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The contribution of occupational risks to the global burden of disease: summary and next steps*

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KEY WORDS

Occupational risk; global burden of disease

SUMMARY

Background: *The Comparative Risk Assessment (CRA) project of the World Health Organization (WHO) assessed worldwide mortality and morbidity in the year 2000 resulting from exposures to selected occupational hazards. This article summarizes findings of the WHO CRA project, presents the estimates of the International Labor Organization (ILO) for total deaths due to workplace risks, and calls for action.* **Objectives:** *Global burden estimates and counts of deaths assist ministers and other decision and policy makers to make informed decisions and to take action regarding risk reduction.* **Methods:** *The WHO CRA methodology combined the proportions of the population exposed to five occupational hazards (excluding numerous risks due to inadequate global data) with relative risk measures to estimate attributable fractions of the selected health outcomes for both morbidity and mortality. ILO estimates of total numbers of global work-related injury deaths apply national fatality rates to employment data for the particular country; for disease deaths ILO uses an attributable risk approach.* **Results:** *In 2000, the selected occupational risk factors were responsible worldwide for 37% of back pain, 16% of hearing loss, 13% of chronic obstructive pulmonary disease (COPD), 11% of asthma, 8% of injuries, 9% of lung cancer and 2% of leukemia, and about 100% of pneumoconioses and mesothelioma. These selected risks at work resulted in the loss of about 24 million years of healthy life and caused 850,000 deaths worldwide, about 40% of the ILO estimate of 2.2 million total deaths.* **Conclusions:** *These global and regional analyses have identified areas where specific preventive actions are required.*

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Riassunto

«Il contributo dei rischi professionali al "Global Burden of Disease": riepilogo e prossimi obiettivi». *Il progetto Valutazione Comparativa dei Rischi (Comparative Risk Assessment) della Organizzazione Mondiale della Sanità ha valutato la mortalità e la morbilità mondiale nell'anno 2000 derivanti da specifici rischi professionali. Questo articolo, che riassume i risultati del progetto WHO CRA, presenta le stime della Organizzazione Internazionale del Lavoro sull'incidenza dei rischi presenti nei luoghi di lavoro e sul totale delle morti e invita all'azione. Le stime e il conteggio delle morti aiutano i ministri e altri uomini politici a compiere scelte informate e ad agire sulla riduzione dei rischi. Il metodo WHO CRA correla la proporzione di popolazione esposta a cinque rischi professionali (escludendone numerosi a causa di dati inadeguati) con la relativa misura del rischio per stimare la frazione di rischio attribuibile per ciascuno degli indicatori scelti (mortalità e morbilità). La stima dell'ILO sul numero globale delle morti dovute a infortuni professionali applica i tassi di mortalità nazionali per ciascun paese ai dati sull'occupazione; per le morti per malattia l'ILO usa un approccio di tipo rischio attribuibile. Nel 2000 i rischi professionali selezionati rendevano conto in tutto il mondo del 37% delle lombalgie, del 16% delle perdite di udito, del 13% delle broncopneumopatie croniche ostruttive, 11% dei casi di asma, 8% degli infortuni, 9% dei tumori del polmone e del 2% delle leucemie e circa il 100% delle pneumocoiosi e dei mesoteliomi. Questi specifici rischi professionali sono responsabili della perdita di circa 24 milioni di anni di buona salute e hanno causato 850000 morti in tutto il mondo, circa il 40% dei 2,2 milioni di morti totali stimati dall'ILO. Queste analisi condotte su scala globale e regionale, hanno identificato le aree dove sono necessarie azioni preventive specifiche.*

Introduction

Estimates of health burden at a population level, whether using a state, national or global focus, have several important potential benefits. They attract the attention of policy makers and the community by showing the size of the problem. They also provide guidance to policy makers on how to expend limited resources by identifying the major disorders and the exposures resulting in the largest burden, so that appropriate interventions can be put in place to reduce injury and illness.

