

ORIGINAL RESEARCH

Evaluation Studies on Education in Occupational Safety and Health: Inspiration for Developing Economies

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Abstract

BACKGROUND Education and training of students, workers, and professionals are essential for occupational safety and health (OSH). We noticed a lack of debate on how to advance coverage and quality of OSH education given high shortages in developing economies.

OBJECTIVES International discussion on future options might be stimulated by an overview of recent studies.

METHODS We employed a search of the Cochrane Library and PubMed/MEDLINE databases for articles from the last decade on evaluation of OSH education.

FINDINGS We selected 121 relevant studies and 6 Cochrane reviews. Most studies came from the United States, Western Europe, and Asia. Studies from low-income countries were scarce. From a global perspective, the number of evaluation studies found was disappointingly low and the quality needs improvement. Most commonly workers' education was evaluated, less often education of students, supervisors, and OSH professionals. Interactive e-cases and e-learning modules, video conferences, and distance discussion boards are inspiring educational methods, but also participatory workshops and educational plays. Ways to find access to underserved populations were presented and evaluated, such as educational campaigns, farm safety days, and OSH expert-supported initiatives of industrial branch organizations, schools, and primary, community, or hospital-based health care. Newly educated groups were immigrant workers training colleagues, workers with a disease, managers, and family physicians.

CONCLUSIONS Developing economies can take advantage of a variety of online facilities improving coverage and quality of education. Blended education including face-to-face contacts and a participatory approach might be preferred. For workers, minor isolated educational efforts are less effective than enhanced education or education as part of multifaceted preventive programs. Collaboration of OSH experts with other organizations offers opportunities to reach underserved worker populations. Increasing international collaboration is a promise for the future. National legislation and government support is necessary, placing OSH education high on the national agenda, with special attention for most needed professionals and for underserved workers in high-risk jobs such as in the informal sector. International support can be boosted by a high-level international task force on education and training, funded programming, and a global online platform.

KEY WORDS education, training, occupational health, safety, evaluation, developing economies, developing countries

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INTRODUCTION

A Need for Education and Training. A recent overview of global working conditions and adverse effects on health and safety presented as World Health Organization (WHO) and International Labor Office (ILO) conclusions that of all fatalities in industrial countries, some 5%–7% are attributed to work-related illnesses and occupational injuries. The economic cost is equivalent to a range of 1.8%–6% of gross domestic product (GDP).¹ Based on the “Workers’ Health: Global Plan of Action” (2007), WHO encourages strongly the education of workers, employers, primary health care practitioners, and professionals for occupational health services. Workers’ health should be integrated in basic training for health care.² It is regarded as a workers’ right in all countries to be well informed, educated, and trained in safety and health at work.

Education in occupational safety and health (OSH) is needed urgently in developing economies.¹ A few examples may serve as illustration. Kumar et al reported about welders in India exposed to flying sparks and particles, ultraviolet radiation, metal fumes, and many other risks. Awareness of hazards and safety precautions was limited and only 20% of them had institutional training.

The authors refer to studies on welders in Saudi Arabia, Pakistan, Nigeria, and South Africa with similar observations and recommend an educational campaign, besides enforcement of safety regulatory measures to control the informal sectors.³ Migrant workers in Oman exposed to pesticides in greenhouses were studied by Esechie et al. Hygiene was poor, personal protective equipment (PPE) was hardly used, and health symptoms were reported frequently. The authors recommend adequate legislation for mandatory PPE provisions and regular training programs.⁴ Education on safe handling of pesticides in a high-risk region in India was evaluated by Sam et al. Knowledge, attitude, and practice improved. They too recommend continuous education and training programs for agricultural workers.⁵

Anderson et al concluded, after studying farmers’ concerns in Alabama, USA, that medical students should be educated in farming practices including

occupational exposures when interested in a rural area practice.⁶ A training course for health care professionals on farmers’ occupational health needs started in Iowa, USA, in 1974 and expanded gradually. This 40-hour course is now also given in Turkey and Australia.⁷ In addition, because only about 10%–15% of the global workforce has access to occupational health services, it is a great challenge to educate large numbers of OSH professionals being experts in OSH prevention and health care tasks. Rantanen et al estimated a global need of 312,000 more OSH experts to be educated.⁸ A tremendous task has to be done in newly industrialized and least developed countries. Delclos et al started a discussion about competencies and curricula in developing and developed countries.⁹ The Occupational Hygiene Training Association (OHTA) created free high-quality e-modules for occupational hygiene and ergonomics to meet a growing demand.¹⁰

Education of Workers Alone Is Insufficient. One of the reasons why improvement of working conditions stagnates is the absence of effective education of workers. Some authors believe that working conditions will improve over the long term when the educated, trained worker becomes an integral part of workplace safety programs.¹¹ Others have strong concerns over the influence of education and training in the real-life situations.¹² We agree that education and training alone cannot solve all problems in health and safety. Just offering education can be an inadequate answer to complex problems when legislation and inspection are needed as well as comprehensive prevention programs in which workers and employers cooperate not only in education but also in improving working conditions and social relationships. On the other hand, health risks and high job demands cannot always be eliminated. High-demand jobs can even be challenging such as teaching adolescents, firefighting, removing asbestos in demolition work, or treating patients with AIDS or Ebola. Therefore, education in how to cope with risks is necessary for many jobs, today and in the future.

