Chapter **60**

Occupational Health

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Workers around the world—despite vast differences in their physical, social, economic, and political environments—face virtually the same kinds of workplace hazards. These hazards are traditionally categorized into four broad types: chemical, biological, physical, and psychosocial. What emerges from our incomplete knowledge of their risk, however, is that the more than 80 percent of the world's workforce that resides in the developing world disproportionately shares in the global burden of occupational disease and injury. Several classic occupational diseases, such as silicosis and lead poisoning, that have been substantially eliminated in industrial countries remain endemic elsewhere in the world. Whether this high and preventable burden of ill health faced by workers in the developing world is the result of ignorance, inattention, or intent, compelling evidence indicates that work-related health conditions could be substantially reduced, often at modest cost.

NATURE AND CAUSES OF OCCUPATIONAL HEALTH CONDITIONS IN THE DEVELOPING WORLD

Despite country-to-country differences, some commonalities exist within the workforce of the developing world that are worth noting. Workforce distribution by economic sector is different from that in the industrial world. Compared with industrial countries, where single-digit percentages prevail—for example, approximately 2 percent in the United Kingdom—developing countries employ about 70 percent of their economically active population in the agricultural sector (World Bank 2003). For many of these workers, the distinction between health at work and health at home is blurred, because health in the workplace is integrated into all aspects of daily life for these often subsistence agricultural workers. For example, pesticide poisoning is a hazard faced by workers and their families and communities.

The informal workforce, which in industrial countries is rarely larger than 10 percent of total employment, looms large in developing countries. This workforce includes self-employed, household-based unpaid labor (family members, for example) and independent service workers such as street vendors. In the developing world, employment in the informal sector may reach 70 percent, with the contribution to the gross domestic product (GDP) ranging from 10 to 60 percent (ILO 2002).

Informal economy workers are often unprotected in the regulatory arena even in the industrial world. This circumstance is exacerbated when the vulnerable employment status in the developing world is coupled with problems of poverty and ill health. Cottage-industry workers abound in the informal sector, and home-based work can fully blur distinctions between occupational and other environmental hazards. Not uncommon across the developing world are lead-poisoned adults who manufacture batteries in crude facilities at home and their lead-poisoned children, exposed to the lead while sleeping and playing in the next room.

The migrant workforce, which is increasing worldwide, is estimated to be 120 million (ILO 2000). In the industrial world, immigrant workers often perform work deemed unattractive (seasonal agricultural work in the United States, service sector work in the United Kingdom), but the issues of a migrant workforce in some parts of the developing world take on even greater import. In southern Africa, for example, migrant mining workers face the extraordinary burden of risk for the triad

of silicosis, tuberculosis, and HIV/AIDS—diseases that are inextricably linked to interactive determinants of workplace, housing, and social and economic factors (Trapido and others 1996).

Workers in the developing world face different risks in the health transition than do their counterparts in the industrial world. They may be exposed to the combined and often synergistic risks of both traditional and emerging hazards. Workers may also face unregulated and unprotected exposures to known hazards just as those same hazards—silica and asbestos, for example—were faced decades ago by millions of workers in the industrial world. A significant difference, though, is that workers in the developing world are being exposed when widespread knowledge is available about the risks and effective preventive measures (Kjellstrom and Rosenstock 1990). Even as these workers are forced to replay history, despite the availability of information and knowledge transfer unthinkable just a generation ago, they face other hazards, including the production, marketing, and importation of environmental hazards such as cigarettes. In the instance of asbestos and tobacco, both products are being aggressively marketed and exported by the industrial world (especially asbestos from Canada and tobacco from the United States) to the developing world.

A real example of hazards faced by developing workers in what might be called the *risk transition* is that posed by dual exposure to asbestos and cigarette smoke and risk for lung cancer. This example is especially troubling not only because the risk is dauntingly high but also because exposures to both are occurring with full knowledge of their individual and cumulative effects. As shown in table 60.1, against a background of relative risk for lung cancer of 1 for a nonsmoking, nonasbestos-exposed population, a working population with significant asbestos exposure but no tobacco exposure may face a relative risk of lung cancer of 5; a smoking population not exposed to asbestos faces a relative risk of 10; and rather than these risks being additive (that is, 15) the smoking, asbestos-exposed population has the extraordinary relative risk of lung cancer of 50. Most important, in this well-recognized multiplicative-effect scenario, if the smoking exposure alone were eliminated among the asbestos-exposed workers, the overall risk of lung cancer would be reduced by 90 percent; even if the smoking exposure continued, elimination of the asbestos exposure would reduce the overall risk by 80 percent. Those considerations are not theoretical but well supported by empirical data. In parts of China and elsewhere in the developing world, asbestos exposure abounds as cigarette smoking is rising. Effective intervention strategies will be those based on a comprehensive approach to the overall burden rather than those addressing the individual burdens of specific exposures, recognizing that organizational or institutional interventions (such as eliminating asbestos from the workplace) are far more effective than those targeting individual behaviors (such as smoking cessation).

Table 60.1 Relationship between Asbestos, Smoking, and Risk for Lung Cancer

	Asbestos exposure[a]	
Smoking[b]	**No**	**Yes**
No	1	5
Yes	10	50

Source: Kjellstrom and Rosenstock 1990.
a. If asbestos exposure eliminated, eliminate 80 percent lung cancers in asbestos workers.
b. If smoking eliminated, eliminate 90 percent lung cancers in asbestos workers.

GLOBAL BURDEN OF DISEASE FROM OCCUPATIONAL HEALTH RISKS

The overall picture that emerges from all parts of the developing world is one of increased health and safety risks in all occupations for which data are available.

Dramatic changes in the global labor force will occur as globalization and population growth continue to affect the global economy. For example, the labor force in Latin America and the Caribbean is one of the fastest growing in the world, with 217 million workers in 2000; the number of workers is expected to reach 270 million in 2010 (PAHO 2002). The burden of disease and injury attributable to workplace risks in the formal and informal sectors is grave and will continue to rise. Inadequate data and reporting systems make capturing the effect of workplace risks problematic. Nonetheless, several recent efforts by international bodies have shed some light on the staggering burden, although in general attempts to derive evidence-based estimates are likely to systematically and significantly underrepresent the extent of the problem.

The gravity of workplace risks is seen in the recent International Labour Organization (ILO) estimate that among the world's 2.7 billion workers, at least 2 million deaths per year are attributable to occupational diseases and injuries. The ILO estimates for fatalities are the tip of the iceberg because data for estimating nonfatal illness and injury are not available for most of the globe. The ILO also notes that about 4 percent of the GDP is lost because of work-related diseases and injuries (Takala 2002).

A recent effort of the World Health Organization (WHO) has provided insight into the global dimensions of several selected occupational health risks. WHO included five occupational risk factors in its comparative risk assessment in a unified framework of 26 major health risk factors contributing to the overall global burden of disease and injury (Ezzati and others 2004; WHO 2002). The WHO comparative approach used a common statistical model that allows a reader to compare the contribution (attributable fraction) of several risk

factors to a single outcome—lung cancer, for example. Stringent requirements for consistency in describing risk factors limited the number of occupational risk factors that could be included in the study. For all risk factors, it was necessary to estimate an exposed population and exposure levels for 224 age, sex, and country groups in the 14 WHO geographic regions of the world. Where possible, data could be extrapolated to age, sex, and country groups for which data were not available, based on similarities in demographic, socioeconomic, or other relevant indicators. Because knowing the existing burden of disease and injury globally was necessary, the only outcomes included were those for which WHO had rates of disease or injury for all regions calculated by International Classification of Disease (ICD) codes. Finally, estimates of the risk factor–burden relationships by age, sex, and WHO subregion were generated. 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 to account for differences in levels of exposure; exposure duration; and age, sex, and subregion, as appropriate. The information about each risk factor was entered into the WHO common model for comparative analysis. The resulting burden was described as the attributable fraction of disease or injury, using mortality and disability-adjusted life years (DALYs) lost, with one DALY being equal to the loss of one healthy life year—the common currency measure that includes mortality and morbidity.

Because of the requirements for global data, only five occupational risk factors could be described: risks for injuries, carcinogens, airborne particulates, ergonomic risks for back pain, and noise. 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 that organizes all economic activities by economic sectors and relevant subgroupings (UN 2000). The ISIC system is used almost universally by national and international statistical services to categorize economic activity; therefore, it allows global comparisons. The ILO has developed economically active population (EAP) estimates by applying economic activity rates, by sex and by age group (older than age 15), to the population estimates and projections of the United Nations (ILO 1996). The EAP provides the most comprehensive global accounting of people who may be exposed to occupational risks because 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 in the informal sectors (ILO 2002). 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), on the basis of country-level data for 31 countries (ILO 1995).