Over the last decade some significant research has focused on estimating the global burden of ill health due to various health disorders and due to specific exposures (10, 19, 20, 21, 29, 30). This work has included analyses of exposures and outcomes related to work activity. Recent additions to this important topic include a Special Issue of the American Journal of Industrial Medicine (AJIM) entitled *Contribution of Occupational Risks to the Global Burden of Disease* (11) that amplifies for an occupational health readership the work prepared for the Comparative Risk Assessment (CRA) project of the World Health Organization (2, 3, 10). The International Labor Organization has published new updated estimates of numbers of global occupational accidents and work-related diseases in its *Introductory Report: Decent Work – Safe Work* for the 17th World Congress on Safety and Health at Work (15). *Global estimates of occupational accidents* are analyzed in detail by Hamalainen et al (2006) (12).

The international organizations responsible to the member states of the United Nations (UN) on global occupational health and safety are the World Health Organization (WHO), which primarily relates to National Ministries of Health, and the International Labor Organization (ILO), which relates primarily to National Ministries of Labor as well as to representatives of Employers and of Labor. Traditionally ILO and WHO issue independent estimates of burden related to work activity (15, 10). The editorial in the AJIM Special Issue by occupational health leaders in WHO and ILO brings a desired unity of opinion to the occupational health community (9).

This article summarizes some of the information published in the 2005 Special Issue of the American Journal of Medicine devoted to the *Contribution of Occupational Risk Factors to the Global Burden of Disease* (11), provides the methodology and the findings, and places the WHO results in context with estimates of the ILO of total annual fatalities due to occupational risks.

METHODS

Global burden of disease

A "burden of disease" study estimates the gaps between current population health and a normative goal for population health, for a comprehensive set of disease and injury causes, and for major risk factors. The World Health Organization's ongoing Global Burden of Disease (GBD) project provides comprehensive, consistent, and regularly updated estimates of mortality and morbidity for more than 135 causes of disease and injury (33). WHO conducted a Comparative Risk Assessment (CRA) using global data for the year 2000 and a common methodology to estimate the contribution to the health outcomes due to exposures to 26 risk factors grouped in seven major categories of risk factors: childhood and maternal under-nutrition, other diet-related risk factors and physical inactivity, sexual and reproductive health, addictive substances, environmental risks, selected occupational risks, and other risks to health (10). The CRA used a consistent methodology throughout the project so that the impacts of these risk factors could be compared, thus improving the evidence base on distribution and costs of diseases and injuries by risk factor. The purpose was to support rational health policy decisions worldwide to develop interventions to reduce risks. All estimates were stratified by age, gender, and WHO subregions, thus providing regional results for the 191 Member States of WHO that are located in six geographical regions (Africa, Americas, Europe, Eastern Mediterranean, Southeast Asia, and Western Pacific).

Comparative risk assessment

Various measures have been developed to quantify population health, but the most useful for the GBD studies is the disability-adjusted life year (DALY). This is a summary measure, which calculates the years lost from an ideal lifespan due to both morbidity and premature mortality. The DALY thus represents the gap between the current situation, and an ideal situation where everyone achieves standard life expectancy (82.5 years for women, 80 years for men) in perfect health (25, 26).

The heart of CRA was determining the number of DALYs and deaths attributable to the various risk factors, in a manner that allows comparisons to be made. This determination is based on attributable fractions, i.e., the proportion of the incidence of a given health outcome in a given population that is identified as due to a given exposure (25, 26). Attributable fractions of a health outcome were calculated from estimates of the proportion of a population exposed to a risk factor, combined with relative risks of disease or death due to the health outcome resulting from that exposure. The total number of deaths and/or DALYs attributable to the given exposure was determined by multiplying the attributable fraction by the number of deaths and/or DALYs estimated by WHO for the relevant health outcome in the Global Burden of Disease analysis.