Interestingly, education is also a component in new OSH interventions such as on how to retain a job while having a chronic disease as rheumatoid arthritis or serious hearing loss. Workplace health promotion, motivated by epidemics threatening the working population and facilitated by companies accepting social responsibility, can include training such as on how to prevent obesity, cardiovascular diseases, or HIV/AIDS.

¹Most publications in health sciences use the term *developing countries* for all non-high-income countries. Presumably it is more correct nowadays to use the term *newly industrialized countries* to refer to, for example, China, India, Brazil, Turkey, and South Africa. We have chosen the term *developing economies*, aware of still existing problems in terminology.

Information and Education. Education and information are more closely related than in the past. Facilities exist in many countries offering access to reliable online OSH information such as offered by the Canadian Centre for Occupational Health and Safety in Canada.¹³ Online question and answer facilities can be organized gaining both on quality of the information and efficiency^{14,15}; the US National Institute for Occupational Safety and Health (NIOSH) and the European Agency for Safety and Health at Work (EU-OSHA) invested in online interactive risk assessment and control tools,¹⁶ and the International Labor Office (ILO) developed apps for the same goal. Access to reliable online OSH information and tools initiates great opportunities for developing economies, especially when sources are available as m-health on mobile phones and tablets. OSH professionals can be trained in how to find up-to-date, reliable OSH information and tools on the Internet.¹⁷

Target Groups and Lifelong Learning. Various groups of participants need OSH education. First, education is, or should be, organized for students in vocational training learning how to protect themselves in the future. Other students are educated as part of studies at, for example, medical faculties, schools for occupational health nurses, or physiotherapy schools. For them workers' health is a part of future professional practice. Second, we need education of informal workers, formal employees, and the self-employed to learn how to prevent occupational diseases and accidents. Supervisors and managers ought to be educated, which would have a crucial impact on the quality of work of others. In unions and communities, selected workers and leaders may demand training to be a good trainer in OSH. Third, education has to be organized for professionals functioning as experts in OSH and for other professionals who are often challenged by workers' health issues. In most countries, OSH professionals include safety experts, occupational physicians, occupational health nurses, occupational hygienists, ergonomists, and occupational psychologists. Relevant non-OSH professionals can be community health workers, family physicians, dermatologists, pulmonologists, clinical psychologists, physiotherapists, occupational therapists, and human resource managers.

Vocational training in work and health includes or has to be followed by training on the job, to learn essential details and practicalities. Given all kind of changes, education is needed during the whole career. Therefore facilities for lifelong learning,

continuous professional development, and continuing medical education (CME) have to be structured.

Goals and Outcomes. For an evaluation, clear goals and outcomes should be defined. Education of students, workers, and professionals can be directed on gaining knowledge, skills, attitude, self-efficacy, motivation to act, and competencies, described as *immediate outcomes* by Robson *et al.*¹⁸ Behavior, hazard controls, hazards, and exposures are distinguished as *intermediate outcomes*. The *final outcome* or *impact* of education is mostly the improved health or safety of workers as visible in a lower incidence of occupational accidents and diseases. The practice of occupational health care has been extended in many countries, currently including prevention and control of sickness absence and work disability, support of good work functioning, and promotion of healthy lifestyles. Corresponding goals and outcomes are lower work disability pension rates, better functioning at work, and lower rates of obesity, cardiovascular diseases, or HIV/AIDS.

Evaluation of Education, Contribution of Science. Robson *et al.* published a systematic review on the effectiveness of OSH training covering publications from 1996–2007.¹⁸ Studies were reviewed on education of workers related to primary prevention of occupational illnesses and injuries, selecting only pre-post randomized trial studies. Based on 22 studies, strong evidence was found for the effectiveness of training on workers' behaviors but insufficient evidence for effectiveness on health outcomes. A lack of studies with a fair or good methodologic quality resulted in the conclusion of insufficient evidence for studies with “knowledge” or “attitudes and beliefs” as outcomes. For future reviews, it was advised to include also non-randomized studies. A recommendation for practice was to “consider more than just education and training when addressing a risk in the workplace.”