The absence of data in much of the developing world limited the range of occupational risk factors that WHO could measure, and the available data excluded children under age 15 who work. The WHO comparative risk assessment also excluded important occupational risks for reproductive disorders, dermatitis, infectious disease, coronary heart disease, intentional injuries, musculoskeletal 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. The potential consequences of omitting just pesticides from the global burden analysis can be illustrated by the situation in Central America (PAHO 2002). The isthmus is primarily an agricultural and forested area of .5 million square kilometers, of which 40 percent is arable. Pesticide imports almost tripled from 15,000 metric tons in 1992 to 41,000 in 1998, and 35 percent of the pesticides were restricted in the exporting countries. In 2000, the subregion imported some 1.5 kilograms of pesticides per inhabitant per year, a quantity 2.5 times greater than the world average estimated by WHO. Exposures in the formal and informal sectors extend to the homes and families of the pesticide workers. Although this situation is common in developing nations, the WHO comparative risk assessment captured none of these exposures.

The ILO and WHO data provide the most current, yet still incomplete, picture of the overall problem of occupational health risks. Nonetheless, with just the few occupational risk factors studied in depth by WHO a picture emerges of the significant effect of largely preventable conditions (Ezzati and others 2004). WHO found that occupational injuries result in about 312,000 deaths per year for the world's 2.7 billion workers; this figure contrasts to the approximately 6,000 deaths per year caused by occupational injuries for the 150 million workers in the United States. As in the industrial world, high injury fatality rates in the developing world are clustered in certain sectors, including agriculture, construction, and mining. Using this metric, occupational injuries account for more than 10 million DALYs and 8 percent of unintentional injuries worldwide.

The second occupational factor WHO analyzed was the effect of exposure to workplace lung carcinogens (such as asbestos, diesel exhaust, and silica) and leukemogens (such as benzene, ionizing radiation, and ethylene oxide). WHO concluded 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 attributable to these two occupational cancers and about 1 million DALYs.

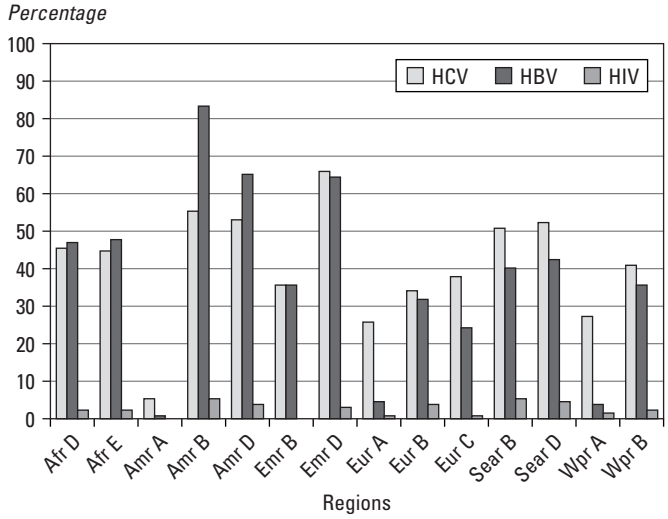
Estimates of the global burden of chronic lung disease demonstrate the significant contribution of occupational exposures, which account for about 13 percent of all chronic obstructive pulmonary disease (COPD) and about 11 percent

of asthma. In total, WHO found the annual worldwide burden of work-related COPD to be about 318,000 deaths per year and about 3.7 million DALYs. The occupational risk contribution to the worldwide asthma burden was about 38,000 deaths and about 1.6 million DALYs, reflecting the fact that a great deal of asthma occurs at younger ages and is not fatal. WHO found that 37 percent of all back pain worldwide is attributable to work, resulting in an estimated 800,000 DALYs, a significant loss of time from work, and a high economic loss. Worldwide, 16 percent of all hearing loss is attributable to workplace exposures, resulting in 4.2 million DALYs.

WHO made a special risk analysis of hepatitis B, hepatitis C, and HIV infections among health care workers caused by contaminated sharps, such as syringe needles, scalpels, and broken glass (WHO 2002). This analysis illustrates the general problem of high risks existing in the small worker population having exposure. WHO found that, among the 35 million health workers worldwide, there were 3 million percutaneous exposures to bloodborne pathogens in 2000. This finding is equivalent to between 0.1 and 4.7 sharps injuries per year per health worker. WHO concluded that of all the hepatitis B and hepatitis C present in health care workers, about 40 percent was caused by sharps injuries, with wide regional variation. WHO also found that between 1 and 12 percent of HIV infections in health care workers was caused by sharps injuries. The comparative risk assessment by region and type of infection indicates where special emphasis is needed (see figure 60.1). Clearly, solutions exist to these problems, as shown by the countries that have engaged in serious prevention efforts. Proper needle handling and waste management, substitutions for sharps, hepatitis B virus (HBV) immunization, postexposure 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 developing countries, where the proportion of health care workers in the population is already small.

In total, the few occupational risk factors considered here were responsible for about 800,000 deaths worldwide in 2000. Not considered by WHO because of lack of global data are the additional 1.2 million deaths that ILO estimated are attributable to work-related risks (Takala 2002). The leading occupational cause of death was unintentional injuries, followed by COPD and lung cancer. Workers who developed outcomes related to these occupational risk factors lost about 25 million years of healthy life. Among the occupational factors analyzed in this study, injuries, hearing loss, and COPD accounted for about 80 percent of years of healthy life lost. Low back pain and hearing do not directly produce premature mortality, but they do result in substantial disability. This feature differentiates these conditions from the others analyzed in the study. Figure 60.2 provides summary results for the occupational risk factors.

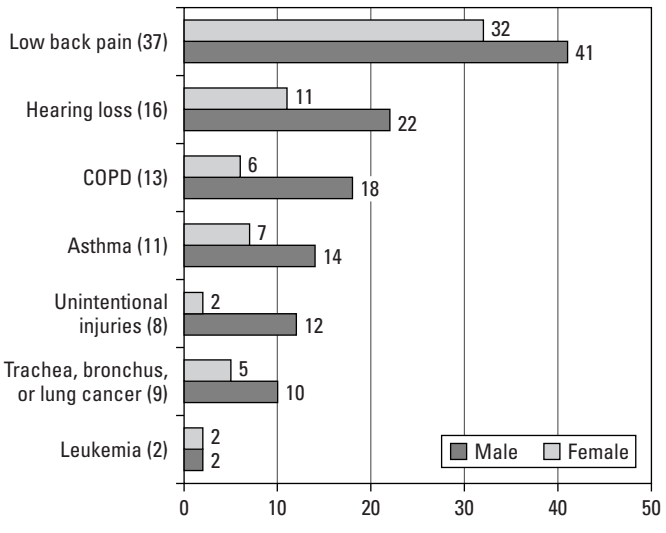
The WHO comparative risk assessment has accounted for only about 800,000 (40 percent) of the 2 million deaths estimated by ILO to occur each year because of occupational illness and injury. Deaths attributable to a wide range of occupational exposures could not be included because of the



Source: WHO 2002, 130.

HCV = hepatitis C virus; HBV = hepatitis B virus; HIV = human immunodeficiency virus; Afr = Africa; Amr = America; Emr = Eastern Mediterranean; Eur = Europe; Sear = Southeast Asia; Wpr = Western Pacific.

Figure 60.1 Fraction of Hepatitis C Virus, Hepatitis B Virus, and HIV Infections in Health Care Workers Attributable to Injuries with Contaminated Sharps, Ages 20 to 65



Source: Adapted from Nelson and others 2005.

Figure 60.2 Fraction of Global Disease and Injury Attributable to Occupational Risk Factors
(percent)

strict requirements for global data. Missing are deaths attributable to asbestosis, silicosis, and other dust diseases; infectious diseases; cardiovascular diseases; and violence. Deaths attributable to workplace exposures to pesticides, heavy metals, solvents, and other chemicals are not included. Outcomes such as dermatitis, psychological disorders, and upper-extremity musculoskeletal disorders that cause little mortality but substantial disability are also not captured by the WHO comparative risk analysis. Additionally, the consequences of underreporting in existing systems and the dearth of record-keeping systems in the developing nations lead to substantial undercounting by both the ILO and WHO. Nonetheless, the analyses provide important insights into the immense global burden of disease and injury attributable to occupational risk factors.