WHO comparative risk assessment for selected occupational risk factors

The methodology by which the WHO CRA methodology was used to assess the contribution of occupational risk factors to the global burden of occupational disease and injury is described in Nelson et al, 2005a (22). The stringent requirements of the CRA permitted CRA analysis of only five selected occupational risk factors for which there were adequate global data: occupational carcinogens (6), airborne particulates (7), noise (23), and ergonomic stressors (27) and risks for injuries (3). Also included in the AJIM Special Issue is a separate analysis of Hepatitis B, Hepatitis C and HIV/AIDS infections in Health Care Workers due to needlesticks (26).

Excluded exposures and outcomes

The criteria for inclusion of *risk factors* in the CRA study were: adequate exposure information for all regions, and the applicability of health outcome data to all regions of the globe. Inclusion of a *health outcome* required that it be in the WHO GBD database of diseases and injuries (10). These

strict criteria precluded CRA analysis of many occupational risks, including: some respiratory diseases; some infectious diseases; less widespread cancers and carcinogens; musculoskeletal disorders other than low back pain; intentional injuries in the workplace; commuting injuries; organ and systemic diseases resulting from occupational exposure to solvents, pesticides and heavy metals; maternal and perinatal conditions resulting from occupational exposures; skin disorders; coronary heart disease and other outcomes associated with work-related stress. Child labor could not be included due to the lack of consistent national definitions for the youngest ages included in the labor force, as well as lack of exposure and relative risk information on children.

Estimating exposed populations and risks for the selected occupational hazards

The general methodology is described in Nelson, 2005a (22), with details specific to the occupational risk factors provided in the separate papers in the AJIM Special Issue (11). Risk measures (relative risks or mortality rates) for the health outcomes resulting from exposure to the risk factors were determined primarily from studies published in peer-reviewed journals. Adjustments were made, as appropriate, to account for differences in levels of exposure, exposure duration, age, sex, and subregion.

The exposed-worker populations were estimated using an approach based on the International Standard Industrial Classification of All Economic Activities (ISIC), an economic classification system of the United Nations (UN) that organizes all economic activities by economic sectors and relevant sub-groupings (31). The ISIC system is used almost universally by national and international statistical services to categorize economic activity, and therefore allows global comparisons. The ILO has developed economically active population (EAP) estimates by applying economic activity rates (EAR), by sex and age group (greater than age 15) to the population estimates and projections of the UN (14). The EAP provides the most comprehensive global accounting of persons who may be exposed to occupational risks as it includes people in paid employment, the self-employed, and people who work to produce goods and services for their own household consumption, both in the formal and informal sectors. For the WHO Comparative Risk Assessment, the EAP was further divided into nine economic subsectors (where people work) and seven occupational categories (what type of work people do), based upon country-level data for 31 countries (13, 22).

Methodology of the ILO

The ILO regularly updates its estimates of regional and global numbers of occupational injury deaths as new data become available. The estimate is obtained by applying national fatal injury rates for each country to the total employed labor force for that country. Where rates are not available for a country, rates from "similar or comparable" countries are applied. For estimates of total occupational disease deaths, ILO uses an attributable risk approach. Attributable fractions are taken form the Finnish study by Nurminen and Karjalainen (2001) (24), with some minor modifications to take account of particular conditions and regions. These fractions are applied to overall disease death estimates by age and sex in the WHO Global Burden of Disease database (8).

Results

The WHO Comparative Risk Assessment data provide detailed, yet still incomplete, results for the global problem of occupational health risks. In total, the selected occupational risk factors accounted for 850,000 deaths per year, and for almost 24 million disability-adjusted life years lost (DALYs). Figure 1 illustrates the attributable fractions for the selected occupational risk factors.

