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Review Article

Essential Occupational Safety and Health Interventions for Low- and Middle-income Countries: An Overview of the Evidence

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ABSTRACT

There is still a considerable burden of occupational diseases and injuries in the world. It is not well known which interventions can effectively reduce the exposures at work that cause this burden. The objective of this article is to summarize evidence from systematic reviews of interventions to prevent occupational diseases and injuries. We included systematic reviews of interventions to reduce the incidence of work-related cancer, dust-related diseases, occupational asthma, chronic obstructive pulmonary disease, noiseinduced hearing loss, back pain, and occupational injuries. We searched Medline and Embase with predefined search strategies to locate systematic reviews of these interventions. We found 23 systematic reviews of which the results are also applicable to low- and middle income countries. Effective measures to reduce exposure leading to work-related cancer, dust-related diseases, asthma, chronic obstructive pulmonary disease, noise, and injuries are available. However, better implementation of these measures is needed. Regulation, enforcement of regulation, and incentives for employers are effective interventions to achieve this goal. There is evidence that feedback and rewards for workers help in reducing occupational injuries. There is no evidence in many studies that back pain can be prevented. Personal protective equipment technically has the potential to reduce exposure but this is difficult to put into effect. There is no evidence in the studies regarding the effectiveness of education and training, preventive drugs, or health examinations. There is evidence that the implementation of technical measures enforced by regulation can prevent occupational diseases and injuries. For other interventions such as education or health examinations, there is no evidence that supports their effectiveness. More systematic reviews are needed in the area of injury prevention.

1. Introduction

Experts estimate that less than 15% of the global workforce has some coverage with occupational health services [1]. Even though this number is probably not very accurate owing to problems with definitions, it does reflect that coverage is not very high [2]. Therefore, the 60th World Health Assembly in 2007 urged the 193 member states of the World Health Organization (WHO) to work toward full coverage with essential interventions and basic occupational health services, particularly in agriculture, small- and medium-size enterprises, the informal economy, and migrant workers. The WHO was requested to provide guidance to countries on basic packages, tools, working methods, and models of good practices for occupational health services and to stimulate international efforts for capacity building as part of the Global Plan of Action on Workers' Health 2008–2017 [3].

The range of the interventions addressing occupational and work-related diseases and injuries may include both clinical (e.g., health examinations) and nonclinical interventions (e.g., workplace risk assessment). The interventions can be categorized as preventive and treatment interventions, wherein preventive interventions are usually offered to persons unsolicited and without symptoms urging them to seek help. Preventive interventions, in turn, are classified as primary, secondary, or tertiary prevention. Primary preventive interventions aim at preventing disease or injury outcomes before the disease or injury process has started, whereas

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other preventive interventions address later stages. In occupational health, primary preventive interventions aim at eliminating and decreasing exposure known to be hazardous to health or to create a barrier to exposure by means of vaccination.

The mechanism behind primary preventive occupational health interventions is that they cut the causal chain between exposure at work and the resulting occupational disease or injury (Fig. 1) [4]. These interventions can be categorized into three major classes: environmental, behavioral, and clinical [5]. Environmental interventions aim at changing the working environment such as eliminating the source of noise in a workplace to prevent noise-induced hearing loss. Behavioral interventions focus on individual workers' behavior to eliminate exposure such as promoting the use of personal protective equipment. Clinical interventions use a clinical method to prevent disease such as preemployment health examinations or drugs. For environmental interventions, it is important to make a distinction between technical feasibility under laboratory conditions and the effect of these interventions under field conditions, which can vary widely. The results of field studies of the implementation of technical environmental interventions have been disappointing, probably because it has been underestimated how difficult it is to engage employers and management in workplace improvements. After all, they are the crucial decision-makers who are responsible for workplace health and safety policy [6–8].

