

Global Estimates of Fatal Work-Related Diseases by Region and Disease Group, 2002

PÄIVI HÄMÄLÄINEN, KAIJA LEENA SAARELA, JUKKA TAKALA

Work-related and occupational diseases are multifactorial diseases among the working population that have a heavy impact on workers, enterprises, and society. We calculated estimates for 2002, using global regional estimates of disease mortality, and adjusted attributable fractions produced for work-related diseases in Finland. The estimated number of fatal work-related diseases is about 2 million worldwide. The most common fatal work-related disease groups are cancers (25%), circulatory diseases (21%), and communicable diseases (28%). Though estimates of fatal work-related diseases have some limitations, they are needed for prevention. *Key words:* occupational diseases, mortality, epidemiology

INT J OCCUP ENVIRON HEALTH 2011;17:49-56

Ascertaining the total number of work-related diseases worldwide is challenging. Issues such as the combination of various exposures, daily exposure time, duration of use, and heredity vary across regions and affect the incidence of work-related disease.^{1,2} However, it is important to estimate the number of work-related diseases because they have a heavy impact on workers, enterprise, and society. In addition to the physical and psychosocial effects, the costs of work-related diseases are also considerable. Leigh et al. (2006) estimated total costs—including medical costs, wage loss, household production loss, and loss due to pain and suffering—to be US\$77 billion.³

Work-related diseases (WRD) include occupational diseases and those diseases caused at least partly by occupational exposures. In many countries, not all WRD are included in official definitions of occupational disease, which specify a causal association between disease, exposure, and work.⁴ (For example, ILO defines occupational disease as disease that results from exposure to risk factors during a work activity.⁵) WRD are estimated to be a much bigger problem^{1,2,6} than official occupational disease data show.⁷⁻⁹ Weevers et al. (2005)

have defined WRD as: “multifactorial diseases among a working population, which are partly caused by work, and/or aggravated, accelerated, or exacerbated by occupational exposures, and/or the cause of impaired work capacity.”¹⁰ The definition covers diseases that have been shown to have an association with work, while not necessarily officially accepted as a compensable occupational disease caused by work, such as some cancers, musculoskeletal disorders, psychosocial problems, and circulatory diseases.¹¹

Work-related cancers have received the most attention from occupational disease researchers. Conservative estimates of the number work-related cancers have used the attributable fraction from Doll and Peto, who estimated that the proportion of cancer deaths attributable to occupation is 4%, with a range from 2% to 8%.¹² However, there has been some criticism that Doll and Peto's attributable fraction is no longer valid.¹³ For example, Ruston et al. estimated that, for six cancers assessed, 4.9% of deaths were attributed to workplace carcinogens.¹⁴

Incidence of occupational respiratory diseases, and especially occupational asthma, are estimated to be greater than official occupational disease statistics show.^{15,16} Occupational asthma is one of the most common occupational diseases in the world.¹⁶ Blanc and Toren¹⁶ estimated that 9% of adult asthma is associated with occupational factors, while Driscoll et al. estimated the figure to be 17%.¹⁵

Mental disorders seem to be an increasing problem, at least in industrial countries.^{17,18} For example, job strain¹⁹ and shift work²⁰ have been reported to cause mental disorders, as well as circulatory diseases.²¹ On the other hand, the results of some studies do not support this association.^{22,23}

The authors' research on global estimates of occupational accidents and fatal WRD consists of three studies carried out from 2001–2006. The main objective of the first study was to develop models to estimate global occupational accidents in 1998,²⁴ and fatal WRD in 2000.²⁵ The second study estimated global incidence of occupational accidents for the year 2001. The third study was meant to correct our models to update the estimates while retaining comparability between the results. Our estimates of occupational accidents and fatal WRD at regional and country levels were published in the *Journal of Safety Research* in 2009.²⁶ The present paper further describes the results of the third study, giving global estimates of fatal WRD in 2002 by disease groups at the regional level.