INTERVENTIONS

Strategies for controlling injury and occupational disease, developed by industrial hygienists and others over many decades in industrial countries, are as fully applicable in developing countries. The strategies include a hierarchy of controls in the following decreasing order of preference: substituting major hazards for less hazardous materials or processes; applying engineering controls to separate workers from hazards that remain; using administrative controls to minimize contact uncontrollable by engineering; and, as the last line of defense, using personal protective equipment such as respirators and protective garments. What differs in developing countries is the context in which the paradigm must be applied. Options are often sharply limited, and knowledge of them even more so; economic and political factors may impede otherwise obvious or desirable solutions; and the differing workplace context may demand that attention be paid to certain problems and concerns that would not be relevant in industrial countries in temperate climates.

The following generic factors associated with work in developing countries may alter industrial hygiene practice and must be considered in every effort to intervene to improve working conditions and occupational health:

- Access to industrial hygiene consultation is limited; professionals, sampling equipment, and laboratories are all in short supply.
- Knowledge level about occupational health among managers and workers is often limited.
- Markets for production materials as well as safety equipment may be limited and may include more hazardous materials or less effective protective equipment "dumped" from industrial countries where they are no longer marketable (Hecker 1991; Ives 1985; Jeyaratnam 1990).
- Regional conflict, economic pressures, climatologic factors, and lack of foreign exchange may make otherwise straightforward choices impractical.
- Supply of labor is often high, as is turnover, so economic incentives for investment in health capital are lower than in industrial countries.

Strategies for Improving Working Conditions

With these differences in context in mind, we now consider the major types of intervention: international, national, workplace, and individual.

International Interventions. The ILO–WHO Joint Committee on Occupational Health was formed in 1950 to provide guidance to the ILO and WHO regarding international occupational health issues. The committee meets periodically. At its 13th session, held in December 2003, the committee recommended that WHO and ILO pursue the following priorities (ILO and WHO 2003):

- Guide and support national occupational safety and health programs. Such guidance and support includes providing models for organizing at national or subnational levels; providing basic occupational health services; promoting management systems and tools, including control banding; developing national profiles and indicators; assessing the cost-effectiveness of interventions; and establishing effective enforcement agencies.
- Enhance regional collaboration and coordination, including the development and dissemination of models for cooperation, such as the African Joint Effort.
- Coordinate and enhance information and educational programs and materials (for example, by developing a joint Internet-based global portal) and statistics.
- Provide awareness-raising activities and instruments through campaigns, events, and special days.

State or Government Interventions. The major role the government can play is to establish workplace rules and provide a system of dissemination and enforcement. Evidence from industrial countries is overwhelming that conditions are substantially improved when both a strong regulatory framework and enforcement are achieved. An added benefit of government, rather than private sector, control is to "level the playing field": all employers in an economic sector carry the same burden. Conversely, improved health of the workforce, achieved by developing strategies beyond the minimum required, could be used to confer competitive advantages, a message to reluctant employers that has been used in different parts of the world with some success.

Regulatory decisions, such as the choice of exposure limits or allowable practices, often stimulate the biggest discussion—

for example, the debate about dust levels to be allowed in South African mines—but the larger issue for most countries is garnering resources to ensure compliance, to attract adequately trained personnel to conduct inspections, and to establish and monitor laboratories to support regulatory efforts. The most stringent exposure levels (often referred to as *threshold limit values,* or *TLV*s) are useless if the offending hazard cannot be routinely and accurately measured. Indeed, the South African experience, despite the presence of excellent regulations, is not encouraging in this regard (Joubert 2002).

Other forms of government intervention may indirectly improve working conditions. Among these are workers' compensation regulations and stipulations that employers of certain sizes must engage professionals in health and safety (most often nurses). Each of these interventions has the advantage of stimulating certain behaviors and practices without requiring the government to maintain the elaborate and technically complex machinery required for direct monitoring of workplace conditions.

Constraints on governmental regulatory and other interventions are many. Occupational and environmental regulations are often perceived as burdensome costs that impede investment and growth, perhaps creating what has been referred to as "the race to the bottom," in which threat of outmigration of industry from one jurisdiction enhances reluctance to regulate or enforce control strategies (Frumkin 1999). Moreover, the costs to the government itself, notwithstanding technical support from such agencies as the ILO, may be considerable in terms of personnel and equipment, and occupational health has to compete with other public health priorities for scarce resources. The result may be the promulgation of minimal standards or emasculated enforcement of those that already exist. The general impression of those working throughout the developing world is that the level of regulation and enforcement is woefully inadequate compared with that in industrial countries. Detailed case examples from Brazil (Bedrikow and others 1997); Kenya (Mbakaya and others 1999); Nigeria (Asuzu 1996); and Taiwan, China (Chen and Huang 1997), underscore the ubiquity of this problem.

Workplace-Based Interventions. Issues beyond the economic and legal ones impede application of the principles of industrial hygiene. A primary factor is ignorance; many employers may be uninformed about available controls and their value. Insurance agencies, local safety groups, and—in some regions of the world—trade unions may serve as facilitators of positive influence. In general, however, such resources fall short of the benefit of on-site industrial hygiene expertise that is lacking in many regions of the world.

Economic factors often impede efforts to institute voluntary controls. Materials used are frequently far cheaper than safer substitutes, often precisely because these materials no longer have markets in industrial countries that have banned or restricted their use—for example, solvent mixtures containing benzene and construction materials containing asbestos. Similarly, equipment such as machines that are well guarded to prevent injury or well baffled to limit noise may be prohibitively expensive in a marketplace geared to "hand-me-downs" compared with respirators or gloves. Unfortunately, even these last lines of defense may be difficult to obtain or relatively expensive unless local suppliers are available.

The single strategy for which no compelling economic disincentive exists—training—may also be difficult. Through the efforts of the ILO and numerous nongovernmental organizations and with widening access to the Internet, vast resources have become available. Ample documentation from the industrial and developing world indicates that even rudimentary knowledge by supervisors and workers about risks and risk-prevention measures is beneficial. Major impediments remain, however, such as educational proficiency, language barriers, and the applicability of training materials—often developed in other contexts—to local situations. Thus, for example, although the ILO has recently reported success with information programs in rural Thailand (Kawakami and Kogi 2001), a report from Ghana (Smith-Jackson and Essuman-Johnson 2002) suggests that workers and supervisors were unable to correctly interpret four of the most common warning signs used for hazard identification, despite having been trained in their use. Worker training appears, on the whole, widely underused.

Problems of infections in patients and health care workers from reused needles and needlestick injuries have prompted the international organizations to develop model interventions that can be transferred elsewhere. WHO initiated Project Focus: Ensuring Immunization Safety in Burkina Faso in July 2002 as a pilot project to use WHO materials in a focused effort to address all issues related to injection and immunization safety: availability of equipment and supplies (auto-disposable syringes, safety boxes, incinerators); safe injection practices; safe vaccine delivery; and safe waste management (WHO 2002). In 2000, WHO conducted a survey to assess the safety of injections in a study group of a random sample of 80 health centers. The situation was reassessed in June 2003 to evaluate the use of safety boxes (which had been provided in a WHO immunization campaign in Burkina Faso in 2001) and the impact of Project Focus. Table 60.2 shows results of the reassessment. Dramatic reductions were found in needle recapping, needlestick injuries, and misuse of safety boxes. Additionally, the number of clinics using safety boxes increased from fewer than half to 86 percent.

Small enterprises present special challenges because they lack resources and expertise to address health and safety problems. Thailand's National Institute for the Improvement of Working Conditions and Environment has used the ILO

Table 60.2 Prevalence of Risk Factors and Injuries at 80 Observed Health Centers
(percent)

Year	Needle recapping	Needlestick injuries	Lack of safety boxes	Misuse of safety boxes
2000	55	71	51	83
2003	17	32	14	18

Source: S. Khamassi, WHO Mediterranean Centre, personal communication 2003.

training approach called WISE (Work Improvement in Small Enterprises) with some success. In one example, six enterprises in the metal industry in Bangkok with between 15 and 115 workers participated in the WISE program, in which practical workshops involved workers and management in deciding on changes to be made in the workplaces. A wide range of inexpensive changes were put in place, and a booklet to illustrate good practices for others was prepared (Krungkraiwong 2000).