Many countries have already in place some form of basic occupational health services to deliver essential interventions for the prevention of occupational and work-related diseases and injuries. However, it is not well known what evidence exists for the effectiveness of these interventions. Roelofs et al reviewed the control strategies for chemical hazards, and they concluded that despite their theoretical primacy, primary prevention strategies are not commonly considered in practice [9]. To be better able to develop guidance on essential primary preventive occupational health and safety interventions, evidence of their effectiveness is needed. The WHO is especially interested in evidence for essential interventions in basic occupational health services targeted at underserved working populations with constrained resources and integrated in primary health care. The first step in this process of guidance development is to locate systematic reviews that have synthesized the evidence available from primary studies.

Based on available systematic reviews, we report in this article what evidence is available for the effectiveness of the most essential occupational health interventions for primary prevention of work-related diseases and injuries in agriculture, small- and medium-sized enterprises, and the informal economy across WHO regions.

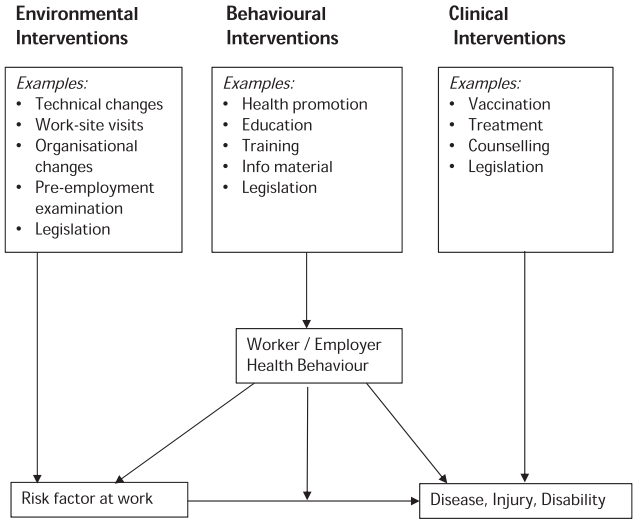

Fig. 1. Model of primary preventive occupational health interventions.

2. Materials and methods

2.1. Essential primary preventive occupational health interventions

We defined essential primary preventive occupational health interventions as interventions that aim at eliminating occupational exposures with the biggest impact on the global burden of occupational diseases and injuries. We took the diseases and injuries mentioned in the WHO global burden of occupational disease report as the point of departure [10,11]. Next, we determined which exposures lead to these diseases and injuries [12]. This resulted in a limited list of exposures that should be addressed by essential interventions (Table 1).

When doing so, we kept in mind that the target group consists of workers in small businesses in low- and middle-income countries, especially in agriculture, and the so-called "informal sector". Virtually all exposure to asbestos, silica, and welding fumes occurs through inhalation. Also, prevention of pneumoconiosis occurs through prevention of inhalation exposure as does prevention of occupational asthma and chronic obstructive pulmonary disease (COPD). Therefore, we focused on inhalation exposure prevention.

We defined systematic reviews as reviews of the literature that had a clearly formulated question and searched at least one electronic database.

2.2. Search strategy

To locate occupational safety and health intervention studies, we used the search strategy developed by the Cochrane Occupational Health Field, and for systematic reviews we used the search strategy developed by the Perosh Systematic Clearing House Working Group (www.perosh.eu) [39]. We combined these search strategies with search words for the exposure of interest. We searched first in Medline through PubMed and then in Embase through OvidSP to see if any additional systematic reviews could be located (Appendix 1). We did not apply any language restrictions. We did not search any other databases because we felt that the yield of searching other databases would not outweigh the effort needed to adapt the search strategy. Moreover, we expect that systematic reviews of some quality will be published in journals indexed in one of the major databases.

2.3. Data analysis

From the references found, we selected those that were likely to fulfill our inclusion criteria and assessed inclusion from the full-text article again. Because our review question was very broad and we included all kinds of reviews, we did not attempt to provide quantitative estimates of risk reduction. We present the results as the existence of systematic reviews and if existing reviews provide evidence of effectiveness of the intervention or not or that no studies were reported.

2.4. Funding source

The funding organization did not have any influence on the design, execution, and analysis of the study, nor on the decision to submit the paper for publication.

