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Research Priorities in Occupational Safety and Health: A Review

Sergio IAVICOLI[1]*, Bruna RONDINONE[1], Alessandro MARINACCIO[2] and Marilyn FINGERHUT[3]

[1] ISPESL National Institute for Occupational Safety and Prevention, Via Fontana Candida, 1, 00040 Monteporzio Catone, Rome, Italy
[2] ISPESL National Institute for Occupational Safety and Prevention, Via Alessandria, 220/E, 00198, Rome, Italy
[3] NIOSH National Institute for Occupational Safety and Health, Room 715H Humphrey Bldg, 200 Independence Av. SW, Washington DC 20201, USA

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Abstract: Changes in the world of work in the last few decades have markedly affected questions regarding occupational safety and health (OSH). Jobs in our economy continue to shift from manufacturing to services. Longer hours, shift work, reduced job security, temporary work are realities in the modern workplace, new chemicals, materials, processes are developed at an ever accelerating pace. The workforce is also changing. It will become older and more racially diverse and women are increasing. These changes present new challenges to protect worker safety and health and it was been indispensable to redefine priorities, by consulting all those involved in OSH. The present study therefore made a critical comparative analysis of the main published projects to identify research priorities in the OSH field, comparing methods, approaches and results. Comparison of the priority areas established in each of these studies is inherently difficult due to differences in socio-cultural backgrounds, in the methods employed to identify priority topics, and the many factors involved. However, it is clear that the Delphi technique is widely used as a reliable method, in that it covers a broad range of qualified witnesses, from a variety of backgrounds —such as trade union representatives and researchers— providing different viewpoints. It also takes account of the intrinsic features of OSH which —compared to other disciplines— involves multidisciplinary factors calling into play a range of scientific settings, such as toxicologists, molecular biologists, epidemiologists, occupational hygienists and occupational physicians. This analysis showed how important it is to reach consensus among all those operating in the OSH sector, in order to establish standard methods that can be applied in different contexts, and give results that can be validly compared.

Key words: Delphi technique, Research Priorities, Consensus, OSH, Stakeholders

Introduction

Safeguards for workers' health and safety are the legislative response to the problem of accidents at work and occupational illnesses. This is a field that has grown enormously, especially since the end of the 19th century, with the vast development of industry and the increasing numbers of people employed in factories. Questions related to workers' health have always been followed closely in the scientific community and by the main international organizations, such as the International Labor Organization (ILO), the World Health Organization (WHO) and the European Union (EU).

In recent decades we have witnessed great changes, calling for a fresh look at safety and health, particularly in the world of work. These changes oblige us to redefine and modify the policies and priorities of all those involved —public and social bodies, companies, public and private insurance agencies— in managing these emerging situations. This continuously shifting scene brings to light new risk factors, so we have also to adapt existing models for risk exposure. However, in many countries the extent of these problems is not reflected in the proportion of overall occupational health

*To whom correspondence should be addressed.

research funds allocated, nor in the amount of attention they attract from policymakers.

In recent years, numerous studies have looked at demand for research in this sector, with a view to establishing priorities in order to respond better to the growing range of requirements to safeguard occupational safety and health (OSH).

The present study therefore made a critical comparative analysis of the main projects to identify OSH priorities and measures reported in the literature. The aim was to compare the approaches taken, the methods used to contact people, the results and their impact on social and economic, political and scientific decisions to foster collaboration between different areas, and set in motion a standardized process of identifying research priorities so as to obtain results that can be validly compared.

Analysis of studies to identify research priorities

Table 1 sets out the projects designed to identify research priorities reported in the literature. The methods and results of these investigations are briefly commented on here.

The BOHRF project

In the mid-80s an EU analysis found a lack of organization in Europe for identifying research priorities related to health in the workplace; funds were inadequate and there was too little cooperation between the various institutions for joint projects. Great Britain decided to tackle this problem — since financing for such projects was rapidly drying up— by setting up the British Occupational Health Research Foundation (BOHRF) in 1991.

In a study to identify priority research areas for OSH in 1993[1], the BOHRF employed the Delphi technique; this involves cycles, each based on the results of the previous one, in which experts in various fields are called in to give their opinions with a view to reaching consensus on each given theme.