Individual Interventions. The general principle that, for most public health intervention, organization-level change is more effective than strategies targeting the individual is even more true when it comes to the workplace. With the exception of self-employed workers, such as those in the informal sector and subsistence farmers, occupational health and safety does not lend itself readily to individual solutions, with the same factors limiting employees more likely to limit individuals.

Improvement of Access to Health Care

In a few developing countries, workers enjoy broad access to high-quality health care. Chile, for example, has a system of nonprofit employer mutual associations that provide advice on reducing risks in workplaces and medical treatment and sick pay for work-related illness and injury (Contreras and Dummer 1997). In most countries, the role of on-site services is generally limited to emergency services for an injury or accidental overexposure and the conduct of medical surveillance examinations for workers at risk for chronic conditions such as noise-induced hearing loss, pneumoconiosis, or cancer.

In the developing world, access to health care is critical both for work-related and other health issues. In many areas, especially remote or rural areas, on-site service may be the only health care services available to workers and their families. Moreover, the blurred distinction between "general health" and "occupational health" in societies where people live and work in the same community and environment, and where children and spouses of workers may share common exposures and adverse conditions with workers, serves to confer some advantage to a more holistic approach to health services often best provided at or near the workplace itself.

Control of Nonoccupational Exposures

In industrial countries, a sharp demarcation exists between environmental risks associated with work and those associated with home life. This differentiation is not the case in many developing countries, especially at large, remote industrial complexes and farms. Workers—with or without their families—often cohabit with the workplace—and often with many or all of its risks, including noise, chemicals, and biohazards. The most dramatic examples of this situation were the industrial disasters at Chernobyl and Bhopal. It is not just in disaster, however, that risk occurs. Pesticides, for example, result in hundreds of thousands of cases of poisoning a year, a high fraction from the misuse of farm chemicals for nonwork applications, such as the appropriation of empty (but not clean) drums for transporting water or other household goods, a disturbingly common practice. In the industrial setting, carcinogens, neurotoxins, and other hazardous chemicals often pollute homes, drinking supplies, and common areas for recreation on a daily basis, adding to the exposure of workers and placing nonworking family members at risk from what would normally be seen as workplace hazards.

The remedy is often complex and beyond traditional industrial hygiene practice. Housing, which in any event may be substandard, needs to be modified to exclude the possibility of contamination by effluent from farm or factory under any foreseeable circumstances. Children and family members need to be apprised of the hazards of all materials used for work and prevented from even accidental access, a situation complicated by the fact that children are themselves often inappropriately engaged in the workplace. Food and water supplies need to be secure and protected from cross-contamination, a particular problem in the farm setting.

Surveillance and Reporting

Even in industrial countries, the strategies for recording any aspect of workplace harm beyond acute injury has been an issue; in most developing countries, even injury reports are largely nonexistent. Still, broad agreement exists on the value of statistical summaries of occurrences.

Unfortunately, a strong disincentive exists for such reporting unless it is required by law or by a parent company (as in the case of some multinationals). If reporting is required, as in the formal laws of many countries, successful implementation calls for resources for systematic review, verification, and maintenance of the information. Even records whose limitations are otherwise legion, such as workers' compensation records or regional reporting schemes, have proven highly advantageous to control efforts in industrial countries. These, too, have a role in developing countries, helping target even rudimentary and limited control efforts.

Capacity Building

Human capital in the form of professional capacity is critical to improving working conditions. Professional capacity varies greatly in developing nations but is higher where recognition of the field is high and the need for professionals and for workplace expertise is driven by occupational safety and health legislation and enforcement. In Malaysia, for example, four decades of rapid industrialization have included a series of legislative acts; development of federal agencies; and inclusion of training at various levels in occupational health in universities, the public sector, and the private sector (Rampal, Aw, and Jefferelli 2002). Key international events, such as joining the World Trade Organization, encourage the development of an economic culture that better recognizes the value of safe workplaces. Enforcement of national regulations, adoption of International Standards Organization standards, and establishment of management systems lead to broadening of training for workers and managers, although the scarcity of trained professionals is a major obstacle to adequately implementing regulations and policies and providing occupational health services (Christiani, Tan, and Wang 2002; Wang, Cheng, and Guo 2002).

In countries with some capacity, the expertise tends to be medical, rather than in other areas, such as industrial hygiene, engineering, or ergonomics. In most countries, ministries of health and of labor have jurisdiction over working conditions but often have too few experts and inadequate coordination. Moreover, the large percentage of work conducted in the informal sector presents a special challenge to these ministries. Because globalization has brought the need for professionals in occupational health to a crisis level, it is appropriate for international trade and development bodies to support national and international capacity-building programs.

In 1970, when the United States enacted the Occupational Safety and Health Act that established the National Institute for Occupational Safety and Health (NIOSH), the country had little professional capacity in that field. The new law charged NIOSH with ensuring an adequate number of trained professionals and accomplished this task successfully by funding graduate programs in U.S. universities. A follow-up 25 years later found that 90 percent of NIOSH-supported trainees pursued careers in the field, with more than 50 percent working in private organizations and the balance in government and academia (U.S. DHHS 1996). Similar results could be achieved by a determined, large-scale effort focused on assisting developing countries in achieving adequate professional capacity.

Both infrastructure and programs are necessary to build adequate capacity. In the international arena, a number of successful coalitions exist that provide experienced institutions and individuals. The WHO Global Network of Collaborating Centers in Occupational Health is a strong international coalition of 70 national, governmental, and academic centers of occupational health that work together with WHO and ILO headquarters and regional offices and three international nongovernmental organizations: the International Commission on Occupational Health, the International Occupational Hygiene Association, and the International Ergonomics Association (Fingerhut and Kortum-Margot 2002). These partners, located in approximately 40 countries, work together in 15 priority areas within a 2001–2005 Work Plan. More than 300 projects are under way, independently or jointly, to benefit workers in developing and industrializing nations in about 15 priority areas (WHO 2003).

Another strong regional coalition, coordinated with and benefiting from the Global Network of Collaborating Centers, is the WHO–ILO Joint Effort on Occupational Health and Safety in Africa (WHO and ILO 2002b). This partnering coalition—where centers outside Africa assist African partners—includes individual occupational safety and health professionals, employers, labor unions, and governmental and academic institutions in all countries in Africa.

Enlarging small but successful existing programs is one approach to capacity building. The U.S. National Institutes of Health Fogarty International Center, NIOSH, and the National Institute of Environmental Health Sciences sponsor a successful program, International Training and Research in Occupational and Environmental Health, which has developed small but strong programs between U.S. universities and institutions in more than 30 developing nations (NIH 2003).

Capacity building requires high-quality educational opportunities. Advances in information technology over the past decade are revolutionizing methods of education, and universities worldwide are developing large numbers of Internet-based courses. Fostering access of students from developing nations to these courses in leading universities is now feasible, but a national or international program is needed to address issues such as tuition, competition, intellectual property, and degree requirements. This effort might be called Access to Universities, following the model WHO program Access to Biomedical Journals, through which WHO and the world's largest medical journal publishers have provided about 100 developing countries with Internet access to journals at no cost or at deeply reduced rates (WHO 2001).

Professional associations have a long history of assisting in capacity building through training, research, and conferences. Recently, when the University of Witwatersrand in Johannesburg developed the first Diploma Occupational Hygiene program in South Africa, the country had too few industrial hygienists to provide mentors for the field research of the graduate students. The American Conference of Governmental Industrial Hygienists responded to a request of the International Occupational Hygiene Association, and 11 U.S. industrial hygienists volunteered to be occupational hygiene field practitioner long-distance mentors for the

incoming students during the 2003 course year. This approach will continue until there are adequate industrial hygienists in country to serve as mentors to future classes (WHO and ILO 2002a).

The U.K. Health and Safety Executive developed a model program that provides clear solutions to chemical control problems in workplaces. This Web-based, user-friendly product was launched to enable small business owners in the United Kingdom to use information from the suppliers of chemicals to proceed through a series of simple steps to identify practical control solutions that reduce worker exposures to levels that present no danger to health (U.K. HSE 2002). This approach, which eliminates the need to measure exposures and meets the regulatory requirements of the United Kingdom, has immense potential value for employers in developing nations, who could devote scarce resources to controlling exposures rather than to measuring exposures. The approach has gained momentum through adoption by the International Program on Chemical Safety and through formation of an international workgroup to advance the approach in developing nations. To enable global use of this approach, the ILO has translated the U.K.-specific system into a product called the ILO Chemical Control Banding Toolkit (ILO 2003).