Table 1
Overview of preventive occupational health interventions and the evidence for their effectiveness from systematic reviews

Work-related disorder to be prevented	Risk factors to be addressed	Types of interventions		
		Environmental	Behavioral	Clinical
Cancer	Asbestos Silica Welding fumes (cadmium, chrome, nickel) Inhalation exposure Prevention	Technical measures [13–15]: - Substitution † - Enclosure § - LEV ‖ - Special ventilation ‖ - General ventilation § - Suppression ‖ - Separation ‖	Respiratory protection: - Technical properties* - Implementation*	Preemployment examination † [20] Medication to prevent cancer ‡ [21]
Pneumoconiosis Asthma	Coal dust HMW biological agents	Implementation measures [16–19]: - Regulation § - Incentives †		
COPD	LMW chemical agents Nonspecific dusts and fumes			
Noise-induced hearing loss	Sound levels above 80 dB(A)	Technical measures [22] Hearing loss prevention program ‡ Implementation measures [22] - Regulation § - Incentives*	Hearing Protection: - Technical properties [22] Without instruction † With instruction ‖ - Implementation [23] School-based § Work-based †	Preemployment examination* Drugs*
Back pain	Ergonomic risk factors: Manual material handling, bending and twisting, heavy physical load, static work posture.	Technical measures [24,25] - Ergonomics ‡ - Maximum weight lift* Implementation measures*	Aids [26,27]: - Technical properties* - Implementation ‡ Instruction manual material handling/lifting ‡ [26–30] Incentives*	Preemployment examination ‡ [20]
Injury prevention	Hazardous situations at work	Technical measures - Fall Prevention* - Other measures* - Rollover protection § [31] Implementation measures: [31–33] - Regulation † - Experience rating ‖ - Enforcement § - Inspections § - Penalties ‖ - Subsidies*	Safety equipment: - Technical measures* - Implementation* Education ‡ / training † [31,34–37] Education agriculture ‡ Safety Climate* Worker Incentives [38] - Monetary § - Praise and feedback § - Team competitions §	Preemployment examination ‡ [20]

* No evidence such as systematic reviews found.
† Evidence available and some indication of effectiveness.
‡ Evidence available but no indication of effectiveness.
§ Evidence available and indication of effectiveness.
‖ Evidence available and strong indication of effectiveness.
COPD, chronic obstructive pulmonary disease; HMW, high molecular weight; LEV, local exhaust ventilation; LMW, low molecular weight.

3. Results

3.1. Results of the searches

The search for reviews of interventions for reducing exposure to agents that cause work-related cancer, pneumoconiosis, silicosis, COPD, or asthma did not return any systematic reviews. We assumed that this was attributable to the different vocabulary used in occupational hygiene studies and the lack of a systematic review tradition. Therefore, we revised the search for these agents into prevention of inhalation exposure, dust control, and respiratory protection. This yielded 378 references. For noise exposure, we found 157 references, for biomechanical exposure and back pain 356 references, and for injury prevention 229 references. Preemployment examinations yielded 60 references. Medline was searched up to March 2011. Searching in Embase did not yield additional references. Selection of the references based on the criteria of a systematic review and the reduction of the appropriate exposure resulted in 23 systematic reviews published between 1989 and 2010 included in this overview.

3.2. Results of systematic reviews

Table 1 summarizes the evidence in the systematic reviews that we found.

3.3. Interventions for preventing work-related cancer, pneumoconiosis, COPD, and asthma

3.3.1. Environmental interventions: technical measures

Fransman et al summarized the effectiveness of what they called "risk management measures" based on 90 studies that compared the exposure with and without control measures [13]. The average percentage exposure reduction for the various control measures was as follows: enclosure [50%; 95% confidence interval (CI), 4–74%], local exhaust ventilation (82%; 95% CI, 78–84%), specialized

ventilation systems (87%; 95% CI, 73–94%), general ventilation (43%; 95% CI, 17–61%), dust suppression techniques (83%; 95% CI, 77–88%), segregation of sources (no studies), separation of the worker (87%; 95% CI, 71–94%).