To start with, 25 university specialists in occupational medicine were consulted. Subsequent assessment of the end-users of the findings led to consultations with OSH experts working in industry and government bodies. The sample of 25 universities was thus extended to admit 28 representatives from industry and government. The first questionnaire used open questions to identify three main areas of research, which were considered to have priority. Replies were provided by 86% of those questioned, and pointed out five priority areas, which were then divided under subheadings and used to draft a second, more detailed questionnaire, which required the experts to rate the five main areas and their subgroups in order of importance. Replies to the second questionnaire were received from 91% of the participants and were analyzed by adding up the rankings for each area and calculating the mean score.

Table 2 shows the priorities assigned to the five main themes and subheadings. Analysis of the two groups of experts consulted indicated a general agreement on research priorities. The study was later extended, in 1996, with the same methods, and collected priorities from the employers' viewpoint[2].

The NIOSH study

In 1995, to meet increasing demand and new OSH research requirements, the U.S.A. National Institute for Occupational Safety and Health (NIOSH) and its partners in the public and private sectors set up a program known as NORA[3] (National Occupational Research Agenda), as the first step in a broader project to coordinate research on health and safety in the workplace. The aim was to provide a framework to guide OSH research, not only for NIOSH but also for the entire OSH community.

Using a modified Delphi process (iterations of expert opinion), an initial planning work-group of senior scientists from inside and outside NIOSH established a framework and drafted a list of 48 potential research topics. This list was modified and increased to approximately 80 items, with input from four additional working groups (OSH researchers from outside NIOSH, NIOSH scientists, OSH professionals and other professionals in the field), as well as oral and written comments from individuals and representatives of other institutions and organizations. Each group was allowed to modify the list by adding or merging topics as deemed appropriate; and were then asked to arrive at a list of 15 to 25 priority topics, again using a modified Delphi process (iterations of individually ranked priority areas). The Agenda identifies 21 research priorities (Table 2), reflecting a remarkable degree of concurrence among a large number of stakeholders[4].

To ensure that research in these priority areas would be encouraged, NIOSH set up a NORA Team for each of the priority areas, consisting of about 15 people with about half from outside NIOSH. These teams worked with various partners to develop national research agendas for the particular priority areas, to help organize national conferences and to develop useful information.

The Dutch study

To help fill the gaps found by the EU in the OSH field, in 1997 the Netherlands also organized a study[5] to establish research priorities in occupational medicine. One of the first steps was to identify six key informants for each of the following areas: work stress, musculo-skeletal disorders, safety and biological, chemical and physical hazards, occupational rehabilitation/sociomedical guidance, occupational health care/occupational health services. The group of six key informants, three of them scientific

Table 1. Methods and subjects investigated in studies of research priorities

Country	Reference	Method	Subjects
United Kingdom - BOHRF	Harrington JM.—Research priorities in occupational medicine: a survey of UK medical opinion by the Delphi technique. *Occup Environ Med* 1994; *51*:289-294	Delphi	Sample consisting of occupational medicine specialists from universities, industry and government agencies.
USA - NIOSH	Rosenstock L., Olenec C., Wagner GR.—The National Occupational Research Agenda: a model of broad stakeholder input into a priority setting. *Am J Public Health* 1998; *88*:353-356	Modified Delphi	Sample consisting of senior scientists from inside and outside NIOSH, Researchers, Stakeholders, Health professionals.
The Netherlands - University of Amsterdam	Van Der Beek AJ., Fring Dresen MH., Van Dijk FJ., Houtman IL.—Priorities in occupational health research: a Delphi study in The Netherlands. *Occup Environ Med* 1997; *54*:504-510	Modified Delphi [1]	Sample consisting of scientific researchers from universities and research institutes, Occupational health and safety services, Governmental and other administrative bodies, Representatives of companies.
Europe - European Agency for Safety and Health at Work	European Agency for Safety and Health at Work 1998—Future occupational Safety and Health research needs and priorities in the Member States of the European Union	No Delphi [2]	Different subjects from the various countries. Most Member States interviewed representatives of universities and research institutes, government bodies, trade unions and other workers' organizations. In Belgium only universities were represented, and in Ireland the subjects contacted were not specified.
Italy - ISPESL	Iavicoli S., Marinaccio A., Vonesch N., Ursini C.L., Grandi C., Palmi S.—Research priorities in occupational health in Italy.—*Occup Environ Med* 2001; *58*:325-329	Delphi	Representatives of university occupational medicine departments; local health offices, trade unions.
Malaysia - Institute of Occupational Health, University of Birmingham	Sadhra S., Beach JR., Aw T-C., Sheikh-Ahmed K.—Occupational health research priorities in Malaysia: a Delphi study. *Occup Environ Med* 2001; *58*:426-431	Delphi	Sample consisting of government departments; universities; major industry (mainly large companies with occupational health departments).
Japan	Tachi M., Sakurai H., Araki S. *et al*.—National occupational health research strategies. *Ind Health* 2001; *39*:287-307	No Delphi	OH specialists from occupational health institutions, universities, representatives of companies, Japanese Trade Union Confederation.
Global	Fingerhut M., Kortum-Margot E.—2002 Network of WHO Collaborating Centres in Occupational Health, communication and information dissemination. *Asian-Pacific Newsletter on Occupational Health and Safety* 2003; *9*:28-30	Modified Delphi	Directors of WHO Collaborating Centers in Occupational Health.