The WHO CRA analysis found that occupational injuries result in about 312,000 deaths per year for the world's 2.7 billion workers (3). As in the industrialized world, high injury fatality rates in the developing world are clustered in certain sectors, including agriculture, construction, and

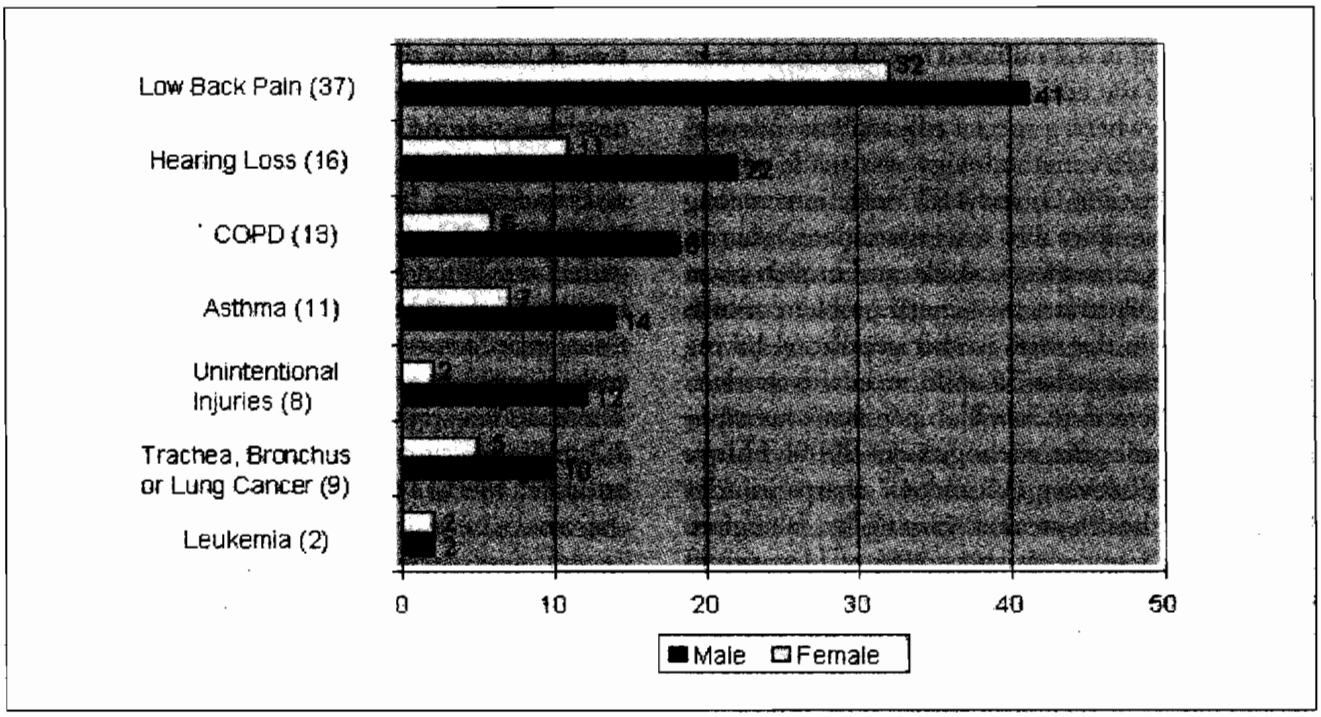

Figure 1 - Attributable fraction of global disease and injury due to occupational risk factors (the attributable fraction for the each of the pneumoconioses (silicosis, asbestosis and coal workers' pneumoconiosis) and for mesothelioma is assumed to be 100%, since virtually all exposure occurs in an occupational setting). Source: Adapted from (2)

mining. Occupational injuries accounted for more than 10 million DALYs and 8 percent of unintentional injuries worldwide. ILO estimated 335,000 deaths from occupational accidents in 1996 (29) and 350,000 in 1998 (12). The somewhat different methods give similar results, all of which noted by the authors to be underestimates of the true number.

The second occupational risk factor was exposure to workplace lung carcinogens (such as asbestos, diesel exhaust, and silica) and leukemogens (such as benzene, ionizing radiation, and ethylene oxide). The WHO CRA analysis found that occupational exposures account for about 9 percent of all cancers of the lung, trachea, and bronchus and about 2 percent of all leukemias. Overall, about 102,000 deaths were due to these two occupational cancers and about 1 million DALYs. An additional 43000 deaths and 563,000 DALYs were estimated for malignant mesothelioma, caused by asbestos. (6).