OBJECTIVES

The purpose of this study is different from that of Robson *et al.* Our goal is to stimulate the discussion on policies needed to improve coverage and quality of OSH education in developing economies. Therefore, we decided to investigate evaluation studies presented in the recent international peer-reviewed literature: which countries were active, and what target groups, topics, and outcomes were chosen? Implementation strategies and educational methods evaluated might show us new perspectives to encourage education in developing economies.

Being primarily interested in an overview of recent initiatives, we did not select primarily on a high quality of methodology. Consequently, we did not reconsider the concluded effectiveness of the education presented by the authors. Finally, we reviewed relevant Cochrane studies on their judgment of study quality and effectiveness of OSH education.

For our study we included publications on education in OSH, regardless of subject, level, and method of education, but excluding mere dissemination of information. We often abbreviated “education and training” using only the term “education.” First we present an overview of recent scientific studies on the evaluation of education, limited to publications of the last 10 years accessible via PubMed/MEDLINE and to Cochrane systematic reviews. Second, considerations are given about the findings, followed by recommendations on how to improve coverage and quality of education and training in OSH, especially in developing economies.

METHODS

PubMed Search. For this article we chose to search in PubMed/MEDLINE, considered a database of choice in health sciences. The recall ratio of MEDLINE for high-quality intervention studies in occupational health is close to 90%. Psychiatric and psychological topics are relatively less often indexed in MEDLINE than somatic studies.¹⁹ We searched only for articles in English. In addition, we searched for systematic reviews in the Cochrane Library.

Abstracts published from 2005–2015 (last search date June 20, 2015) were screened to find original studies on evaluation of education in OSH, without selection on participants. A first string of search terms was related to occupational safety and health, a second to education, and a third to evaluation outcome terms.

The search filter was:

(“Chemical Safety”[Mesh] OR “Occupational Injuries”[Mesh] OR “Disability Evaluation”[Mesh] OR “Accidents, Occupational”[Mesh] OR “Return to Work”[Mesh] OR “Occupational Diseases”[Mesh] OR “Occupational Health”[Mesh]) AND (“Learning”[Mesh] OR “Education”[Mesh]) AND (Coverage OR Reach OR Knowledge OR Literacy OR Skills OR Coping OR Attitude OR Competence OR Competenc* OR Self-efficacy OR “Self efficacy” OR PPE OR Participation)

In a next step, we used inclusion criteria to select relevant articles. Selection questions and inclusionary responses are shown in Table 1.

Questions	Inclusionary Response
Is the article written in English?	Yes
Is education or training named as one of the components?	Yes
Is the article presented with abstract?	Yes
Is the study including education, training, or learning as topic of the study?	Yes
Is education related to an outcome in the area of work and health?	Yes
Is the study evaluating the quality or the outcomes of educational interventions?	Yes
Is education delivered through a lesson, training, course, or workshop or as a part of a complex intervention or program?	Yes
Is the study dealing with patient care or with patient education, without work-related topics?	No
Is the article only concluding or recommending that education of workers or professionals is needed?	No

Education or training could be part of a comprehensive intervention but had to be specified as education. Outcomes in the area of work and health could be related to prevention or control of hazards or risks at work; prevention, diagnosis, guidance, or treatment of occupational and work-related diseases, injuries, work disability, or sickness absence; improvement of work functioning; and workplace health promotion.

Cochrane Library Search. We searched the database of the Occupational Safety and Health review group (www.osh.cochrane.org) within the subtopic “occupational health outcomes” (last date: June 26, 2015). We found 101 reviews and 20 protocols. We selected reviews with “education” or “training” in the title or abstract.

Data Extraction and Management. The search results were reviewed for duplicates by the main author. Publications not written in English or without abstract were excluded. Next, selection questions were applied (Table 1). We did not select on

the design or scientific quality of the study. Publications were assessed on the basis of titles and abstracts to gauge their potential relevance. The full text was reviewed to determine the appropriateness for presentation as an example in this paper.

RESULTS

PubMed Search. Using the search filter as described we found 1549 titles. The number of citations per year before 2014 varied between 134 and 218, followed by only 115 and 5 titles in, respectively, 2014 and the first half of 2015. These low scores originated in the MEDLINE database because applying the MeSH terms “occupational health” and “diabetes mellitus” showed similar results. Therefore, we were actually covering around 10 years of publications. Relevant articles were selected in a second step using inclusion criteria, so we could include 121 studies (Fig. 1).

Countries. Most studies were completed in the United States, followed by Japan, 3 European countries, China, and Australia (Table 2). North America generated 46 publications, 35 came from Europe, 26 from Asia, 5 from Australia, 3 from Latin America, and 1 from Africa. Publications by an international group of authors were noted since 2009. There was a lack of studies from Latin America, Eastern Europe, and Africa. Almost no studies came from low-income countries.

Participants and Topics. Different groups of participants and various topics of education were described in the selected publications (Table 3).

