹. One retrospective cohort study reported the incidence of Q fever among vaccinated and unvaccinated employees (0.05 and 1.3 cases / 1,000 exposure months)³³. A second cohort study reported a prevalence of 0% among vaccinated and 43% among unvaccinated employees³⁸. Another open trial study reported a prevalence of 0.2% among vaccinated and 4% among unvaccinated employees³⁹. The RCT reported an incidence
of 0% among vaccinated and 7% among unvaccinated employees. This study was terminated when the stopping criterion (six Q fever cases) was reached. Some cases of Q fever amongst vaccinees were detected, but they were all reported in employees vaccinated during the incubation period of a natural attack. Apart from these cases, the studies demonstrated 100% effectiveness of vaccination against Q fever. In addition, one study showed that the number of sick days differed significantly between the intervention and control group: zero days versus a median of seven (range 1-23) days.

**Quality of evidence**

The quality of evidence was graded for three outcomes: ratings of perceived discomfort as a result of added rest breaks, prevalence of eczema after a skin protection intervention, and Q fever prevalence after Q-Vax administration (Table 4).

Two non-randomized intervention studies addressed ratings of perceived discomfort. Both studies displayed a high risk of bias which led to downgrading of the quality of evidence. Furthermore, there were no other factors that weakened the quality of evidence. Overall, there is very low quality evidence for the effectiveness of added rest breaks on ratings of perceived discomfort among meat processors.

Eczema prevalence was addressed by three articles on one RCT. The RCT displayed a high risk of bias, which led to downgrading of the quality of evidence. No other factors weakened or strengthened our confidence in the study findings. Therefore, the overall quality of evidence for prevention of skin disorders is moderate.

Q fever incidence was addressed by one RCT. This study displayed a high risk of bias which led to downgrading of the quality of evidence. On the other hand, the effect was strong, which strengthened the confidence in the results. No other factors weakened or strengthened our confidence in the study findings. Overall, there is high quality evidence for strong effectiveness of Q fever vaccination.
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Table 4 Quality of evidence of outcomes addressed by multiple articles.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Number of articles (RCT/NRI)</th>
<th>Initial quality</th>
<th>Risk of bias</th>
<th>Indirectness</th>
<th>Inconsistency</th>
<th>Imprecision</th>
<th>Publication bias</th>
<th>Effect size</th>
<th>Dose-response gradient</th>
<th>Confounding</th>
<th>Overall quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratings of perceived discomfort</td>
<td>2 (0/2)</td>
<td>++</td>
<td>2 High risk</td>
<td>No serious indirectness</td>
<td>No serious inconsistency</td>
<td>No serious imprecision</td>
<td>No indications for publication bias</td>
<td>Results pointing in the same direction</td>
<td>No dose-response gradient</td>
<td>Residual confounding</td>
<td>Very low quality</td>
</tr>
<tr>
<td>Eczema prevalence</td>
<td>3 (1/0)</td>
<td>+++</td>
<td>High risk</td>
<td>No serious indirectness</td>
<td>No serious inconsistency</td>
<td>No serious imprecision</td>
<td>No indications for publication bias</td>
<td>No large effect size</td>
<td>No dose-response gradient</td>
<td>Residual confounding</td>
<td>Moderate quality</td>
</tr>
<tr>
<td>Q fever prevalence</td>
<td>1 (1/0)</td>
<td>+++</td>
<td>High risk</td>
<td>No serious indirectness</td>
<td>No serious inconsistency</td>
<td>No serious imprecision</td>
<td>No indications for publication bias</td>
<td>The study shows strong results</td>
<td>No dose-response gradient</td>
<td>Residual confounding</td>
<td>High quality</td>
</tr>
</tbody>
</table>

RCT: randomized controlled trial; NRI: non-randomized intervention study. ++++: high quality evidence; +++: moderate quality evidence; ++: low quality evidence; +: very low quality evidence; -1: quality of evidence is downgraded by one +; +1: quality of evidence is upgraded by one +.
Chapter 2

DISCUSSION

Main findings

The objective of this review was to describe the effectiveness of preventive occupational health interventions in the meat processing industry on work- and health-related outcomes. Three intervention types were identified: ergonomics programs (workplace health & safety; added rest breaks), skin protection, and Q fever vaccination. Due to the small number of studies and the high risk of bias for each study, the quality of evidence was limited. First, four studies on workplace health and safety programs provided low-level evidence for their effectiveness in reducing injury severity, injury costs, and lost work days. Second, two studies provided very low-quality evidence that rest break schedules were effective to reduce ratings of perceived discomfort in various body regions at the end of a workday. One study, with a high risk of bias, showed that added rest breaks were effective to improve productivity at the end of a workday. Third, one study provided moderate-quality evidence that skin protection was effective to reduce eczema prevalence. Fourth, one RCT provided high-quality evidence for strong effectiveness of Q fever vaccination. The results of the RCT were confirmed by three non-randomized intervention studies.

Comparison with other research

In agreement with our findings, one study showed that sickness absence, in a variety of occupational settings, was seemingly reduced by programs promoting both healthy lifestyle and ergonomics, although the quality of evidence was weak. Partial evidence for a reduction of sick days due to MSDs, as a result of participatory ergonomics in various work settings, was provided by another review.