[1]Priority areas were assigned outside the Delphi model. [2]The Agency supplied a list of topics which had to be ranked according to priority.

researchers and three from OSH services, with the addition of three senior governmental policy makers, was assigned the task of indicating research areas which, in their opinion, deserved priority as regards OSH. This list served as the starting point, using the Delphi technique, for two series of questionnaires.

The first series was administered to 105 selected Dutch experts from OSH services, scientific research institutes and universities, governmental and other administrative bodies, of whom 86% replied. The second series included another

Table 2. Main research priority areas identified in the studies analyzed

United Kingdom	USA	The Netherlands	Europe*
Incidence, prevalence/natural history of work related diseases and identification of susceptible groups · Back problems · Work-related upper limb disorders · Occupational asthma · Injuries/accidents · Occupational dermatitis · Hand/arm vibration syndrome · Suicide/depression · Noise-induced hearing loss **Audit** · Pre-employment screening · Clinical reasoning in OH · Benefits of health promotion · Behavior modification · Rehabilitation techniques · Effects of removal from exposure **Environmental impact of industrial activity** · Community health effects · Individual health effects · Community exposure criteria **Stress and work** · Identify risk factors/physiological correlates · Develop prevention strategies · Develop rehabilitation techniques **Neuro-psychological effects of work exposures** · Effective diagnostic tests for early effects · Effective performance tests	**Disease and Injury** · Allergic and Irritant dermatitis · Asthma and chronic obstructive pulmonary disease · Fertility and pregnancy abnormalities · Hearing loss · Infectious diseases · Low back disorders · Musculo-skeletal disorders of the upper extremities · Traumatic injuries **Work environment and workforce** · Emerging technologies · Indoor environment · Mixed exposures · Organization of work · Special populations at risk **Research tools and approaches** · Cancer research methods · Control technology and personal protective equipment · Exposure assessment methods · Health services research · Intervention effectiveness research · Risk assessment methods · Social and economic consequences of workplace illness and injury · Surveillance research methods	**Design, implementation or evaluation of measures** · Cost-benefit analysis of measures · Design of solutions by workers for their own work situation · Development of methods for implementation of measures · Implementation of solutions in the design of the production process · Effectiveness of stress prevention and stress management **Assessment of exposure-effect relations** · Work pressure - business effects · Perception of stress risks - objective health effects · Repetitive strain neck-shoulder-arm complaints · Working postures - musculo-skeletal complaints · Indoor environment - subjective perception · Exposure to toxic hazards - reproductive effects **Occupational rehabilitation or socio-medical guidance** · Beneficial and impeding factors for return to work · Organizationally gear all those involved in rehabilitation to each other · Preventive orientation in sickness absence policy · Clinical guidelines for socio-medical guidance · Treatment and strategies for occupational rehabilitation **Occupational health care or occupational health services** · Cost and benefits of occupational health care · Occupational health care in SME · Promotion of preventive orientation in occupational health services · Early indicators of sickness absence and turnover · Effectiveness of instruments **Special population at risk and standards** **Assessment of exposure to work demands** **Assessment of health effects**	**Society and work organization** · Small and medium- sized enterprises (2) · Cost-benefit studies of OSH (3) · Cost analysis of OSH, cost of accidents and diseases (3) · Subcontracted labor (3) · Aging workers (3) · People with reduced working ability (3) · Tele-working (4) · Self-employed (4) · Organization cultures (4) · Temporary workers (4) · Young workers (4) **Management and technology** · Risk assessment (2) · Risk management in SMEs (2) · Substitution of dangerous substances (2) · New safe products, production methods, processes and equipment (3) · OSH management systems, certification of OSH management (3) · Best practices, benchmarking (3) · Learning and competence development, training methodologies (3) · Accident prevention (4) · Workplace health promotion, methods for occupational health services (4) · Risk communication and perception (4) · Management and worker participation (4) · Machinery, plant safety and mechanical handling (4) **Risks in working environment** · Psychosocial factors (1) · Ergonomic factors (1) · Chemical risk factors (1) · Safety risk (1) · Physical risk factors (2) · Biological risk factors (4) **Health effects** · Occupational and other work-related diseases (1) · Occupational accidents (4) **Specific topics** · Risks in specific activities (2) · Development and methodologies (4)

*In brackets the priority ranking in the general classification.