Students. Much attention was given to health disciplines. The main goal could be different: nurse students were trained to protect themselves for work-related health effects; medical and pharmacy students to diagnose occupational diseases and intoxications in patients. Compulsory education of medical students to improve the attitude toward occupational health (OH) was evaluated in Brazil and Germany. The education, consisting of lectures and online virtual patient cases, improved self-rated knowledge and interest in OH in both countries.²⁰

In Germany, 521 health care trainees were evaluated after a 3-year training period. The intervention group received a regular training program to prevent irritant contact dermatitis, including evaluation of the hand skin condition. In this group, hand washing was reduced compared with the control group. A significantly better skin condition of the hands was found in the intervention group at the end of the training period than in the control

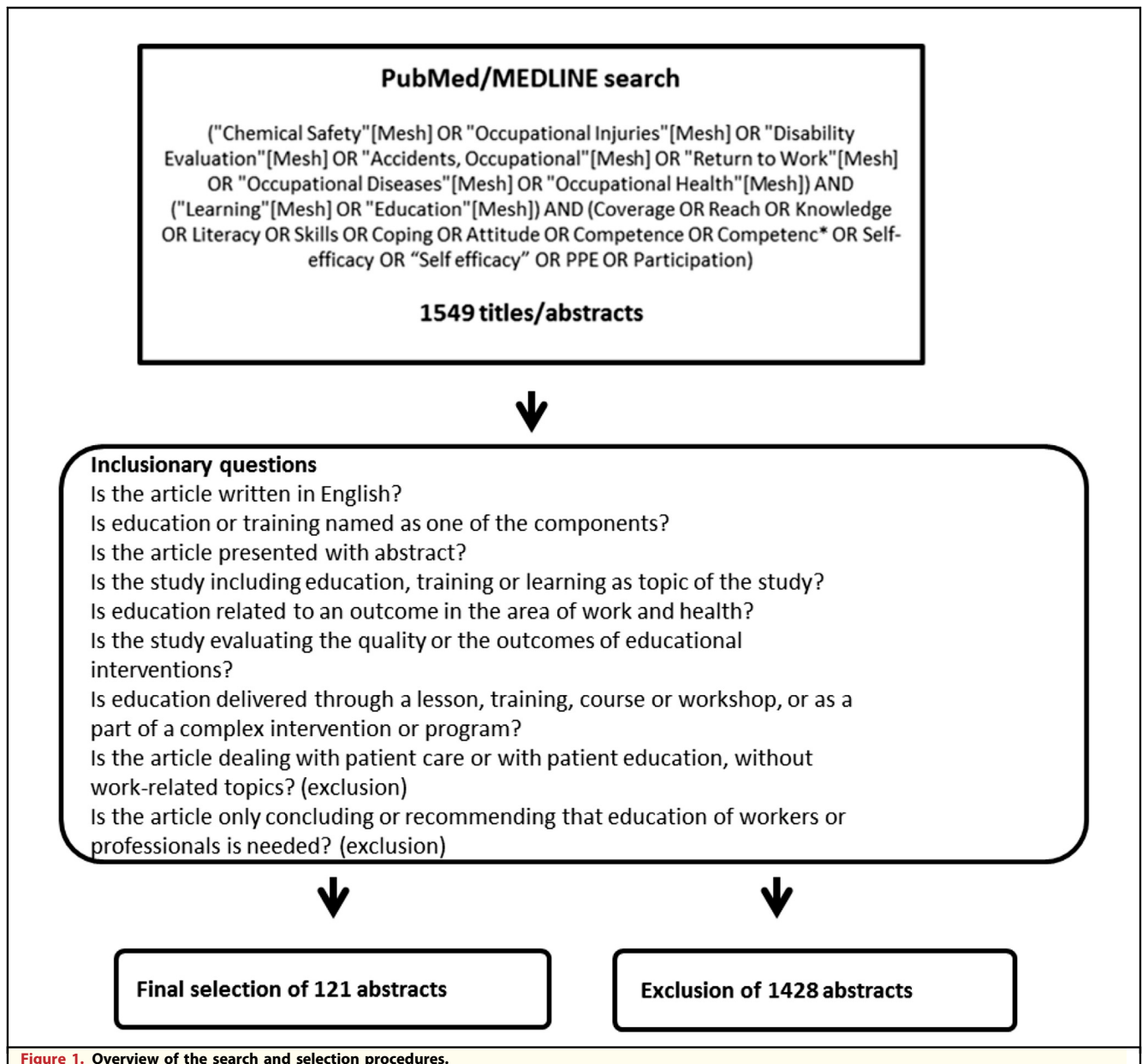
group.²¹ In a study in Taiwan, a series of 14 e-lectures on OH promotion for music performers enhanced music students’ awareness on music practice and performance issues. An online interactive discussion board with experts, a form of distance learning, generated many questions and answers.²² Another study reported on education of occupational skin hazards at German high schools (n = 1015); students were seriously interested.²³