Received from: Tampere University of Technology, Center for Safety Management and Engineering, Tampere, Finland (PH, KL) and the European Agency for Safety and Health at Work, Bilbao, Spain (JT). Funding for this study was provided by the Programme on Safety and Health at Work and the Environment (SAFEWORK) of the International Labour Organization. Please send correspondence to Päivi Hämäläinen at VTT Technical Research Centre of Finland, Tekniikankatu 1, P.O. Box 1300, FI-33101 Tampere, Finland; email: <paivi.hamalainen@vtt.fi>.

Disclosures: The authors report no conflicts of interest.

METHODS

WRD can be either communicable or non-communicable. Communicable diseases usually have a short incubation time or latency period. Non-communicable WRD often have a long latency period,^{6,27} and may be caused by combined effects of several work-related factors at different times.

The methods used here for estimating global fatal WRD incidence are the same as those used in the authors' previous studies and are explained in more detail elsewhere.²⁵ In this article, the most important aspects of methods are given. Some corrections and changes to the methods were made after the first study and these corrections and changes are presented here.

For regional estimates of fatal work-related diseases, we previously used World Bank regional divisions. In this update study, we used World Health Organization (WHO) regional divisions instead. The reason for this is that the World Bank changed its regional division in the period between the second and third study. The WHO regional divisions are also more specific, containing more regional areas than those of the World Bank. In addition, our data source gave figures according to the WHO regional divisions. The WHO uses six main regions:

- Africa (AFRO);
- Americas (AMRO);
- Southeast Asia (SEARO);
- Europe (EURO);
- Eastern Mediterranean (EMRO);
- Western Pacific (WPRO).

These regions are divided further into 14 subregions. The subregions were used to obtain the best possible estimates. In the authors' previous studies, China and India were considered their own region. In the WHO divisions, China belongs to the WPRO and India to the SEARO region.

Previous studies of global estimates of fatal WRD used two main sources of information: the Global Burden of Disease (GBD) estimates from the WHO²⁸ and the Epidemiologic Estimate of the Proportion of Fatalities Related to Occupational Fraction in Finland.⁶ In this update project, GBD statistics have been updated to reflect ongoing work on the WHO estimates.²⁹

Both GBD estimates^{28,29} provide worldwide estimates of deaths categorized by age, sex, and cause of disease, and are the only two attempts to estimate disease burden for the entire world. Global burden estimates include not only occupational diseases, but all diseases and deaths. Diseases are further divided into more specific disease groups. The seven main disease categories used: communicable diseases, malignant neoplasms, respiratory diseases, circulatory diseases, neuropsychiatric conditions, digestive diseases, and genitourinary system diseases.

The attributable fractions for this study were mainly taken from Nurminen and Karjalainen,⁶ as their attributable fractions were formed for the same disease categories as used in the global burden of disease estimates; and were the most current available. Nurminen and Karjalainen's attributable fractions are largely based on western studies, reflecting exposures in temperate climates and relatively modern work environments.

We disregarded clearly non-work-related categories of disease included in the WHO GBD estimates, including childhood-cluster diseases, maternal and perinatal conditions, and nutritional deficiencies. Disease groups not included by Nurminen and Karjalainen were also excluded (rheumatic heart disease, inflammatory heart disease, and other cardiovascular diseases). In this study, circulatory system diseases included only ischaemic heart and cerebrovascular diseases.

In both GBD estimates, age groups were divided into seven categories: 0–4, 5–14, 15–29, 30–44, 45–59, 60–69, and 70+. We considered all age groups, except the groups from 0–14 years. We included the 70+ group due to the long latency time of many diseases. We assumed that any error caused by excluding the 0–14 years group, and thereby missing WRD among child workers, was assumed to be quite small, as including the eldest age group would at least partially compensate for the youngest's exclusion.

Adjustments were made for all age groups depending on disease group, as Nurminen and Karjalainen (2001) had divided the age groups differently. Their study excluded all deaths for people under 25 and over 74 years old. Their study also excluded groups over 65 years for two disease groups (communicable and digestive system diseases), but included persons over 65 in the other disease groups because of the long latency period of these diseases. For circulatory system diseases, Nurminen and Karjalainen included only 25% of cases in the oldest age group. These exclusions and selections have affected the calculation of age groups from both GBD estimates.