Table 2. Main research priority areas identified in the studies analyzed (continued)

Italy*	Malaysia	Japan*	Global
Research methods, approaches and strategies · Quality in occupational medicine (2) · Worker information, education and participation (4) · Organization, strategies and optimization of prevention and safety services at the workplace (5) · Biological monitoring: identification of markers for low-dose exposure (6) · Medical surveillance and work ability criteria (8) · Work organization and new types of work (11) · Methods of assessing and measuring occupational stress (25) **Mechanisms of action and development of indicators** · Occupational carcinogenesis (1) · Exposure to low doses and multiple exposure (3) · Individual susceptibility and development of susceptibility indicators (15) · Mechanisms of action of occupational stress and occurrence of disease (23) · Mechanism of skin absorption of xenobiotics (27) **Diseases and work accidents** · New work-related diseases (7) · Work accidents (9) · Musculo-skeletal and repetitive trauma disorders (12) · Occupational allergies (16) · Occupational asthma and respiratory diseases (18) · Reproductive and pregnancy disorders (24) **Risk assessment** · Electromagnetic fields (10) · Asbestos substitute fibers (14) · Biological agents (17) · Load handling (20) · Occupational exposure to urban chemical pollutants (22) **Work environment, workforce and working sectors** · Health-care and hospital sectors (13) · Agriculture (19) · Special populations at risk (elderly, minors, disabled people) (21) · Air quality and indoor environment (26)	**Occupational health problems for specific occupational groups/ industries** · Construction workers · Pesticide sprayers · Plantation workers · Health care workers · Migrant workers · Quarry and mine workers · Small-scale industries · Electronic industry · Commercial and heavy vehicle drivers · Woodworkers · Hotel and restaurant workers · Administrative workers **Investigation of specific occupational health problems** · Chemical poisoning · Injuries at work from industrial accidents · Noise-induced hearing loss · Skin diseases associated with work · Occupational lung disease including asthma · Musculo-skeletal problems and repetitive strain injury · Work-related back problems · Psychological disorders (stress at work) **Incidence and prevalence of work- related disease** · Mechanical equipment injuries or accidents · Chemical poisoning · Noise-induced hearing loss · Occupational asthma · Occupational dermatitis · Occupational cancer · Suicide or depression **Health problems associated with industrial development** · Community health effects from industrial pollution · Road accidents · Community health effects from vehicle emissions · Indoor air quality and health effects · Evaluation of outdoor air quality and the development of air standards **Hazards associated with new industries and new technology**	**Changes in life and health at work** · Work style and health: *Night and shift work and work time (7); Change in industrial structure (46); Overseas company and workers (51); Work force (58)* · Information technology: *Tele work, home work and free-work time (16)* · Work stress and mental health: *Work stress (1); Mental health and quality of work and life (4); Industrial fatigue (48)* · Work-related disease (12) · Elderly workers (2) · Women workers: *Women workers and maternity protection (3)* **Mechanism of health effects** · Toxicity assessment: *Endocrine and reproductive effects of chemicals (6); Immunological effects and allergy (14); Nervous system effects (23); Kinetics and metabolism of chemicals (37); Respiratory effects (38); Skin, nose and eye effects (52)* · Gene effects and carcinogenicity: *Gene effects (15); Occupational cancer (19)* · Multiple exposure (11) · Individual differences in health effects: *Hereditary traits and susceptibility (21)* · Ergonomic factors and workload: *Job type and design (30); Musculo-skeletal effects and heavy-weight work (35); Human factors in accidents (36); VDT and information-processing work (44); Physical function in ergonomics (45); Operability of equipment (56)* **Assessment and management in OSH** · Risk assessment and health effect index: *Hazard and risk assessment (4); Biological effect index (9); Exposure limit value (18); Biological monitoring (20); Epidemiology in occupational health (24); Environmental assessment at work (28); Electromagnetic and radiation effects (34); Physical environment and health effects (42); Effect of biological agents (50)* · Risk communication: *Risk communication and material safety data sheet (7); Health education and information service (26); Occupational health statistics (29); New technology and materials (31); Evidence-based medicine (49)* · Measurement and control of work environment: *Sampling and analysis of chemicals (10); New measurement techniques (27); Measurement and control of physical factors (39); Control and management of work environment (41); Collection and measurement of dusts (53); Protective equipment (54); Measurement and control of noise and vibration (55)* · Business administration and health and safety management systems: *Business strategy and health and safety management (22); Health assessment services (32)* · Occupational health in small industries and self-employed: *Small industries and self-employed (13); Health in agriculture, forestry and fishery (57)* · Quality of working life and health promotion: *Work of diseased and disabled and return to work (25); Health promotion (32); Health examination and guidance (40); Comfortable work environment (42); Lifetime health (47)* · International standards and collaboration (16)	· Technical guidance in occupational health · Intensive partnership in Africa · Child labor and adolescent workers · Elimination of silicosis · Health care workers · Health promotion activity · Mental health and stress at work · Promotion of OS&H in small enterprises and in the informal sector · Prevention of musculoskeletal disorders · Preventive technology · Training of occupational health and safety personnel · Internet resources and networks · National and local profiles and indicators · Cost-effectiveness of interventions · Global burden of disease