ECONOMIC ASPECTS OF INTERVENTION

Measures to prevent occupational risks are not cost-free, and where those costs ultimately come to rest affects the willingness of employers to implement the preventive measures.

Who Bears the Costs of Preventive Measures?

In industrial countries, compelling economic incentives exist for employers to control risks for injury and illness on the job, especially those that result in demonstrable near-term lost work or function. These include the high cost of medical care (especially in the United States), the burden of workers' compensation payments, high replacement costs for the labor, risk of litigation and liability, and negative business consequences of adverse publicity. Although these factors may differ by country and sector, they are less likely in the developing world to confer on employers a strong economic imperative for prevention—labor is plentiful, its replacement cost is low, and—most important—a high portion of the real cost of injury and illness will not be borne by the employer. The statistics in Latin America are staggering: although an estimated 2 to 4 percent of the GDP of the region is lost because of occupational fatalities alone, no evidence exists of private sector investment to reduce the risk (Giuffrida, Iunes, and Savedoff 2002). Multinational companies appear to be an exception. For many, the costs of injury and illness may accrue to the parent country in terms of legal liability and adverse publicity, a lesson well taught by Union Carbide's experience in the aftermath of the Bhopal disaster in 1984.

One approach to align economic incentives is to use regulatory and legal reform to shift the existing cost burden to those in a position to remedy the situation—that is, to employers. Increasing workers' compensation benefits, especially those for long-term effects and disabilities, is an example of such an approach. Some evidence exists that, at least in southern Africa, this approach does stimulate preventive behavior by employers. An alternative is to critically reexamine the assumption that employers do not harbor substantial underrecognized costs of injury and illness even under the current situation, especially in terms of indirect costs such as lowered productivity and morale. Harari and his colleagues in Ecuador (Cullen and Harari 1995) have been studying the effect of such exposures as solvents and organophosphate pesticides on production levels. They are attempting to make the case that relatively inexpensive strategies for exposure control are economically advantageous to employers.

Intervention Costs and Cost-Effectiveness

Workplace illness and injury produce personal suffering and high economic costs. The ILO estimates that about 4 percent of GDP worldwide is lost because of work-related diseases and injuries (Takala 2002). The European Agency for Occupational Safety and Health at Work (1998) indicates that the costs to society in European countries ranged from 0.4 percent to 4 percent of gross national product.

Examining Industrial Countries. Identifying interventions to successfully reduce or prevent workplace injuries and illnesses will benefit society, employers, and workers. In 1996, stakeholders in the United States identified intervention effectiveness research as one of 21 priority areas in occupational health research for the next decade (U.S. DHHS 1996). From 1996 to 2002, research conducted or funded by NIOSH to develop and evaluate the effectiveness of solutions to prevent work-related injury and illness has increased nearly sixfold, from about US$5.5 million to US$33 million (U.S. DHHS 2003).

Research studies of workplace interventions often use surrogate or implied measures for economic evaluation. For example, economic benefit is assumed to occur following an intervention if symptoms of illness or injury in a workforce decrease while productivity remains constant. Intensive data-entry workplaces are increasing rapidly in both industrial and developing nations. Three studies of U.S. Internal Revenue Service data-entry clerks by NIOSH found that short, strategically placed rest breaks of 5 to 15 minutes during the regular daily schedule reliably reduced eyestrain, fatigue, and

Box 60.1

Use of a Toolkit to Determine Return on Investment in Central American Garment Factories

The Regional Occupational Safety and Health Center (Centro Regional de Seguridad y Salud Ocupacional) Project in Central America developed an occupational safety and health toolkit to enable managers and line workers in garment factories to self-diagnose plant and workstation hazards and to estimate the costs and benefits of interventions (Amador and others 2003). Managers and employees at more than 100 Central American garment factories have been trained to use the toolkit. An in-depth evaluation of the use of the toolkit in three garment factories, each employing between 700 and 1,000 workers, in El Salvador, Guatemala, and Nicaragua found that within one year the factories generated savings that were four to eight times the costs of the interventions.

The overall investment by Confecciones La Palma in 2002 was US$6,360, and the savings attributed to that year were US$27,242 from reduced injury, illness, and absenteeism and an increase in productive days (see table).

Source: Amador and others 2003.

Change in Illness and Injury Indicators in the First Quarter of 2003 Compared with the First Quarter of 2002 at Confecciones La Palma

Indicator	2002	2003	Percent change
Number of accidents	63	36	−40
Days of absenteeism	200	149	−25
Sick days	822	426	−48
Visits to factory clinic	2,716	2,163	−20
Productive person-days	Not given	Not given	+12

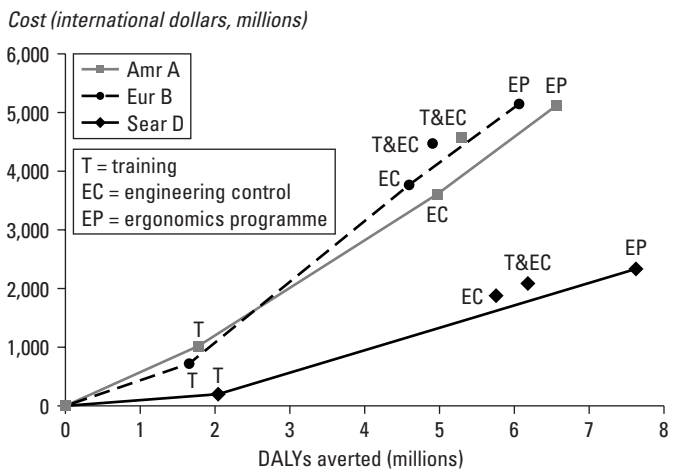
Source: Data provided by Confecciones La Palma.

A CD-ROM version of the tool kit in Spanish and English also contains the guide "How to Design and Establish an Occupational Safety and Health Program in a Garment Factory" and can be found on the NIOSH Web site at http://www.cdc.gov/niosh.

musculoskeletal discomfort for video-display terminal operators without decreasing productivity (Galinsky and others 1999, 2000). Similar benefits of improved comfort and reduced stress from short rest breaks were observed among workers in a meat-processing plant without affecting productivity (Dababneh, Swanson, and Shell 2001).

Including economic costs of interventions is more difficult but is an important measure to allow employers to make decisions about interventions. A model intervention study, "Evaluation of a Best Practices Back Injury Prevention Program in Nursing Homes," received the 2003 National Occupational Research Agenda Partnering Award for Worker Safety and Health (APHA 2003; Collins and others 2004). Members of the partnership that carried out the intervention study included a large nonprofit U.S. health care system that owns nursing homes; manufacturers of lifting equipment; researchers at Washington University, West Virginia University, and NIOSH; and health care workers. The prevention program combined measures to reduce back injury by identifying the movements and postures that put nursing assistants at risk of back strain, stress, and injury in lifting and moving residents. Mechanical lifting devices for reducing those stresses and strains were evaluated in the laboratory and then in the nursing homes. A best-practices training and lifting program was put in place on the basis of researcher and employee input, and rates for key measures of success were recorded for the three years before the intervention and for the three years after the intervention. The successful project reduced the frequency of back injuries in six nursing homes by 57 percent, lowered injury rates by 58 percent, and decreased workers' compensation expenses by 71 percent. Box 60.1 illustrates the value of evaluating costs of interventions in garment factories in Central America.

Reducing Risk for Back Pain. The WHO summary of a variety of cost-effectiveness studies for interventions addressing all aspects of global health illustrated that the cost-effectiveness of interventions in some areas of personal health has been well studied but that environmental and occupational topics have had relatively few studies. The WHO comparative risk assessment concluded that about 37 percent of back pain globally is attributable to occupational risk factors (WHO 2002). A cost-effectiveness study of interventions to reduce occupational back pain was also reported, using economic models developed to calculate costs of interventions in three WHO geographic regions that illustrate different levels of development. Intervention studies were obtained from the published and unpublished literature. All costs of running the interventions were measured in international dollars (not exchange rate dollars, as in the analysis reported later in this chapter) and



Source: Reprinted from WHO 2002, 130.
Amr = Americas; Eur = Europe; Sear = Southeast Asia

Figure 60.3 Cost-Effectiveness of Interventions for Lower Back Pain

effectiveness was measured as age-weighted DALYs gained by the intervention. The interventions for the prevention of back pain were grouped into three major categories: worker training (awareness education and hazardous job training); engineering control (physical measures that control the exposure to the hazard, including equipment that assists lifting, pushing, and pulling); and the full ergonomics program (which includes both of the previous interventions and implementation procedures).