Low-quality evidence was reported for no effect of added rest breaks on discomfort ratings (neck, upper limb) at the end of a workday in office workers. These results are contradictory to the findings in this review, which may be explained by a difference in workers; only blue-collar workers were included in this review, whereas Hoe et al. presented results from white-collar workers. The difference may be caused by variations in adjustment latitude, since white-collar workers normally have better opportunities to take added rest breaks. Interestingly, activities during added rest breaks appeared to be similar
The objective of this review was to describe the effectiveness of preventive occupational health interventions in the meat processing industry on work- and health-related outcomes. Three intervention types were identified: ergonomics programs (workplace health & safety; added rest breaks), skin protection, and Q fever vaccination. Due to the small number of studies and the high risk of bias for each study, the quality of evidence was limited. First, four studies on workplace health and safety programs provided low-level evidence for their effectiveness in reducing injury severity, injury costs, and lost work days. Second, two studies provided very low-quality evidence that rest break schedules were effective to reduce ratings of perceived discomfort in various body regions at the end of a workday. One study, with a high risk of bias, showed that added rest breaks were effective to improve productivity at the end of a workday. Third, one study provided moderate-quality evidence that skin protection was effective to reduce eczema prevalence. Fourth, one RCT provided high-quality evidence for strong effectiveness of Q fever vaccination. The results of the RCT were confirmed by three non-randomized intervention studies.

Previously, a review was performed on interventions for the prevention of occupational irritant hand dermatitis (OIHD). Our results seem to confirm their findings, although the study included in our review mainly focused on educational activities regarding the use of creams, moisturizers, and protective gloves. Furthermore, the other review only looked at populations where OIHD was not present, whereas in the population in our review, OIHD was present in a proportion of workers.

The effectiveness of Q fever vaccination looks very promising. This finding is confirmed, but mitigated, by a recent review on Q fever vaccination, although that review was partially based on the same studies we included. However, Delsing et al. have stated that infection remains asymptomatic in about 60% of patients. In patients that do present with symptoms, these symptoms are very non-specific, which may both lead to underreporting of Q fever. This may, in turn, lead to an overestimation of the relative, but probably not the absolute, effectiveness of Q fever vaccination.

Within our search, no studies were identified on interventions addressing prevention of hearing loss in the meat processing industry. A report by the Dutch Labor Inspectorate reported noise levels of over 85 dB(A) in slaughterhouse production rooms. Long-term exposure to noise levels above 80 db(A) can result in noise deafness. Two Cochrane reviews summarized interventions on noise-level reduction and protection. Low-quality evidence for the reduction of noise levels as a result of stricter legislation was reported. Protective hearing devices may be effective, when training is received and they are used properly. Based on these reviews, it is assumed that such regulations may be useful in the meat processing industry.
Chapter 2

Next to the studies included in this review, two by the authors known studies are currently being performed in the meat processing industry; one on participatory ergonomics\(^50\) and one on sustained employability\(^51\). The results of these studies will add to the knowledge base of (effective) interventions in the meat processing industry.

**Strengths and limitations of the review**

To our knowledge, this is the first review on occupational health interventions in the meat processing industry. Most health intervention research so far has been conducted among white-collar workers\(^3,52\), and relatively little is known about the effectiveness of occupational health interventions among blue-collar workers. This review presents some evidence for the effectiveness of a variety of workplace interventions. From a practical (i.e., industry) point of view, this is a particular strength, because the review presents interventions that not only address employee health, but also employability. From a scientific point of view this might be considered a drawback, since the diversity of interventions makes it more difficult to synthesize evidence and draw uniform conclusions.

There are some limitations to this systematic review that deserve attention. Although an elaborate search strategy was used, we may have missed relevant studies. Next, approximately 130 articles were excluded on language criteria. Although the majority would most probably have been excluded on other criteria as well, we cannot rule out the fact that we might have missed relevant studies.

**Conclusion and implications for practice and future research**

The interventions described in this review were mainly aimed at primary prevention. They addressed skin protection, Q fever vaccination, and workplace health and safety programs. High-quality evidence was found for the effectiveness of Q fever vaccination, moderate-quality evidence for the effectiveness of skin protection on eczema prevalence, and low-quality evidence for the effectiveness of added rest breaks on ratings of perceived discomfort. For the other outcomes, the overall low quality of evidence was determined by the fact that they were addressed by single non-randomized intervention studies with high risk of bias. This calls for more robust studies on work- and health-related outcomes (e.g., absenteeism, productivity) in the meat processing industry. Several outcomes of various
interventions were described in this review. On one side, this demonstrates the wide applicability of occupational health interventions. On the other side, this makes it difficult to compare various studies. We therefore postulate that future effectiveness evaluation studies use similar outcomes.

It is surprising that only part of the interventions addressed physical aspects of the work. Considering the fact that the work in the meat processing industry is physically demanding, it seems plausible that future interventions focus more on these physical aspects. Preventive interventions might not only benefit the employee by early detection of and protection from possible health risks, they may benefit employers as well by reducing absenteeism and health-care costs.

Occupational health interventions might be effective as a whole, but also parts of them may be effective. Therefore, it seems valuable to first evaluate the needs of employees and then select intervention components that fit these needs. Employers should not restrict themselves to interventions described in this review, but also look for interventions outside the boundaries of the meat processing industry and tailor these to their own needs.
Chapter 2

REFERENCES


Chapter 2


Chapter 3

OBJECTIVE COMPARISON OF ENERGETIC WORKLOAD AND CAPACITY IN OLDER PRODUCTION WORKERS: A PILOT STUDY

Submitted

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