*In brackets the priority ranking in the general classification.

45 experts, representatives of OSH in industry. From this total of 150, 81% answered. Analysis of the two series of questionnaires showed there was virtually complete consensus among the four groups interviewed in these two rounds, and Table 2 sets out the research areas identified, in order of priority.

The European Agency for Safety and Health at Work

In 1998 a study was conducted[6] by the European Agency for Safety and Health at Work, which was set up in 1994 to facilitate the exchange of information between EU Member States relating to future OSH requirements. The aim was to obtain comparable information from the various countries on research priorities and emerging risks, taking account of the viewpoints of the various social partners —trade unions and other workers' organizations— and the main research institutes. The European Agency for Safety and Health at Work agreed that each Member State (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, The Netherlands, Portugal, Spain, Sweden, United Kingdom) should draft a National Report following a standard outline, focusing on certain points such as data collection, processing and analysis, and procedures for reaching consensus. Besides defining the reference structure for the National Reports, the European Agency proposed a classification of priority areas under three main headings: Society and work organization, Management and technology, Working environment and health; each divided into subclasses.

However, despite all attempts to unify the data, the National Reports demonstrated substantial differences between Member States: different subjects were involved in the project, different degrees of agreement were reached, and the proposed outline was followed closely by some, less strictly by others. Some countries contacted only a limited number of institutions, and completed the data with existing information. This meant they did not adhere closely to the standard classification suggested by the European Agency.

Priority topics were identified on the European level by simply adding the number of times a certain area was assigned priority. The result is set out in Table 2; each area was cited by at least two thirds of the Member States as meriting research priority in the field of OSH.

The ISPESL study

In Italy, studies to identify and assign priority to OSH research topics have been conducted by ISPESL[7–9], the National Institute for Occupational Safety and Prevention, whose task comprises research, consultancy, training, information and regulations related to OSH. ISPESL also used the Delphi procedure, sending two cycles of *ad hoc* questionnaires to experts in this sector. The mailing targeted the two main areas daily involved with OSH in Italy: university occupational medicine and health departments, and local health offices (known as ASL in Italy). Subsequently we also contacted trade union organizations, in view of their special relations with workers in different sectors.

In the first stage, 310 questionnaires were sent to universities and local health offices, and 56.4% replied. They were asked to reply to open questions to identify three areas they believed merited research priority in the field of OSH. A total of 27 priority areas were suggested, under five main headings—macro-sectors. A second questionnaire was then sent out to the ASL and universities, listing the items identified most frequently in the first round, and asking them to rank them by priority for each topic. Replies were received from 65.5% and we then calculated the mean score for each sector, and rankings for the whole group of experts and separately for the university and ASL experts. The medians of the ratings assigned to the research areas for each macro-sector were used as scores. Table 2 lists the macro-sectors assigned priority by representatives of the ASL and universities. We arranged meetings with high-level national representatives of the workers' organizations to obtain their opinions, using a method similar to that described above. Recently a brief commentary has been published in which methods, results and impact of priorities setting system created in different countries have been discussed[10].