Substitution of latex in surgical gloves was reported to be effective in reducing occupational asthma in one review [14]. This was also the conclusion of a review of case studies of asthma prevention [15].

There were no systematic reviews of exposure reduction in welding.

3.3.2. Environmental interventions: implementation measures

Creely et al summarized 25 papers of trends in inhalation exposure with the aim of finding the factors responsible for the changes over time [16]. Across studies, the average yearly decrease in exposure was between 7% and 15% for various chemical agents. Regulatory changes were mentioned most often as the reason for decline of exposure. Other reasons were implementation of occupational health programs, changes in production equipment or methods, and installation of controls. Another review on the time trends in exposure to metal working fluids between 1949 and 2007 came to the same conclusions [17]. Symanski et al reported a yearly exposure decline between 5% and 60% for various geographical regions [18].

Elsler et al reviewed case studies of economic incentives in various European countries and concluded that they can be an effective strategy for improving occupational health [19].

3.3.3. Behavioral interventions

We found no systematic reviews of the effectiveness of respiratory protection under field circumstances. Given all the practical constraints for proper use, it seems unlikely that respiratory protection can be an effective measure of control of inhalation exposure in low- and middle-income countries [40,41].

3.3.4. Clinical interventions

The effectiveness of preemployment examinations has been debated for a long time [42]. Most authors have argued against their effectiveness based on the argument that the tests used in practice are not specific enough. A Cochrane systematic review found one study that showed a positive effect of incorporating a bronchial challenge test in the preemployment examination for workers in the aluminum industry to decrease occupational asthma [20]. Another Cochrane review concludes that there is currently no evidence to support the use of vitamins such as alpha-tocopherol, beta-carotene or retinol, alone or in combination, to prevent lung cancer. On the contrary, this could be harmful [21].

3.4. Interventions for preventing occupational noise-induced hearing loss

3.4.1. Environmental interventions: technical measures

One systematic review found contradictory evidence in 14 studies that hearing-loss prevention programs are effective in the long term. Even though case studies show that substantial noise reductions can be achieved, there is no evidence that this is realized in practice [22]. Studies on the short-term effects of hearing protectors showed that these can reduce noise levels sufficiently but only if they are worn properly.

3.4.2. Environmental interventions: implementation

The same review located one study on new legislation that found that the median noise level decreased by 28 dB immediately after the introduction of legislation [22].

3.4.3. Behavioral interventions

One Cochrane systematic review found three studies showing evidence that school-based and work-based interventions can enhance the use of hearing protection [23].

3.4.4. Clinical interventions

We found no reviews.

3.5. Interventions for back pain prevention

3.5.1. Environmental interventions

A review on the effectiveness of participatory ergonomic interventions included seven studies with mixed results, but the authors concluded that participatory interventions are effective [24]. A more recent review of ergonomic interventions to prevent back pain in workers included 10 randomized controlled trials (RCTs) and concluded that these interventions were no more effective than no intervention [25].

The U.S. National Institute for Occupational Safety and Health has presented a simple assessment tool that can be used to assess a recommended weight limit [43]. We found no systematic reviews of its effects on back pain.

3.5.2. Behavioral interventions

Van Poppel et al found six RCTs of education for correct lifting, but these contained no evidence of a preventive effect on back paim [44]. Since then, several reviews have addressed the effectiveness of manual material handling advice to prevent back pain [26–30]. They are mostly based on the same studies, and all conclude that training in manual handling of patients or materials does not lead to a reduction of back pain or back injury.

3.5.3. Clinical interventions

A Cochrane review found three studies that used a functional capacity evaluation test in applicants for jobs with high physical work load, but the studies led to contradictory effects on musculoskeletal injuries [20]. All studies led to an increase in rejected applicants.