Some exclusions and selections were made for disease groups. For communicable diseases, we took into account all deaths in the age groups 15–29, 30–44, and 45–59. For the 60–69 age group, we counted only half the deaths (50%), because many workers retire in this age bracket. For the > 70 years group, no communicable disease deaths were calculated. For malignant neoplasms, respiratory diseases, circulatory diseases, neuropsychiatric conditions, genitourinary system, and digestive diseases, one third (33%) of death figures were taken into account for those age 15–29 years, because at least in developed countries people in this age bracket are just beginning to enter into working life. All data were included for all of the other age groups, except for digestive diseases, from which the > 70 years group was excluded. For circulatory diseases, approximately 58% of deaths in the

TABLE 1 Attributable Fraction by Gender and Region

Causes	Men			Women		
	AMRO, SEARO, EURO A, EMRO, WPRO ^a	AFRO ^b	EURO B, C ^c	AMRO, SEARO, EURO A, EMRO, WPRO ^a	AFRO ^b	EURO B, C ^c
Communicable diseases	4.8	3.05	4.36	32.5	20.68	29.55
Malignant neoplasms	13.8	8.78	12.55	2.2	1.40	2.00
Respiratory diseases	6.8	4.33	6.18	1.1	0.70	1.00
Circulatory diseases	14.4	9.16	13.09	6.7	4.26	6.09
Neuropsychiatric conditions	6.6	4.20	6.00	1.8	1.15	1.64
Digestive diseases	2.3	1.46	2.09	1.5	0.95	1.36
Genitourinary system	3.0	1.91	2.73	0.4	0.25	0.36

^aAttributable fraction from Nurminen and Karjalainen (2001).^o

^bRevised attributable fraction.

^cRevised attributable fraction for neuropsychiatric condition.

60–69 age group, and 10% in age group > 70 were included because of the limitation made by Nurminen and Karjalainen (see above).⁶

We calculated work-related mortality using the same attributable or revised attributable fractions as in previous estimate studies for each region, with some exceptions (Table 1). In previous projects, the attributable fractions of Formerly Socialist Economies (FSE), India, and Sub-Saharan Africa (SSA) were adjusted: attributable fractions for communicable diseases were raised, and all non-communicable diseases were lowered compared to attributable fractions for other regions. In the present project, attributable fractions for communicable diseases in FSE, India, and SSA were also lowered from levels previously used. These adjustments were made because attributable fractions for communicable diseases was based on the Finnish situation, in which work-related communicable diseases are quite uncommon, however after infection often lead to a serious outcome or death. Deaths because of work-related communicable diseases form a bigger part of all deaths caused by communicable diseases than in developing regions, where communicable diseases are a major disease group, and only a smaller part of these diseases and deaths are work-related. For that reason the attributable fraction for communicable diseases is probably higher in Finland than in developing countries, and is likely to put too much emphasis on communicable diseases in developing regions. Revised attributable fractions were used for AFRO D and E (former SSA) and EURO B and C (former FSE) regions.

In previous projects work-related mortality was calculated separately by age group and gender. The two total estimates differed from each other because the attributable fractions were largely based on work-related mortality in Finland, and the distribution of WRD differs in different countries. In the present project, only attributable fractions by gender were used. The WHO GBD estimates are given separately for men and women and both gender groups are considered by age.

RESULTS

In 2002, the number of deaths due to fatal WRD was approximately 2 million (Table 2). Most of these deaths occurred in Western Pacific and Eastern Asian regions, where most of the world's people live. However, mortality rates per 100,000 workers show that in AFRO, AMRO D, and EURO C regions, the proportion of deaths due to WRD was highest. Communicable diseases, malignant neoplasms, and circulatory diseases comprised 90% of all fatal WRD.

The proportion of fatal WRD in developed regions differs clearly from those in developing regions (Figure 1). In the developed regions AMRO A (50%), EURO A (79%), and WPRO A (67%) the main cause of fatal WRD is malignant neoplasm. Another major cause of death is circulatory diseases, totalling approximately 20% of deaths.