The Malaysian study

Problems arising from changes in the labor market in Malaysia and the substantial increase in occupational diseases led the central government to assign funds to OSH research in 1986. In 2001, priority research topics were identified using the Delphi technique[11] with two cycles of questionnaires, in line with the surveys made in the United Kingdom and the Netherlands. The first round of questionnaires was sent to 78 representatives of the universities, government bodies and industry, using open questions to name three priority areas for research in occupational medicine. Replies were received from 71%, permitting the identification of five macro-areas and a series of sub-items, which were used to draft the second questionnaire. This was then sent to 95 people—the 78 originally approached in the first round, and 17 new names, representing the same organizations; 76% replied. They were all asked to rank the topics identified in the first round, in order of priority (Table 2). The mean scores for the broad groupings and their sub-items provided the final rank order with the highest priority choice receiving the lowest numerical score.

The Japanese study

In 2001, a report was presented at the third NORA Symposium held by NIOSH which described the preparation during 1998–2001 of a national research agenda for Japan[12, 13].

This effort was initiated at the Conference on Occupational Health Research Strategies in the 21st Century, organized by the Japanese Ministry of Labor.

This effort was divided into several steps. In the first stage, 34 of the 52 Conference participants identified 344 original occupational health (OH) research topics, which were then grouped as 58 research topics. Then, 96% of the Conference members used criteria of importance, utility, accessibility and diffusion of the results to establish 29 research topics with short-term priority (5 yr) and 29 with longer-term priority (6–10 yr). The selections of the Conference participants were then assessed by 241 extramural occupational health specialists representing all the sectors covered by the survey: research institutes, industrial medicine specialists, government bodies, workers' representatives, etc. The final agenda lists 18 research priorities grouped in three key research areas. These areas and priorities are listed in Table 2.

The Global agenda

The World Health Organization (WHO) Network of Collaborating Centers in Occupational Health currently includes 70 national institutes or academic departments of occupational health located in countries at all levels of development. The Network also includes the International Labor Organization (ILO), the International Commission on Occupational Health (ICOH), the International Occupational Hygiene Association (IOHA), and the International Ergonomics Association (IEA) and all six WHO Regional Advisors for Occupational Health[14].

In June 2001, WHO occupational health staff sent suggested priorities to and solicited input from all Directors of the WHO Collaborating Centers (60 at the time) for a Draft 2001–2005 Plan of Action, a work plan to implement the WHO "Global Strategy on Occupational Health for All".

A total of 20 (33%) Centers sent replies, which provided the basis for a revised document discussed by the 68 attendees from Collaborating Centers, WHO, ILO, ICOH, and IOHA at the Collaborating Center Network Meeting in Chiangmai, Thailand in November, 2001. The attendees agreed upon 15 priority areas to which every Collaborating Center would commit at least one project to benefit developing nations.

Fifteen Task Forces, co-chaired by experts from WHO and the Network members were established and more than 300 projects were contributed to the 2001–2005 Global Work Plan. At the Collaborating Center Network Meeting in Iguassu Falls, Brazil, in February 2003, the 93 attendees met in Task Force working groups to review progress and set focused goals for each Task Force.

Results

Comparison of the priority areas established in each of these studies is inherently difficult because of differences in the socio-cultural backgrounds, the routes followed to reach agreement, and the methods employed to identify priority topics and group them in macro-areas[15]. For instance, some studies present the research priorities in considerable detail, referring to highly specific topics, while others refer to broader sectors that are hard to compare usefully—see Table 2. Although the research agendas have varying structures, some topics are included in all eight approaches and therefore clearly have importance to workers globally, whether in developed or developing nations. Musculo-skeletal disorders, psychosocial/work organization/stress, and special vulnerable worker populations are reflected in all agendas. Injuries, dermatologic (skin) disorders and respiratory diseases are included in six (75%) of the eight agendas and hearing loss is found in five (63%). The recent WHO Comparative Risk Assessment confirms the substantial contribution of selected occupational risk factors to total global illness[16]. The WHO concluded that occupational risk factors are responsible for 37% of back pain, 16% of hearing loss, 10% of injuries, 13% of chronic obstructive pulmonary disease, 11% of asthma, and 9% of lung cancer globally.