3.6. Interventions for prevention of injuries

3.6.1. Environmental interventions: technical measures

There were no systematic reviews of the effects of interventions such as guarding to prevent entanglement in machines or preventing falls from roofs [45].

3.6.2. Environmental interventions: implementation

Tompa et al reviewed the effectiveness of incentives used by insurance and in regulation [32]. They found that experience rating decreased injuries, an observation that was also reported in another review [31]. It was unclear if introduction of regulation decreased injuries. Enforcement of regulation, however, resulted in a lowering of the injury rate. The authors warn for the possibility of so-called perverse incentives. Another Cochrane review did not find evidence in three studies that regulatory interventions were effective in construction industry [33]. In again another review, legislation requiring rollover protective structures on new tractors was associated with a decrease in fatal injuries, but the same requirement for existing tractors showed no effect [31].

3.6.3. Behavioral interventions

Cohen et al found five studies on the effects of training on injuries in 1998. Of these studies, four reported a reduction of injuries, and one study reported no effect [34]. In 2010, this review was updated, but then the authors concluded that there was

insufficient evidence that training improved health outcomes [35]. Another review concluded that the effectiveness of training depends on the engagement of workers in the training [36].

A review of educational interventions to prevent childhood farm injuries included 23 studies, but none showed a reduction of injuries [37]. Another review of educational interventions in agriculture did not find an effect on injury rates in three RCTs of adults (Relative Risk = 1.02; 95% CI, 0.87−1.20) or in two RCTs of children [31]. In the construction industry, another Cochrane review reported an effect of both a safety campaign and a drug-free workplace program on nonfatal injuries [33].

An older review of the use of incentives and feedback to enhance workplace safety summarized 24 studies and reported that monetary incentives, praise and feedback, and team competitions were effective in reducing injuries [37]. Even though it has been shown that there is a strong relationship between safety climate in a company and the injury rate, we found no reviews on safety climate interventions for reducing injuries [46].

3.6.4. Clinical interventions

A Cochrane review on preemployment examinations included two studies that aimed at preventing injuries [20]. There was low-quality evidence that workplace accommodations and worker training for those at risk reduced potential risks.

4. Discussion

To reduce the burden of work-related cancer, pneumoconiosis, COPD, and asthma, many technical preventive interventions are available. Regulation and incentives for employers are probably one of the main causes of inhalation exposure reduction in the industrialized world in the past 40 years. Even though personal protective equipment can reduce exposure in a technical sense, there are many practical barriers that impede its effectiveness in practice. Hearing loss prevention programs are not sufficiently protective, but regulation and enforcement can help to reduce noise levels in workplaces. There is no evidence in the available studies that back pain can be prevented by training and education, by ergonomic improvements, or by preemployment examinations. For preventing injuries, technical hazard controls such as rollover protection structures on tractors can reduce fatal injuries, but for most technical controls there are no studies or no systematic reviews. Incentives such as feedback and rewards for workers improve safety behavior and probably reduce injuries; however, there were no systematic reviews of measures to improve the safety climate in a company. Education and training to prevent injuries produced mixed results with some reviews providing evidence of effectiveness, whereas other reviews showed none.

One of the strong aspects of this study is that it used a systematic approach to primary prevention of occupational diseases and injuries. We followed the global burden of disease approach and used a theoretical framework to underpin a general intervention approach of environmental, behavioral, and clinical interventions. This allowed for a broader view on prevention than just medical studies. This justified our focus on exposure prevention both from the viewpoint of occupational hygiene and from the viewpoint of occupational medicine. This also allowed us to consider more concrete interventions such as local exhaust ventilation and preemployment examination, especially compared to a more general approach usually adopted in occupational medicine such as health surveillance or workplace health surveillance.

The limitations of this study are that, because of the diversity of reviews, we could not assess the quality of the evidence and that we could not more concretely provide specific effect sizes for the included interventions. However, we do not expect that a more precise assessment would have altered our conclusions. There are still many white spots where there is no or little evidence available. In the field of occupational injury prevention, in particular, systematic reviews of technical measures to prevent injuries are missing. This might be attributable to the technical nature of the interventions and little attention paid to the implementation of these measures.