Communicable diseases comprise the majority of WRD in many developing regions, and were the main cause of work-related deaths in both AFRO regions, while in other developing regions circulatory diseases and malignant neoplasms are also important causes of fatal WRD. In the WPRO B region, respiratory diseases were also a big problem, causing 11% of the region's fatal WRD. Respiratory diseases are especially a problem in China, where there is a huge mining industry.

There is a clear difference between men and women when comparing fatal WRD. In total, men suffer approximately 60% of all fatal WRD, but the difference is bigger when different disease groups are compared (Table 3). Communicable diseases occurred far more often in women, while almost all other diseases predominantly occurred in men. Women often work in areas such as agriculture, health care, and food-related industry, which carry a higher risk of communicable diseases. The difference is also due to the fact that men often have longer working histories than women, and are also disproportionately represented in dangerous and physically demanding jobs. Typically, WRD occur in workers age 45 or older. Compared to communica-

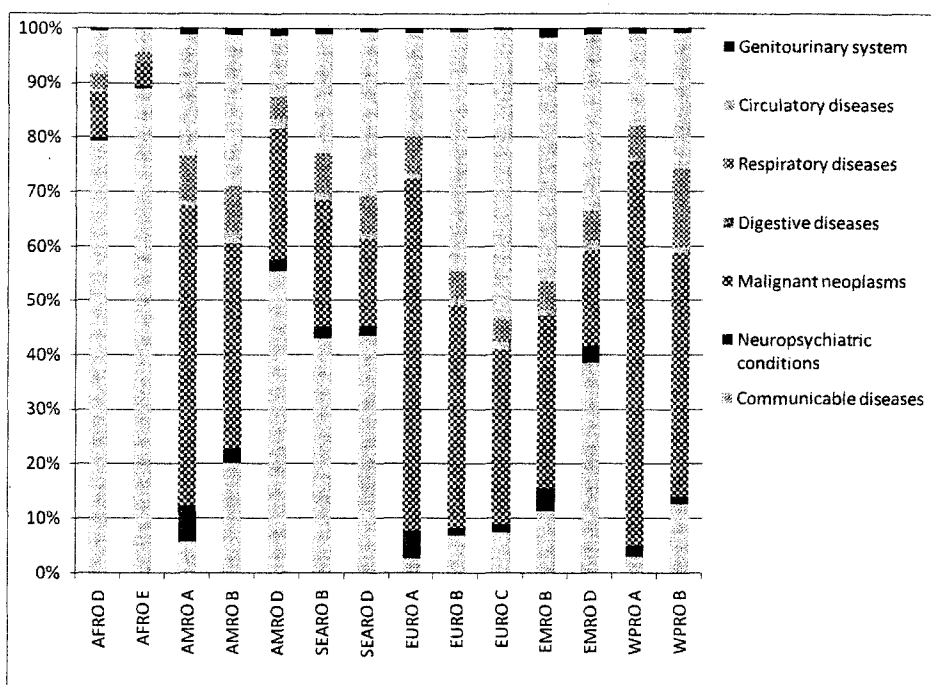


Figure 1—Proportion of Fatal Work-related Diseases in Each Region in 2002

ble disease, all other diseases need a longer time to develop and hazardous materials affect even workers who have retired.

DISCUSSION

The estimated total number of fatal WRD for 2002 was 2 million. This means that everyday 5,300 workers die due to WRD. The most common fatal WRD by disease group are cancers (25%), circulatory diseases (21%), and communicable diseases (28%). Although the number of deaths due to neuropsychiatric conditions is low (2%), it can be assumed that they will increase in the future. In developed countries, neuropsychiatric conditions and musculoskeletal disorders are the main disease groups causing absences from work and leading to disability pensions. In 1999, the most common work-related health problems in EU countries were musculoskeletal disorders (about 60%) and stress, depression, and anxiety (14%).⁸ In Canada, at least 11.7% of the population between the ages of 15 and 64 suffers from a mental disorder or substance dependence,³⁰ and 30% of disability claims are attributed to mental health.^{30,31} Weevers et al. found in their review that the main reasons for absenteeism from work were musculoskeletal disorders (39%), respiratory disorders (29%), and psychological disorders (13%).¹⁰ While musculoskeletal disorders are a well-studied area and the exposure and response relationship is well understood,³² there is no clear consensus on how various factors affect mental health.³⁰ However, the link between mental illness among workers and work-related stress is clear.^{17,30} The

estimated total number of fatal WRD worldwide for 2000 was almost identical to the estimate for 2000.²⁵