The absence of data in much of the developing world limited the range of occupational risk factors that could be measured by the WHO, and the available data excluded children under 15 who work. The WHO comparative risk assessment also excluded important occupational risks for reproductive disorders, dermatitis, infectious disease, coronary heart disease, intentional injuries, musculo-skeletal disorders of the upper extremities, and most cancers. Psychosocial risk factors, such as workplace stress could not be studied, nor could pesticide, heavy metal, or solvent exposures.

Discussion

As shown in Table 1, most studies aimed at identifying OSH research priorities used the Delphi technique. This method offers advantages that make it preferable to other approaches when it comes to identifying areas of agreement and disagreement, such as OSH research priorities. It involves proposing one or more topics to a group of experts in the sector who then rate them through an iteration process, in successive rounds, until they reach a consensus, with all the replies remaining anonymous.

The most delicate part of the Delphi procedure is forming the panel of experts, since this is not covered by the guarantees of the theory of samples. To make sure the results are reliable and unbiased, the panel must be highly representative of all the bodies involved in the study. This implies that panels selected in the studies considered here must be assessed too.

In almost all cases —the UK, USA, Netherlands, Malaysia— the sample was selected with a view to

representing all the parties involved in safeguarding workers' health and safety. The viewpoints of researchers at universities and other centers directly involved with occupational medicine were all taken into account, as were those of the prime beneficiaries of the research, people with powers of decision and action on health and safety in the workplace. This meant interviewing OSH physicians working in industry, government and administration, stakeholders and health professionals, and unions representing the workers.

Unlike these four countries, which used a sample representative of all the experts in OSH, the Italian study interviewed experts from the universities and local health offices throughout the country. Italy and the UK employed a pure Delphi model, whose first step involves obtaining an absolutely free opinion on the OSH research fields to be examined, while the second is the stage when the topics that come to light in the first questionnaire are rated in order of importance.

In The Netherlands, the Delphi procedure was preceded by a first step in which various groups of key informants expressed their opinion on the priorities of OSH topics, and these were then used to establish priority lists through the two questionnaire rounds. The NIOSH also used a modified Delphi procedure which initially took account of the opinions of a group of senior scientists inside and outside NIOSH and then identified research priority areas using written and verbal comments from other working groups as the input.

The study that differs most from the others regarding the methods and the subjects involved is the one by the European Agency for Safety and Health at Work. With the Delphi technique the first round of questionnaires leaves the interviewees free to list what they consider priority research areas, but the European Agency used as its basis for study the National Reports of each Member State, listing research priorities identified by samples of experts that were not always fully representative of OSH, on the basis of lists of research topics proposed by the Agency itself. The interviewees were not free to select the areas where they considered it necessary to extend knowledge in order to safeguard workers' health. There were also problems in comparing the results from the various countries because in some cases topics were added to the Agency's list and the subjects involved were different. In some cases the limited information produced by this study was boosted by data obtained in previous analyses, which are therefore hard to compare.

The Japanese study did not use the Delphi technique, but took into account the opinions of representatives of all the occupational health sectors attending the Conference on Occupational Health Research Strategies in the 21st Century, who identified about 350 research areas, which were subsequently grouped under 58 headings. The opinions expressed by those attending the Conference were then confirmed by consultations with 240 extramural OH specialists.

The Global Agenda had its origin in a modified Delphi technique in which the Directors of WHO Collaborating Centers from developed, industrializing and developing nations reviewed proposed priorities applicable to workers globally and agreed upon 15 priority areas. All WHO Collaborating Centers in Occupational Health, as well as Network partners ILO, IOHA, ICOH and IEA are conducting projects within these priority areas within the 2001–2005 Global Work Plan[17]. Many of the projects are practical efforts to build capacity and to share solutions to work problems. WHO is currently reviewing progress of the projects and will bring proposals to the Network partners in 2005 for review and decisions regarding the 2006–2010 Work Plan.

Comparative analysis indicates that the Delphi technique is a good method, in that it covers a wide range of qualified witnesses, from a variety of backgrounds —such as trade union representatives and researchers— providing different viewpoints. It also takes account of the intrinsic features of OSH, which —compared to other disciplines— involves multidisciplinary factors calling into play a range of scientific settings such as toxicologists, molecular biologists, epidemiologists, occupational hygienists and occupational physicians.

The importance of the surveys to identify priority research areas for OSH is clear from the impact they have had in various countries. In the United Kingdom, the British Occupational Health Research Foundation has assigned a large part of its research budget to the topics that were given priority. Current research at the BOHRF is focused on musculo-skeletal disorders and rehabilitation techniques, aimed at restoring workers' health in the shortest possible time so they can return to work, and on intervention techniques for acute cases to prevent chronic illness. Numerous other projects are nearing completion, regarding, for example, stress and methods to reduce it by reorganizing work; or occupational asthma and its causes, and strategies to eliminate them.