As shown in figure 60.3, the analysis found that the most effective intervention is the full ergonomics program, offering a 74 percent reduction in back-pain incidence. Lesser benefits are obtained by engineering control (56 percent reduction) and training (20 percent reduction). The total costs of worker training are largely labor related, the costs of engineering control are primarily capital costs, and the full ergonomics program costs are equally shared between the two. Training was found to be the most cost-effective intervention, as indicated by the lower slopes of the lines from 0 to T, and was recommended as the first choice when resources are scarce. However, the incremental cost-effectiveness ratios for the other options (indicated by higher slopes of the lines) demonstrated that both engineering control and the full ergonomics program are attractive alternatives. Thus, even the full ergonomics programs were found to be cost-effective in all three regions for their health effects alone, without even considering the possible increase in productivity that could be brought about by the interventions (WHO 2002). Recalculating these results according to Disease Control Priorities Project methods—using exchange rate dollars and removing the age weights from DALYs (see chapter 15)—would increase effectiveness somewhat because back pain is more common at later ages and would reduce the apparent costs in both Europe and Southeast Asia. It would have little effect on costs in the high-income countries of the Americas. The relative cost-effectiveness of the three interventions would be unchanged in each region.

Reducing Risk for Silicosis. Silicosis is a disabling and often fatal workplace lung disease caused by inhalation of silica dust. The high-risk sectors of the economy include construction, mining and mineral processing, foundries, and manufacturing of pottery and glass. Large numbers of workers in both industrial and developing nations are exposed. Box 60.2 illustrates control of silica caused by grinding wheels in the agate cottage industry in India. In the United States, more than 3.2 million workers are exposed to silica dust, even though methods exist to eliminate exposure (Harley and Vallyathan 1996).

A study was conducted to evaluate the cost-effectiveness of alternative interventions to reduce silicosis in industrial and developing nations (Lahiri and others 2005). The authors used the limited published and unpublished data on costs of the various interventions and on the efficacy of exposure reduction. To analyze the cost-effectiveness of each intervention in reducing disease incidence, they used models developed for WHO (Murray and others 2000). The WHO DALY concept was used to combine mortality and morbidity resulting from silicosis. Two WHO regions were studied: the highly developed America A region, represented by the United States and Canada; and the developing Western Pacific B1 region, represented by China, the Democratic People's Republic of Korea, the Republic of Korea, and Mongolia. Exposure estimates were taken from the WHO comparative risk assessment study (Ezzati and others 2004).

The interventions included engineering control interventions that protect many workers (use of the wet method—that is, spraying a surface or wetting a blade to reduce dust; of local exhaust ventilation; and of total plant ventilation) and worker training plus personal protective equipment, an intervention that protects the individual worker. The training involved four types of personal protective equipment: comfort masks, dust masks, full-face respirators, and half-face respirators. Lahiri and others (2005) summarize the evidence of reduction in exposure through the use of selected interventions from the literature. The difference in the health life years gained with and without the intervention represented the effectiveness of the intervention and was used as the denominator for the cost-effectiveness ratio.

The engineering control interventions involve large capital expenditures, whereas the implementation of personal protective equipment requires ongoing large equipment costs (filters and cartridges) as well as labor costs for training the workers. Costs of interventions vary from region to region, depending on wage rates and raw material costs, but the costs of equipment seem not to vary. The authors found the least expensive alternative is training associated with use of a comfort mask. However, that intervention has a relatively low efficacy of

Box 60.2

Economic Evaluation of an Engineering Control for Silica Dust in India

The agate industry is a cottage industry concentrated in residential settings in Khambhat and Dahegam, in the state of Gujarat, India, where 15,000 grinders and 60,000 other workers, family members, and neighbors are exposed to silica dust. The making of key chains, necklaces, and art pieces involves baking, chipping, grinding, and polishing agate stones. The grinding-machine wheels are driven at speeds of 1,440 rpm, generating large amounts of dust containing respirable silica. The table shows the extraordinary prevalence in the total exposed populations (noted above) of silicosis and tuberculosis caused by silica exposure.

Prevalence of Diseases in Agate-Dominated Areas of Khambat and Dahegam

	Silicosis		Tuberculosis[a]	
Category	Percent	Number	Percent	Number
Grinders	30	4,500	36	5,400
Nongrinding workers, family, and neighbors	8	4,800	16	9,600

Source: Bhagia, Ramnath, and Saiyed 2003.
a. National tuberculosis prevalence in India of 4 percent and resulting cases have been subtracted.

The National Institute of Occupational Health in India designed and distributed 10 dust control devices for the grinding machines to employers, who generally employ 5 to 10 workers (see figure). The efficacy of the devices was found to be 93 percent, and dust was greatly reduced (Bhagia, Ramnath, and Saiyed 2003). Economic analysis was based on 600 dust control devices that could be installed in the communities. The total costs include the initial one-time cost of the devices (Rs 8,000, or approximately US$92); depreciation (10 percent per year); maintenance of machines (equivalent to the costs saved by recycling the dust to be used in polishing); and the cost of treating the diseases (about Rs 4,000, or approximately US$184 per year per case). The gains included annual income per avoided case of silicosis. Total savings per year were estimated to be between Rs 23 million and Rs 29 million (US$527,039 to US$664,528). The conclusion is that installation of dust control devices in all the agate-grinding units of Gujarat would reduce silicosis and tuberculosis as well as yield financial and health benefits to the workers, families, and the greater society that bears the cost of illness.

Traditional Grinding Machine with Dust Control System

30 percent exposure reduction. Although the initial capital expenditures are high for engineering controls, the annualized costs based on a 10-year horizon are encouraging, with exposure reduction of about 70 to 85 percent. The greatest exposure reduction of 95 percent was achieved at the highest cost, with training plus use of a full-face respirator, but an 80 percent reduction was achieved at half this cost when training was combined with a dust mask.

Table 60.3 shows that engineering controls in both industrial and developing regions are the most cost-effective

Table 60.3 Average Cost-Effectiveness Ratio *(US$/DALY gained)*

	America A region	Western Pacific B1 region
Engineering control	105.89	109.35
Comfort mask	111.04	117.19
Dust mask	191.38	173.90
Half-face respirator	299.82	272.45
Full-face respirator	304.87	265.74

Source: Lahiri and others 2005.

interventions, with expenditures of between US$105 and US$109 per healthy year saved in the two regions. Although exposure reductions with respect to each intervention type are identical in both regions and the cost of interventions is somewhat higher in the America A region, it might seem perplexing that the cost per unit of health gain is relatively lower in the America A region than in the Western Pacific B1 region. The reason for this result is that effectiveness (the denominator of the average cost-effectiveness ratio) is represented by health outcomes that are higher for this region because life expectancy in the America A region is higher than in the Western Pacific B1 region. Therefore, lives saved through interventions in industrial regions contribute more toward the healthy years generated by the model.

The study concluded that engineering controls are the most cost-effective interventions in both regions and should be considered as the first choice in cases in which resources are scarce. The results underestimate the health gains because other silica-related diseases such as tuberculosis and cancer are not considered.

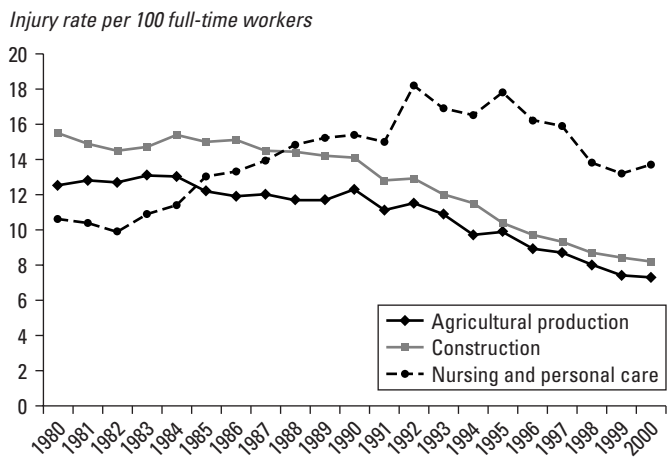
IMPLEMENTATION

The health of a country's workforce, even more than the health of the country's overall population, is critical to its economic and national security. No country has become a successful economic power without sustained attention to the health of workers, who create the successful economy. Responsibility for the safety and health of workers lies with the government, the employers, and the workers themselves. However, it is the governmental framework, whether at a national or local level or both, that is the linchpin on which other efforts rest.