Estimates of the global burden of chronic nonmalignant lung disease demonstrate the significant contribution of occupational exposures. There were an estimated 386,000 deaths (asthma: 38,000; COPD: 318,000; pneumoconioses: 30,000) and nearly 6.6 million DALYS (asthma: 1,621,000; COPD: 3,733,000, pneumoconioses: 1,288,000) due to exposure to occupational airborne particulates. Occupational exposures accounted for about 13 percent of all chronic obstructive pulmonary disease (COPD) and about 11 percent of asthma. For the pneumoconioses (silicosis, asbestosis and coal workers' pneumoconiosis), the attributable fraction was assumed to be 100%, since virtually all exposure occurs in an occupational setting. (7).

The remaining selected occupational risk factors have in common the fact that they do not directly produce premature mortality but do result in substantial disability. This feature differentiates these conditions from the others analyzed in the study. The CRA analysis found that 37 percent of all back pain worldwide is attributable to work, resulting in an estimated 0.8 million DALYs, significant loss of time from work, and high economic loss (27). Additionally, worldwide, 16 percent of all

hearing loss was attributable to workplace exposures, resulting in 4.2 million DALYs (23).

Because of the critical role played by health care workers everywhere, a special risk analysis independent of the CRA methodology was made of Hepatitis B, Hepatitis C, and HIV infections among health care workers due to contaminated sharps, such as syringe needles, scalpels, and broken glass. This analysis illustrates the general problem of high risks existing in the small worker population having exposure. Among the 35 million health workers worldwide there were 3 million percutaneous exposures to bloodborne pathogens in 2000. This is equivalent to between 0.1 and 4.7 sharps injuries per year per health worker, varying by subregion. The analysis found that about 40% of Hepatitis B and 40% of Hepatitis C present in health care workers were due to sharps injuries, with wide regional variation. Between 1 percent and 12 percent of HIV/AIDS infections in health care workers was due to sharps injuries in different subregions, with an overall estimate of 4.4% (26) (figure 2).

In summary, the selected occupational risk factors included in the WHO Comparative Risk Assessment were responsible for about 850,000 deaths worldwide in 2000 and caused workers who developed outcomes related to these occupational risk factors to lose about 24 million years of healthy life. Injuries, hearing loss, and COPD together accounted for about 80 percent of years of healthy life lost. Just three of the selected occupational risk factors (carcinogens, airborne particles and injuries) accounted for the 850,000 deaths. These deaths constitute less than 40% of the total 2.2 million occupational disease and injury deaths estimated by ILO to have occurred in 2000 (15).

Discussion

The AJIM Special Issue examines the role of burden estimates in global health and safety, notes the issues and general principles associated with developing such estimates, and puts the WHO