In the NORA Priority Area Research Agendas numerous scientific papers have already been published on the main topics identified in the NIOSH study. These relate to the development of new research methods for occupational carcinogenesis, exposure assessment, problems of fertility and pregnancy, improvements in the work environment, evaluation of the efficacy of strategies to prevent accidents at work, musculo-skeletal disorders, work organization, and risk assessment. In order to foster research on the 21 priority areas, NIOSH has allocated increasing shares of its budget to the NORA programme. From 1996, when NORA was set up, to 2002, NIOSH investment has risen from 15.4 to 94.8 million dollars. Besides the NIOSH investments, other

partnering US Federal agencies have awarded research funding to competitive academic scientific proposals in the NORA areas, from 15 million in 1996 to more than 30 million in 2002[18].

The European Agency has set aside funds for further work on the topics assigned priority in the 1998 study. Since 2000, each year's European Week —the information campaign designed to promote health and safety at work in the 15 EU Member States— has focused on the priority topics identified. The European Week's themes have been musculo-skeletal disorders (2000), accidents at work (2001), stress at work (2002), handling dangerous substances (2003) and building in safety (2004). In 2005, the European Week will focus on the issue of the noise at work[19].

In Italy, a study on priorities for the allocation of resources has led the Ministry of Health to give absolute priority to financing research into occupational carcinogenesis, allocating 33% of the budget to this topic in 2002. Next in line are themes related to low-dose and multiple exposure (23%), the quality of air and the indoor environment (17%), biological agents (14%) and the health care and hospital sector (13%).

What should happen next with the national and global occupational research agendas? Clearly the burden of occupational disease and injury has not been substantially reduced during the current decade, but some countries have successfully focused on generating research with impact in workplaces in the important areas in their national agendas. The WHO Global Network and NIOSH for the U.S. NORA partners have initiated evaluations of the impact of their current research agendas and plan to return to the stakeholders for a decision regarding the reframing of the next agenda. Preliminary considerations suggest as interest in the U.S. to invite the stakeholders to consider an emphasis on moving research results into practice in workplaces over the next decade, and WHO plans to invite the Collaborating Centers to consider the following priorities identified by the ILO/WHO Joint Advisory Committee on Occupational Health, which held its Thirteenth Session in December, 2003[20]:

Guidance and support for national OSH programmes, including:
- providing models for organizing OSH at national or sub national levels;
- providing basic occupational health services;
- promoting OSH management systems and tools, including control banding;
- developing national profiles and indicators;
- assessing the cost effectiveness of OSH interventions;
- establishing effective enforcement agencies.

Enhancing regional collaboration and coordination, including:
- the development and dissemination of models for cooperation, such as the WHO/ILO Joint Effort on Occupational Safety and Health in Africa.

Coordination and enhancement of information and educational programmes and materials, such as:
- the development of a joint Internet-based global portal;
- statistics.

Awareness-raising activities and instruments, through:
- campaigns;
- events;
- special days.

The Committee recommended that special attention should be paid to the following global occupational safety and health issues in future ILO/WHO collaboration:
- the elimination of silicosis and asbestos-related diseases;
- violence at work;
- list of occupational diseases;
- occupational injuries.

The Committee members also recognized the importance of work-related psychosocial hazards and stress.

Assuming the seven countries and WHO retain or revise the eight research agendas, it would seem beneficial to consider for possible inclusion some of the recommendations of the Joint ILO/WHO Advisory Committee. Greater global sharing is needed of the results of research resulting from the current agendas. Better understanding is needed of "what works" to reduce worker risk, and this can be accomplished through evaluation research and economic analysis of the costs and benefits of workplace interventions, as is occurring now through four (50%) of the eight agendas. Greater availability of tools and training would benefit all nations. The advances of Internet technology in recent years can be exploited to make easily available research results, training (both electronic and traditional courses), and practical solutions to workplace problems in a form that is useful and easily accessible. WHO and ILO are working on the development of a global portal to link occupational safety and health information of all nations, and the European Union has successful EU information portal.

In conclusion, analysis and review of eight agendas indicates that development of a standardized methodology for reaching consensus on these issues is desirable for setting priorities in OSH.

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