Institutions and Programs

The potential to continually improve work-related health status, as measured by morbidity and mortality data across multiple economic sectors and across many countries, has been compellingly demonstrated. Not surprisingly, because these conditions are inherently preventable, what may be the lowest achievable level of risk is debated in industrial countries. In the United States, for example, occupational injury fatality rates have been steadily declining, now approaching 3.8 per 100,000 workers, down from 7.5 just 20 years earlier (NIOSH 2000).

Key elements in improving worker health and safety, regardless of the level of development, include regulatory and enforcement framework; worker, employer, and health professional education; surveillance and reporting systems; and dissemination and implementation of best practices. Often these elements overlap in multifaceted approaches to addressing complex and disparate work settings.



Source: BLS 2002.

Figure 60.4 Incidence Rates of Nonfatal Occupational Injuries (Total Recordable Cases) by Selected Industry Sectors, 1980–2000

In the developing world, a patchwork of some of these approaches has brought success: in Vietnam by reducing silicosis through industrial hygiene practices of wetting the process and through surveillance (effective but much less so than protective equipment or, better yet, substitution of a safer product), and in Nicaragua by efforts to reduce pesticide poisoning through worker and health professional education and reporting systems. Even in highly developed countries, the continued need for a responsive and broadly based framework, with government involvement at the center, is evident.

An example recently identified in the United States is the comparison of injury indicators for workers across three prominent sectors: construction, agriculture, and health care (figure 60.4). Two decades of data demonstrate improving nonfatal injury rates for construction and agricultural workers (falling steadily from about 16 and 12 per 100 full-time workers, respectively). This rate is in contrast to injury rates for health care workers, which have risen by about one-third from a starting point of about 10 per 100 workers (BLS 2002). Why the difference? Although the reason is not fully delineated, major efforts (including government regulation, research investment and policy setting, education, and best-practice efforts)—plus, in the case of construction workers, active trade union involvement—in the two industrial sectors clearly were under way in this time period. In contrast, in the health care worker sector, no such national program existed in the period, and industry pressures resulted in a number of potential workforce problems, such as increasing work demands on a stressed and ill-prepared workforce.

Lessons Learned

As countries undergo rapid economic development, industrialization, and the effects of globalization, leaders can examine

available occupational health system models as they develop their national occupational health systems. The Republic of Korea has experienced major economic and societal changes since it emerged from the Korean War in the 1950s with a need to establish occupational safety and health programs without any historical experience. The system directed by the Industrial Safety and Health Act of Korea is modeled after the specialist-based system of Japan, which relies on medical screening and specialists outside the workplace to deliver health and safety services (Paek and Hisanaga 2002). Paek and Hisanaga note that national traditions and culture strongly influence the choice of system when developing countries examine models from which to choose—for example, from the code-based system of the United States, the performance-based system of the United Kingdom, and the management system of the Nordic countries.

Government involvement is necessary but not sufficient, regardless of the level of development. Because national and local legislation and policies create the framework within which a society functions, international influence, assistance, and requirements play a key role in encouraging developing and industrializing nations to create appropriate laws and policies to support healthy workers. International trade, development, and funding organizations have immense power, which is not fully exercised to date, to influence countries on working conditions. The large multinational trade agreements have also failed to ensure that worker health and safety is adequately addressed, and multinational corporations have generally not transferred the safety and health systems of the industrial world to developing nations. The consequences are grave, as seen in the deaths of 2 million workers each year from occupational injuries and illness. Great power lies in these institutions and trade agreements to produce direct changes in the health of workers globally.

The ILO provides strong guidance internationally for industrial and developing nations through its tripartite conventions and recommendations. Each year the ministers of labor of all member nations, employer representatives, and worker representatives agree on policies in conventions, which the member states are asked to ratify. The models provided by the ILO are regularly used by some countries as they create their national systems. Brazil, for example, has been a member country of the ILO since 1919 and has ratified 75 ILO conventions. Set in place by legislation in the 1970s, the Brazilian model for occupational health services followed the ILO's Recommendation 112 (1959) as a paradigm (Dias, Mendes, and Schwartz 2002). Although few countries ratify most conventions, more than 150 countries have ratified Convention 182, which was passed in 1999 and addresses the worst forms of child labor. A current critical need is assistance to developing nations to meet the obligations required by ratification. WHO sets international policies on health, including worker health, at its annual meeting of health ministers of all member nations. Both ILO and WHO regional offices provide technical assistance and training. An unfortunate gap exists, however, because often the national ministries of labor relate to the ILO and the ministries of health to the WHO. Because working people are influenced by the national ministries of both labor and health, the international organizations have been advised to correct the situation (WHO and ILO 1995). A promising WHO/ILO Joint Effort on Occupational Safety and Health in Africa has embraced partners across ministries and broadly within and outside Africa to work together to assist countries, workers, and employers in the formal and informal sectors (WHO and ILO 2002b).

Several coalitions of organizations have successfully assisted developing countries to increase professional capacity and to improve worker health and safety. A regional illustration is the Association of Southeast Asian Nations Occupational Safety and Health Network, which was established to promote regional cooperation in training and research as well as harmonization of standards in safety and health. The primary international coalition is the WHO Global Network of Collaborating Centers in Occupational Health, described previously. The U.S. Fogarty International Training and Research Program in Occupational and Environmental Health is another stable and experienced network, consisting of U.S. universities working with universities in more than 30 developing nations to increase professional capacity. Some of the institutions are also WHO Collaborating Centers, and others are partners in Africa. The relationships have provided opportunities for synergy and streamlining of training and technical assistance (WHO and ILO 2002b).

Globalization has brought work-related hazards to developing countries lacking the infrastructure and professional capacity to handle them adequately. It is incumbent on the national and international bodies responsible for globalization to assist the recipient nations. Organizations with proven track records in occupational health could play key roles if international and national laws provide the appropriate context and funding.

Globalization

Increased globalization has caused important changes for many developing countries. Dias, Mendes, and Schwartz (2002) identify the series of developmental stages through which a country passes: underdevelopment and poverty, industrial revolution and accelerated economic development, internal adjustments to strengthen national competitive power to enter globalized markets, adjustments to foreign policy to integrate globalized markets, and aims toward long-term sustainable human development. These authors also analyze the positive and negative effects on occupational health conditions in countries such as Brazil, where crises and opportunities are experienced simultaneously. On the risk side, for example, free trade agreements have intensified rapid industrialization and the export of

industry and materials—many hazardous—to regions with poor occupational infrastructure. These effects are likely increasing risk and rates of injury and occupational disease.

Globalization has also engendered major occupational health and safety development projects, most notably sponsored by Scandinavian governments (Partanen and others 1999). These initiatives have infused developing countries with expertise, training programs, and equipment and have provided much-needed (external) economic incentives for adoption of change on national, regional, and local levels. The major concern is sustainability, because the incentives are external.

Globalization has resulted in a rapid increase in the number of multinational companies operating outside industrial countries. Indeed, this outcome was the underlying economic intent of recent free trade agreements such as the North American Free Trade Agreement (NAFTA). In general, these companies bring with them a highly developed infrastructure in occupational health practice from their base countries. Unfortunately, although these model companies undoubtedly upgrade the availability of high-quality services and training, enhance workers' awareness, and create pressure on other industries in the region to conform, the pressure likely goes in both directions. The competitive advantage of lowered investment in health and safety, as long as the labor markets are plentiful and the direct costs to employers of illness and injury low, results in strong pressure to minimize—or at least reduce—the intensity and quality of services.

Even at their best, multinationals may inadvertently create an occupational health and safety "caste system." Many provide extremely high levels of care and service for their international managers and for technical support staff members, while offering local resources to indigenous workers. More broadly, occupational clinics, industrial hygiene services, and the like are often developed but available for the exclusive use of the multinationals, creating communities inside which modern occupational health exists but outside which nothing changes except the incorrect perception that progress has occurred. Often the reverse of progress has actually occurred because the limited numbers of trained physicians, occupational health nurses, industrial hygienists, and safety professionals are siphoned off to the higher-paying, more prestigious positions.

Free trade zones, established by treaties such as NAFTA, create special considerations. Although the agreements offer the potential to incorporate strong industrial world rules regarding labor, environment, and health in underdeveloped zones, the host countries often resist such changes, perceiving these rules as trade restrictions. The final language regarding health and safety in NAFTA, for example, is significantly less stringent than rules in the United States. Moreover, some multinationals resist even these rules, seeking broad economic relief as a foundation of moving across the border (Frumkin 1999).