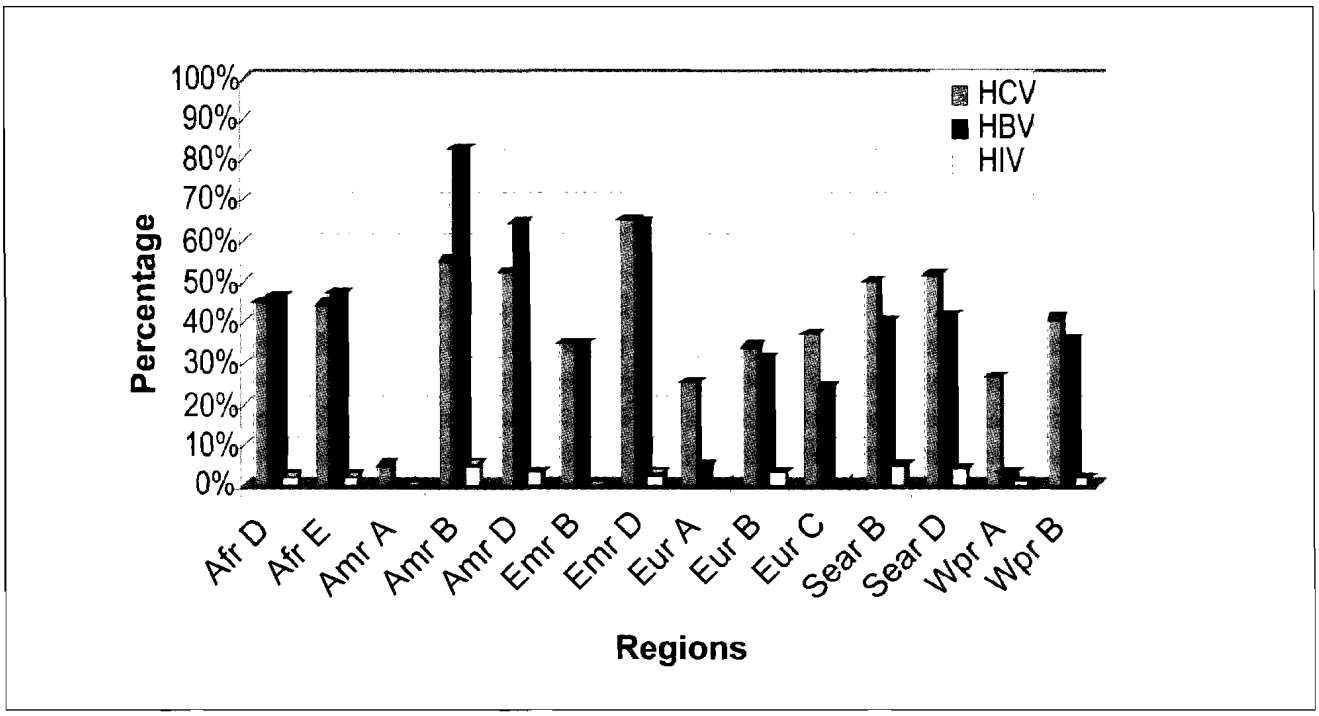

Figure 2 - Attributable fraction of HCV, HBV, and HIV infections in health care workers due to injuries with contaminated Sharps. Source: (32)
HCV: Hepatitis C Virus; HBV: Hepatitis B Virus; HIV: Human Immunodeficiency Virus; Afr: Africa; Amr: America; Emr: Eastern Mediterranean; Eur: Europe; Sear: South-East Asia; Wpr: Western Pacific

CRA estimates into context with ILO independent estimates.

The WHO Comparative Risk Assessment has accounted for only about 850,000 of the more than 2.2 million deaths estimated by ILO to occur each year due to occupational illness and injury (15). This is primarily because deaths due to a wide range of occupational exposures could not be included in the CRA study due to the strict requirements for global data. It is important to note that the consequences of grave underreporting in existing systems and the dearth of high quality record-keeping systems in the developing nations lead to substantial undercounting by both the ILO and WHO. Additionally, the absence of adequate data particularly in developing countries requires that all global estimates utilize extrapolation from developed country data. Despite the data deficiencies, however, the global analyses provide important insights into the immense global burden of disease and injury due to occupational risk factors.

Next steps

Improve data collection

One of the important limitations for carrying out the global burden studies, and also national burden studies in terms of occupation, is the lack of reliable data, particularly in developing countries. Clearly, it is important for countries to improve national statistics describing traditional exposures and health outcomes. Challenges exist for the scientific community to develop methods and criteria for newer etiologically relevant physical and psychosocial exposures and outcomes. Only then can countries develop such databases using standardized methods and criteria.

However, it is critical, particularly in situations with scarce resources, to find the right balance between "perfect data" and "enough data to act". It should be noted that 2.2 million deaths per year place annual occupational fatalities higher than deaths due to tuberculosis (1,644,000) and almost double the deaths from malaria (1,124,000) that were reported in the 2002 WHO World Health Report (32). The analyses reported here and by others provide more than adequate evidence to act to reduce workplace risks.