Workers. We found relatively high numbers of studies in the agriculture, health care, and construction sector. Audiovisual aids and printed literature were used in India, teaching farmers to reduce high levels of work-related musculoskeletal problems. Knowledge scores after education increased substantially in farmers, males and females, creating awareness.²⁴

Many studies aimed at risk reduction in 1 occupation or occupational group (Table 3). A Brazilian study analyzed work-related voice problems affecting teachers. Vocal care improved as a result of a voice workshop educating in decreasing vocal tensions. Changes were recommended in the school environment and organization to prevent vocal overload.²⁵ Chinese military personnel were successfully trained for activities as civil emergency responders, adapting coping styles.²⁶ Municipal kitchens participated in participatory workshops in Finland to optimize musculoskeletal load. More than 400 changes were implemented in 59 kitchens, and knowledge and awareness increased. Afterward, physical load was perceived as decreased and musculoskeletal health as improved.²⁷

Education was evaluated of 204 stone-quarry workers in India about using protective eyewear against eye injuries. An enhanced education package including group education, individual discussions, and educational plays was compared with a single educational session and follow-up visits. Enhanced education increased the use of protective eyewear. Enhanced education plus using eyewear reduced the incidence of eye injuries. Because the provision of suitable protective eyewear played an important role, it can be argued that it is not education per se making the successful change, but enhanced education contributed to continuous use of protective equipment.²⁸

Some studies were aimed explicitly at underserved workers’ populations, such as Latino day laborers in US construction and agriculture²⁹ or female migrants in China with a high risk of unwanted pregnancy and sexually transmitted infections.³⁰



Workers with a disease. The aim of education of workers with a disease can be better coping with hazards and demands at work, retention of the job, and sometimes curation of health problems. In a German study, long-term effectiveness was evaluated of a 6-month dermatologic-educational intervention program inclusive of workplace interventions for hairdressers with a chronic occupational skin disease. The control group only received dermatologic treatment. Positive effects were found on knowledge, behavior, and not giving up work because of an occupational skin disease.³¹

Supervisors and managers. Seven studies had the education of supervisors or managers as the study object related to their high responsibility in preventing and controlling risks. With support of workers' compensation insurance and the restaurant trade association, trainers conducted workshops in California, USA, for more than 200 restaurant and foodservice owners or managers. The aim was to develop a program helping the owners/managers in conducting short training sessions with their own employees, addressing hazards and making changes. Interaction with the

Table 2. Country in Which Education Was Object of Study in 121 Abstracts on OSH Education Evaluation in PubMed/MEDLINE, Published 2005-2015

Country	Number of Selected Abstracts
United States	42
Japan	10
United Kingdom	8
Germany	7
Netherlands	7
China	6
Australia	5
International group	5
Canada	4
India	3
Sweden	3
Brazil	3
Turkey, Norway,	2
Taiwan, Italy, Finland	
Malaysia, Ireland, Iran,	1
Nigeria, Greece, Spain,	
Thailand, Denmark	

other owners and managers was a key to the program's success.³²

OSH professionals. Studies on education of OSH experts mainly came from Europe (8 of 13). The effectiveness of e-learning was compared with lecture-based learning in a Dutch study of CME for occupational physicians. Both approaches were equally effective regarding gain in knowledge.³³ In the United States, tours were organized to historical OSH sites to bridge often separated OSH fields. OSH disciplines were successfully trained in a multidisciplinary approach, ultimately oriented on prevention of future exposures.³⁴ Evaluation studies concentrating on occupational health nurses were not found. However, in several studies nurses were included, such as in a UK study on the effectiveness of a musculoskeletal training package.³⁵

Non-OSH professionals. In Scotland the general population, workers, and non-OSH health care professionals were targeted in an effective comprehensive multimedia campaign (1777 radio advertisements, leaflets, website) about “rest or staying active” in case of back pain.³⁶ In another UK project more than 1000 health care professionals completed an interactive e-learning module on occupational asthma. The result was increased knowledge and more use and awareness of the guidelines.³⁷ In Canada CME was organized to increase knowledge of occupational health for primary care physicians and medical specialists. Online learning and

videoconferencing were both evaluated as equally effective compared with traditional conference lectures and small group face-to-face education.³⁸ In the United Kingdom and Norway some studies focused on sick note certification or functional assessments in long-term sickness absence by hospital doctors and general practitioners.³⁹⁻⁴¹ Knowledge and self-confidence increased. Advisory extension agents for farmers such as financial counselors and agribusiness officers were successfully trained in Australia in recognizing, supporting, and referring mental health problems in farmers. These officers are often “the first port of call for emotional support and referral for farmers.”⁴²

Organization by industrial branch or occupational group. Many studies were on safety, stress management, and ergonomics. Studies on training how to cope with asbestos or nanoparticles exposure were not found. Education was mostly organized sector or branch-wise or for specific occupational groups. This practice reflects presumably not only the existence of institutions able to organize higher quality OSH courses. Another attractive factor might be the occurrence of common risk factors, social conditions, and technical solutions in one branch or occupational group. This forms an attractive starting point for concerted educational, social, and technical efforts, also in low-income countries.