For general interventions such as education and training or inhalation exposure prevention, it is difficult to search the literature. The reason is that some authors use specific terms, for example, “correct lifting postures”, whereas others use general terms such as “training to prevent back pain.” When searching for general interventions, it is easy to overlook the specific ones. That this happens in reality can be inferred from the differences between studies that reviewed all training and education interventions versus those on manual material handling advice to prevent back pain.

It can be that we have overlooked reviews in specific areas such as injury prevention or occupational hygiene because the terminology used is different from that in occupational medicine. However, we believe that by thoroughly looking at the occupational hygiene literature this bias is minimized.

There were only a few studies that evaluated the specific difficulties of small- and medium-sized enterprises that form the majority of the enterprises and employ most workers. The available studies show that specific approaches for these enterprises are needed and that general implementation measures may not suffice.

We found only one other overview of the effectiveness of primary preventive occupational safety and health interventions that included 17 reviews. Its focus was more on stress and health promotion than on chemical hazards and injuries as was done in this study. For ergonomics and training and education, they used similar reviews as we did and they came to similar conclusions. The lack of a proper theoretical framework makes their study difficult to compare to ours [47].

4.1. Implications for practice

Many technical interventions are available that can have a major impact on the global burden of work-related cancer, asthma, COPD, noise, and injuries. Better implementation of interventions by regulation and enforcement is needed to realize this potential. The available reviews do not provide evidence that back pain can be prevented. Personal protective equipment has technical potential to reduce exposure but it is difficult to realize. General education and training probably do not lead to substantial reductions of occupational diseases and injuries. Feedback and rewards probably help in reducing occupational injuries. Clinical interventions such as drugs and health examinations have little to offer for primary prevention of occupational diseases and injuries.

4.2. Implications for research

More and better systematic reviews of primary studies of injury prevention are needed. Better focused questions will enable reviewing the literature on effectiveness of essential occupational safety and health interventions. Interventions to implement measures for exposure reduction should be better evaluated.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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Appendix 1

1. General search strings used in Pubmed to find occupational health systematic reviews

COHF: work

((effect[tw] OR control[tw] OR controls*[tw] OR controla*[tw] OR controle*[tw] OR controli*[tw] OR controll*[tw] OR evaluation*[tw] OR program*[tw] OR prevention*[tw] OR protect*[tw]) AND (work[tw] OR works*[tw] OR work'*[tw] OR worka*[tw] OR worke*[tw] OR workg*[tw] OR worki*[tw] OR workl*[tw] OR workp*[tw] OR occupation*[tw]) NOT animals[mh])*

Perosh: systematic review

(meta-analysis[mh] OR meta-analysis[pt] OR meta-analysis[tiab] OR review[pt] OR review[tiab]) NOT (letter[pt] OR editorial[pt] OR comment[pt]) NOT ((animals[Mesh:noexp]) NOT (humans[Mesh]))

We combined these two with words for specific exposures, for example, beryllium.

2. Search for Preemployment examinations *3.3.2011*

("Pre-employment" OR "fitness for work") AND Perosh systematic review search
Resulted in 60 references.

2. Inhalation exposure 26.2.2011

"inhalation exposure" AND (occupation OR worker*)* AND meta-analysis
Resulted in 256 references.

3. Dust control 26.2.2011

"dust control" AND Perosh systematic review
Resulted in 25 references.

4. Respiratory protection

Respiratory protection[mh] AND Perosh systematic review
Resulted in 97 references.

5. Noise *2.3.2011*

Noise, occupational[mh] AND Perosh systematic review
Resulted in 157 references searched from 1990 to 2011.

6. Back Pain 26.2.2011

Back Pain[MH] AND COHF strategy *AND* Perosh Systematic Review
Resulted in 356 references.

7. Injury prevention

(injur OR accident*) AND* COHF strategy *AND* Perosh systematic review
Resulted in 229 references.

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