Improve methodologies

Future analyses need to use different approaches in order to "triangulate" results, hopefully leading to confidence regarding which estimate is closer to the true burden. Improvements in injury estimates are likely to come from more country-specific outcome data; clearer delineation of the type of cases included (particularly by excluding disease cases, separately identifying commuting cases, including homicide cases, and deciding whether to include or exclude suicide cases); better estimates of the true population at risk by including child workers and workers in the informal sector; and inclusion of bystanders. Improvements in disease estimates will probably arise from the use of better country or region-specific exposure data, allowing more appropriate attributable risks to be used, and improved relative risk estimates for cardiovascular, malignant, respiratory, and communicable diseases.

It should also be noted that as a basis for decision-making and policy setting, information on global burden, whether measured by deaths or DALYs, needs to be complemented by additional information, in particular on the cost-effectiveness of various interventions. This information is required if preventive activity is to be targeted as appropriately as possible, although information on the number of deaths makes an important contribution to awareness raising, monitoring, and to initial prioritization of resources. The AJIM Special Issue includes 3 articles illustrating how cost-effectiveness studies could be done (16-18)

Calculate national and regional burden

In order to assist ministers and other policy makers, as well as scientists in the countries, WHO has made available guidance for performing national and local assessments of disease and injury burden due to the selected occupational risk factors. Documents illustrating how to assess the national and local burden of disease from work-related noise, occupational carcinogens, and occupa-

tional particulate exposure are available free of charge at http://www.who.int/quantifying_ehimpacts/publications/en/ (1, 4, 5, 25, 28).

Introduce workplace interventions to reduce risks

Strategies for controlling injury and occupational disease, developed by industrial hygienists and others over many decades in industrial countries, are fully applicable in developing countries. The strategies include a hierarchy of controls in decreasing order or preference: substitution of major hazards for less hazardous materials or processes; application of engineering controls to separate workers from hazards that remain; use of administrative controls to minimize contact uncontrollable by engineering; and, as the last line of defense, the use of personal protective equipment such as respirators and protective garments. What differs in developing country situations is the context in which the controls must be applied.

An example of an approach supported by WHO and ILO to use knowledge about exposure to provide simplified guidance to immediately control the hazards is "control banding", re-named as the Occupational Risk Management Toolbox (see http://www.ilo.org/public/english/protection/safework/ctrl_banding/index.htm). The approach of, for example, a Chemical Toolkit is to provide practical risk assessment and management approaches that can be applied across the board by employers and workers.

The WHO Global Network of about 70 Collaborating Centers in Occupational Health fosters such projects, which can be seen in the new 2006-2010 Work Plan of the Collaborating Centers at www.who.int/oeh.

Solutions exist to address risks experienced by health care workers from contaminated sharps, as illustrated in figure 2, in the countries and regions that have engaged in serious prevention efforts. Proper needle handling and waste management, substitutions for sharps, Hepatitis B virus (HBV) immunization, post-exposure prophylaxis, training, and legislative measures have been successful. Beyond the personal and workplace consequences, the potentially devastating societal impact of loss of this critical worker group can be anticipated if prevention measures are not ensured in the developing countries where the proportion of healthr care workers in the population is already small. This situation is so critical that the topic this year for the April 7, 2006 WHO World Health Day is Health Workers (See http://www.who.int/world-health-day/2006/en/.)

Conclusion

The magnitude of the occupational health burden in the world is overwhelming, and the causes and mechanisms behind it are multiple and complex. The magnitude calls for an integrated, coordinated, and strategic response. Particularly the health and labor sectors, together with the social partners (workers and employers), but also non-governmental organizations (NGOs), training institutions, and local governments play key roles in addressing the occupational health and safety issues. Commitment from all partners to improve occupational health and safety for all workers, is essential to translate economic progress to sustainable human development.

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