New methods. Case-based e-lessons for medical students developed by an international group were compared with the use of written material: textbook pages, practice guidelines, and articles. The increase in knowledge and satisfaction was similar; surprisingly the attitude toward occupational health was more negative in the e-lesson group.⁴³ High-quality interactive e-cases with virtual patients developed in Germany and Latin America were used by more than 2000 students and evaluated as feasible and helpful.⁴⁴ Five European universities developed a comprehensive online teaching module on occupational medicine for undergraduate medical students.⁴⁵ The module was evaluated positively on effectiveness in a blended application.⁴⁶

New methods were evaluated for workers. In education on patient transfers of nurses in Sweden, occupational health was combined with patient empowerment. The training improved staff movements, body awareness, and musculoskeletal complaints and also their communication encouraging patients to move independently.^{47,48} The use of ultraviolet face photographs and cancer information sessions educating male outdoor workers in the

Table 3. Participant Groups and Most Frequent Topics of Education in 121 Publications on Evaluation of OSH Education Found in PubMed/MEDLINE (2005 to June 2015)

Students	Workers and Health and Safety Committees	Supervisors and Managers	Professionals
Total 16 studies	Total 88 studies	Total 7 studies	Total 20 studies
4 Student nurses	15 Agriculture sector	5 Supervisors/ foremen	OSH professionals
6 Medical students	13 Health care sector	2 Managers	3 Occupational physicians
3 Students in higher music education	9 Construction sector		2 Occupational hygienists
3 Other categories: students in general secondary schools, high school students, pharmacy students	5 Office work including computer users		3 Social insurance physicians
	4 Education sector		1 OSH trainers
	14 Workers from another sector or from >1 sector		4 OSH professionals from > 1 discipline
	26 Specific occupations or worker/patient groups*		Non-OSH professionals
	2 Health and safety committees, including immigrant safety liaisons		3 Family physicians
			1 Occupational therapists
			1 Advisory Extension Agents for farmers
			2 Non-OSH professionals from > 1 discipline
Most frequent topics	Most frequent topics	Most frequent topics	Most frequent topics
3 Variety of hazards	16 Ergonomics/ musculoskeletal disorders	3 Stress management	Specific topics of various kinds
2 Infectious diseases	12 Safety including eye protection		
2 Skin risks, skin diseases	7 Stress management		
2 Stress management	4 Hearing loss		
	4 A variety of hazards		
	3 Skin risks, skin diseases		
	3 Chemical exposure including pesticides		

* Workers with a work-related skin disorder (5), kitchen work (2), stone quarry work (2), sake brewery work, work with high Lyme disease risk, computer engineers, police officers, workers in noise, poultry factory, military, university custodians, information technology work, motorcyclists, family caregivers, beryllium industry work, firefighters, outdoor workers, manual handling work, Latino day laborers, workers with cognitive dysfunctions.

United States stimulated sun-protecting cognitions, potentially mediating protection behavior.⁴⁹ In a Chinese study of frontline workers in industry working in poor ergonomic conditions, participatory respectively classic didactic training of limited duration did not change the prevalence of musculoskeletal complaints 1 year after training, except for lower extremities and “wrist and fingers.”⁵⁰ In another Chinese study, a game technology–based safety training was tested for a training in operating tower cranes on construction sites. Game technology has many advantages simulating high-risk situations in practice, including challenging communication and collaboration with other workers.⁵¹

Kawakami reports about participatory training programs based on ILO strategies with home workers, construction workers, and waste collectors in

Cambodia, Thailand, and Fiji. Improving safety, health, and working conditions relies on positive efforts of local people, direct observations of work, and learning from local good examples.⁵²

To improve access to difficult-to-reach groups, bilingual training (English and Spanish) is used⁵³ as well as so-called immigrant safety liaisons.⁵⁴ Training led by “worker leaders” from so called Worker Centers, serving as Spanish speaking peer-educators,⁵⁵ or by farmers, fathers of adolescents,⁵⁶ has been evaluated positively. A course in English as a second language for teen farm workers aimed at health and safety education was used fruitfully.⁵⁷ In another US study, farm safety days for children were evaluated as valuable.⁵⁸

Search for Cochrane Systematic Reviews. Six systematic reviews were the result of our selection

related to education and training in occupational safety and health (Table 4).⁵⁹⁻⁶⁴

Any educational intervention was included in a review on preventing eye injuries. The authors did not find reliable evidence that the interventions were effective.⁶⁰ A review on occupational disease reporting distinguished educational materials, educational materials and meetings, educational meetings, and a multifaceted educational campaign. Interventions with educational meetings and educational campaigns both provided (very low-quality) evidence for an effect on the number of physicians reporting occupational diseases compared with no intervention. No studies were found evaluating the effectiveness of Internet-based interventions.⁶⁴

The quality of the original studies found was assessed from moderate to (very) low. The observed effects of the educational interventions on health outcomes, work functioning, job loss, or increased reporting of occupational diseases were, in general, judged as small or absent.