Nonetheless, globalization does offer potential solutions. One is the link provided by international lending agencies such as the World Bank and International Monetary Fund of health and safety considerations to development loans. As a condition of receiving the development funds, control of health and safety conditions could be mandated and enforced. A second opportunity is voluntary initiatives, as were recently developed in the Apparel Industry Partnership, wherein a consortium of European and U.S. garment manufacturers agreed to control labor and safety practices in their facilities in developing countries by joint consent.

Implications for Health System Development

Workers' health and safety in most of the developing world may fall under the jurisdictions of both the ministry of labor and the ministry of health, with little collaboration and coordination between the two. The ministry of labor most commonly is the governmental focus of any regulatory and enforcement efforts, even though without requisite expertise and access to follow-up care, it may mandate services falling squarely within the traditional health system (for example, pulmonary function testing as ongoing screening for individual response to exposure to pulmonary toxicants). Whatever the country-specific organizational and structural constraints, the following set of principles can be applied in providing health services to workers:

- *Coordination between occupational health services and overall health services.* Occupational health services, consisting of efforts to prevent work-related disease and disability as well as to recognize and treat them once they occur, must be coordinated with overall health services. The separation between work-related and other health conditions, often driven by regulatory and liability concerns, insurance, and other external constructs (workers' compensation system or the disability system, for example), is not only clinically challenging but inefficient in optimizing individual health status. Although many work-related injuries and a few specific illnesses, such as asbestosis, can be readily pinpointed as stemming from work alone, most health problems result from multiple causes. This fact is as true in the developing world as in the industrial one—whether it be cumulative pesticide exposure from work and community sources, the interaction of poverty and poor health status with chemical work exposures, or the cumulative psychosocial stressors of life both inside and outside work. A holistic approach to the individual, recognizing the multisectoral, multiple determinants of health on overall health status, should be the goal in the provision of health services.
- *Attribution of causality and access to health services.* In parts of the developing world, as in the industrial world, a phenomenon exists wherein some threshold of causality (such

as "more probably than not work related") is the trigger to workers' compensation or other employer responsibility for taking care of the illness or injury. All too often in this setting, the incentive for the employer to disclaim responsibility leaves the worker, whatever the cause or causes of the condition under question, falling through the cracks of occupational health care and traditional health care. Universal access to health care, unfortunately not available in the United States or in much of the developing world, can mitigate this problem.

- *Health professional workforce expertise in occupational health.* As discussed in the section on capacity building, adequate expertise does not exist in the developing world to address traditional and emerging occupational health problems. Occupational health services are multidisciplinary, including nonmedical (industrial hygiene and engineering expertise, for example) in addition to health (nursing and physician) expertise. Without being prescriptive, health systems need to ensure the existence of an adequately prepared workforce (whether through broadly based training for all health personnel, training for occupational health specialists, or most likely some combination of the two) if they are to grapple even minimally successfully with reducing the human and economic burden of work-related injuries and illnesses.

Unifying the three principles identified above is the need to recognize that occupational health should be in the mainstream of both health education (at the professional, employer, and individual level) and health care. An argument against this approach is the perception that doing so will result in an untenable burden on already underfunded health care. We suggest that not so doing will create a greater burden, in both financial and human terms.

RESEARCH AGENDA

Before 1996, there was no known national effort to identify and promote an occupational health research agenda. That changed with NIOSH taking the lead to launch the National Occupational Research Agenda (NORA) (U.S. DHHS 1996). Since then, a number of other countries in the industrial world have launched similar efforts (for example, Italy, Sweden, and the United Kingdom). Although all these efforts are relevant to the developing world, the reality is that country-specific research, even at the risk of reinventing the wheel, is often needed to strengthen political will to effect policy. Moreover, although traditional epidemiological etiologic research in occupational health is not a priority or even feasible for much of the developing world, research targeted at local conditions and institutions is often what is most needed. Six areas are identified, with appropriate modifications for local conditions, as ongoing research priorities to address injury and disease control strategies in the developing world. This research need not be undertaken solely—and sometimes not even in part—in the countries of concern, but rather is likely to be aided by the capacity building derived from partnership between academic institutions and government agencies across countries of different levels of development.

Public Health Systems Research

Although health services research has emerged as an important area of inquiry in the health field in the industrial world over the past few decades, scant attention has been paid to public health systems research (Institute of Medicine 2003). Given that occupational health sits at the interface between individual and population health, this area of inquiry is particularly germane to research in the field. This research would examine the effectiveness of government systems working in coordination with other sectors (academic institutions, employers, unions, voluntary agencies) in promoting occupational health status.

Occupational Health Policy Research

Public policy to address improving occupational health in the developing world should rest on a sound scientific base (that is, be evidence based) and should be coupled with an understanding of the local and national frameworks for policy (whether through legislative, regulatory, or other means). Adequate research has not been undertaken to evaluate policy development and implementation in public health in general and occupational health specifically. As with the need for new health systems research, this area of inquiry would undoubtedly benefit from partnerships among countries in the industrial world and in the developing and industrializing world.

Intervention Effectiveness Research

Intervention effectiveness research, a cornerstone of the U.S. NORA initiative, is critical to advancing occupational health in the developing world. The absence of data in this chapter to demonstrate cost-effectiveness of occupational health measures is indicative of the need for more such information to target what will always be a demand for limited resources. Recognizing the relative dearth of intervention effectiveness research in countries with high research investments, this recommendation is made cautiously for countries with fewer resources. However, it is assumed all too often that an accepted intervention in a country with higher economic productivity might not be viable in one with fewer resources. The research agenda for the developing world in this arena needs to be tailored to what is known and proven coupled with local and national conditions and needs.

Control Technology and Protective Equipment Research

Investigation of control technology and protective equipment, another NORA priority, is critical for developing effective and feasible control strategies in the developing world. Much of the primary research in this category can be done in the industrial world, but along with investments in intervention effectiveness research, new technologies may still need to be tested in real situations in developing countries. Simplified approaches to management of chemicals suitable to the local work settings have been developed in Indonesia and are being evaluated, and the International Program for Chemical Safety is helping other countries modify, implement, and evaluate the U.K. system, which was originally designed for use by small enterprises in the United Kingdom (ILO 2003).

Disease and Injury Research

Many questions of epidemiologic importance to improving the health of all workers can best be answered in settings in the developing world. This situation is not unique to occupational health, but in the occupational health arena, it is important to recognize that workers are often the first exposed and are exposed to the highest levels of potential hazards (as compared with their community counterparts). So, too, are levels of exposure to many hazards far greater in the developing world than elsewhere, and undertaking studies becomes efficient and feasible in these settings that would prove difficult if not impossible in settings where exposures are lower and larger numbers of study participants are needed to detect meaningful differences in risk. Not surprisingly, then, sentinel studies of health effects of interest to the industrial world have been undertaken in other countries—for example, studies in Latin America identifying the potential for acute pesticide intoxication to cause chronic neurological effects (Rosenstock and others 1991).

Surveillance Research

Surveillance is a critical component of all effective occupational health programs; thus, continuing research is needed into the most effective ways to gather and interpret this information. Surveillance systems are often limited at best in many developing countries, and evaluation research needs to be undertaken to determine the benefits of investing in gathering both generic (absences from work, for example) and specific (blood lead levels, for example) information on which to target public health action.

CONCLUSIONS

The burden of occupational health problems is staggering in both human and economic costs, and workers in the developing world bear this burden disproportionately. Moreover, the most vulnerable—children and the poor—are also disproportionately at risk. Compounding this tragedy is that many effective and economically feasible interventions are available to address these largely preventable health conditions.

Despite relatively little systemic data on cost and cost-effectiveness, even this "tip of the iceberg" picture demonstrates work-related conditions contributing significantly to overall mortality and morbidity and demonstrates the overall societal benefit of their prevention and treatment. Externalization of costs by employers—to the society as a whole—often obscures the actual overall benefit of a framework that relies on government regulation and enforcement, education, and best practices. Effectively addressing these problems takes active involvement from national and local government, employers, and workers and their representatives. The challenges to reducing the burden are heightened to the degree that public health and health care delivery systems isolate occupational health from the mainstream of health and health care.

Despite structural and political barriers to overcoming this high burden of disease and injury, evidence exists of enormous progress in the industrial world and of isolated progress in parts of the developing world. Targeted future investments in research and public health and health systems are critical to ensuring that progress continues and is more equitably distributed.

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