DISCUSSION AND RECOMMENDATIONS

The majority of evaluation studies on education were completed in North America, Western Europe, or Asia. Studies from low-income economies were scarce. Most studies evaluated education of workers; fewer, the education of students, managers, or professionals. Studies related to the agriculture, health care, and construction sector presumably reflect attention for high-risk sectors. Surprisingly no studies were found on education related to asbestos or nanoparticles exposure. Education was often enhanced, for example, also

providing PPE or including a workplace inspection, or embedded in a comprehensive prevention program, improving effectiveness. New educational methods such as e-learning and participatory workshops were tested on feasibility, quality, and effectiveness. Creative strategies were presented to find better access to underserved populations. Education of new groups of participants was evaluated: students in vocational training, adolescents working on farms, workers with a chronic disease, immigrant safety liaisons, supervisors, and family physicians.

Strengths and Weaknesses of This Study. Using publications indexed by MEDLINE has the advantage of good accessibility and presumably of selecting the best evaluation studies. On the other hand, selecting only studies written in English and being indexed by the US National Library of Medicine (MEDLINE) caused selection bias, excluding studies published in other languages and benefiting studies from the United States, Canada, and Western Europe. Because PubMed/MEDLINE focuses on health, studies on safety or mental health may have been missed. The sensitivity of the chosen filters was not 100% and the bibliographies of the publications found were not scanned for new sources. These are important weaknesses of this study. We know several relevant studies not identified in this search, such as from Thailand and China, evaluating basic occupational health care initiatives including education.^{65,66} Only 1 study was found in this search reporting about ILO WISE (small enterprises) and WIND (neighborhood, farmers) programs.⁵² For example, a study of Kogi was not included, reporting about the successful action-oriented community approach applied in many countries.⁶⁷ Finally, the scientific quality of the studies was not systematically analyzed, being outside the scope of this study. Nevertheless, we could notice many problems, confirming reports by others.

Additional literature searches are worthwhile, including public health studies and gray literature. Specific studies may find answers to questions such as on behavioral changes as a result of education or on the most suited design for transfer of knowledge or skills given a specific situation.

Low Number of Studies and Problems With Quality. Given about 3 billion workers in the world, active in a large number of different occupations, and presumably more than 200,000 active OSH experts,⁸ the number of 121 studies published during 10 years on evaluation of OSH education is low, even taking into account that we have missed studies. Selecting publications in PubMed/MEDLINE in

Table 4. Participants and Topics of Education in 6 Cochrane Systematic Reviews Including Occupational Safety and Health Education

Workers	Professionals
Teachers, education sector	Occupational physicians
Construction	
Various workers	
Specific patient group (inflammatory arthritis)	
Topics	Topics
Voice disorders	Reporting of occupational
Fatal and nonfatal injuries	diseases
Eye injuries	
Hearing loss	
Job loss, work functioning	

2013 dealing with occupational health,ⁱⁱ we could find almost 3300 publications, in contrast to only 20 publications on evaluation of OSH education. Surprising is the low number of studies on education of OSH professionals, students, supervisors, and managers. Schulte et al noticed the absence of literature assessing the role and value of OSH training in vocational education.⁶⁸ We did find studies, but not many.

A number of barriers may hinder evaluation studies: lack of funds, not having a tradition of evaluation, regarding education as a complex intervention, missing incentives to publish, or journals not being interested or even incompetent on the topic. One other main reason might be that education in OSH itself is scarce or even absent for some target groups in many countries, as is illustrated in the Introduction.²⁻¹⁰ In many parts of the world OSH education came under pressure by the economic crisis. We recommend analyzing the barriers and promotion factors.

We noticed in a number of studies the lack of a control group, low number of participants, unrealistic expectations of long-term health effects after a modest isolated educational intervention, and the absence of (cluster) randomization when that was an option. We conclude with others that good quantitative and qualitative study designs have to be promoted and supported. The development of effective education can be improved, such as by using focus groups of participants and a literature search in the development process. Chosen outcomes can be discussed: why using knowledge outcomes and not adequate behavior, why striving for behavior changes when concrete working conditions can be improved? Several articles were found elaborating on education being able (or not) to have an impact on behavioral changes of workers via a more positive attitude and new knowledge, and its subsequent influence on workplace safety. Because behavioral changes were not solely the wanted outcome of most interventions, these changes were not the only focus of actions. We need more discussion on goals and outcomes.

The Problem of Low or Modest Literacy. Hazards are present in every workplace. Often, recognition and control of these are not broadly introduced in developing economies, and in addition, are hindered

by low or modest literacy levels of groups of workers. Similar situations are present in high-income countries where migrant workers with modest literacy are employed in high-risk sectors either as a day laborer or as seasonal workers, hampering safety measures. Solutions were evaluated in studies such as peer-to-peer education and safety liaisons, traffic-light symbols in technical information, use of training posters in education, and pictographic tests.

Generalizability. Although we agree that, as an illustration, increase in use of protective eyewear in a stone quarry²⁸ is a successful behavioral change, there are no easy answers to the question of the reproducibility of this success using the same intervention elsewhere. One reason is that successes are influenced by differences in settings, populations, educational attempts, and (changing) culture. How to repeat a success is still to be explained.⁶⁹⁻⁷¹ Finding drivers of behavioral changes emerging from (the environment of) an educational intervention, the dominant culture and the inside of a target group, belongs to the matrix of success.

Recommendations for Developing Economies. The use of online learning and blended educational forms may increase coverage, quality, and efficiency of OSH education in developing economies enormously. Successful examples are interactive e-learning modules such as on occupational asthma and occupational hygiene, e-courses used in a blended application such as EMUTOM, and virtual patient cases for medical students, videoconferencing, and online discussion boards. We expect a rapid growing use of mobile apps running on smartphones, tablets, and other mobile devices. Unfortunately, the use of mobile apps has not yet been evaluated as far as we know. Online repositories providing access to quality online learning materials as part of an adequate knowledge infrastructure can support new developments.⁷²⁻⁷⁴ Integration of health and safety issues in vocational and technical education is crucial, as being advocated by Schulte et al in the United States.⁶⁸ Integration of OSH education in preventive programs and clinical treatment can increase reach and effectiveness. OSH expert-supported initiatives of industrial sectorial or branch organizations, agricultural consultants, schools for vocational training, and primary and community health care may create new opportunities to educate underserved worker populations. Innovative solutions are available to improve the educational efforts.

ⁱⁱUsing as filter: “Occupational Injuries”[Mesh] OR “Accidents, Occupational”[Mesh] OR “Occupational Diseases”[Mesh] OR “Occupational Health”[Mesh]; next selecting only publications in English (June 2015).

To make progress in education in developing economies, we recommend appropriate national legislation and programming. We advise focusing on the education of workers and professionals most in need. Low numbers of OSH experts impede any progress, so OSH experts have to be educated. Programming involving OSH expert-supported primary health care to provide essential occupational health care—inclusive education of workers has the advantage of reaching many vulnerable workers in small enterprises and in the informal sector.⁷⁵ Basic occupational health services^{65,66} and ILO participatory strategies^{52,67} can be integrated and adapted to local conditions. Online learning can improve quality and reach. Prescribing and supporting OSH education in vocational education shapes the awareness of future workers. Employers' organizations, unions, and branch organizations have to be involved in developing programs to educate workers. Well-designed evaluation studies are strongly recommended.

Supporting international initiatives can be boosted by an international task force including educational experts, ILO, WHO, the International Commission on Occupational Health (ICOH), the World Organization of National Colleges, Academies and Academic Associations of General Practitioners/Family Physicians (WONCA) (primary health care), and the International Social Security Association (ISSA). Their unique expertise in this field can contribute to the work to be done. Funded programming and good project management are preconditions to avoid ending up in paperwork without impact. We

recommend the organization of work conferences and a website platform facilitating the exchange of experiences, good practices, studies, and educational materials.

CONCLUSIONS

Given the high shortages of education in developing economies, there is a need to boost progress. This overview of evaluation studies on OSH education shows many opportunities. Use of online technologies offers efficient and effective options for better coverage and quality of education. Blended application including face-to-face contact might be preferred. For workers, enhanced education, for example, including workplace inspection and providing PPEs, or education integrated in a preventive participatory program may be more effective. New alliances between OSH experts and schools, sectorial or industrial branch organizations, and primary or community health care may provide education and care for underserved populations.

On a national level, legislation and governmental support are needed in addition to concerted actions of employers and workers. We recommend boosting international collaboration and support by a high-level international task force. Participation is needed of educational experts and of various international organizations, such as ILO, WHO, ICOH, WONCA (primary health care), and ISSA. The task force may develop funded programming and a global online platform facilitating the exchange of experiences, good practices, studies, and educational materials. We strongly recommend incorporating well-designed evaluation studies.

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