Like our study, reports concentrating on specific disease groups made estimates of fatal WRD that were greater than figures from official occupational disease statistics.^{2,6,11,14,15} Using 1994 data, Leigh et al. estimated that approximately 700,000 fatal occupational diseases occur worldwide each year.² Our estimates are almost three times higher than Leigh et al.'s 1999 figures. Evidence concerning the underreporting of occupational diseases^{33,34} has deepened concern regarding the increasing trend in fatal work-related diseases.

Regional Estimates

Although at the global level the total number of fatal WRD remained essentially the same between 2000 and 2002, within regions some changes can be identified. EURO A is the only region in which fatal WRD have remained almost the same during the two-year period in question. In other regions, the number of fatal WRD has increased or decreased quite substantially. Fatalities within different disease groups have remained quite the same (Table 4). Where increases exist, they are mainly due to an increase in work-related communicable diseases in women, which reflects, in part, the increase of all communicable diseases in the WHO global burden of diseases estimates.²⁹

Most of the WRD occurred in the Western Pacific region, due in large part to the rapid industrialization of recent decades. Industrial production for exports increased significantly at the beginning of the 1990s,

TABLE 4 Estimated Work-related Mortality in the Two Years 2000 and 2002 by Gender

	Total		Men		Women	
	2000 ^a	2002	2000 ^a	2002	2000 ^a	2002
Communicable diseases	625,660	670,487	108,256	117,415	517,404	553,072
Malignant neoplasms	634,984	583,720	570,008	518,533	64,975	65,187
Respiratory diseases	144,788	140,397	127,226	121,759	17,562	18,638
Circulatory diseases	449,343	476,587	337,129	359,900	112,214	116,687
Neuropsychiatric conditions	24,212	40,464	18,827	31,944	5,384	8,520
Digestive diseases	21,266	20,301	16,307	14,872	4,959	5,429
Genitourinary system	10,362	13,159	9,163	11,736	1,200	1,424
Total mortality	1,910,616	1,945,115	1,186,917	1,176,159	723,699	768,956

^aResults taken from the article of Hämäläinen et al.²⁵

and some countries in this region, such as China and Korea, have increased their production for domestic consumption as well. As a result, unskilled workers move from rural areas and occupations to big cities and find work in industries such as construction, mining, steel production, and transport. These workers are exposed to new industrial processes, machinery, and materials, including asbestos, often with no experience and no training in occupational safety. The effects of these hazardous working conditions can already be seen in spite of the long latency time. In addition, changes made in regional divisions have affected the estimated numbers. In our previous study,²⁵ fatal work-related communicable diseases in India were calculated separately using revised attributable fractions. In the present study, India is part of the SEARO region, a region in which fatal work-related communicable diseases are overemphasized. However, even though the number of fatal communicable diseases has increased in the SEARO region, their proportion has slightly decreased, while the proportion of malignant neoplasms among men decreased between 2000 and 2002, mainly because of estimates taken from the WHO study.²³ An increase in the number of circulatory diseases and mental diseases is largely for the same reason. Other WRD have remained the same. Because the period under review is short, nothing certain can be said about the trend in fatal work-related diseases. The number of communicable diseases can be assumed to further decrease in the future, but malignant neoplasms and circulatory diseases will increase or at least remain stable (Table 4).

Communicable Diseases

Communicable diseases are the main problem in most developing regions, for example, in the AFRO, SEARO, AMRO D, and EMRO D regions. While one school of thought holds that work-related communicable diseases should decrease when countries in these regions industrialize, according to WHO estimates the opposite is the case, and the transmission of communicable diseases is accelerating worldwide.³⁵ Although WHO estimates include all communicable diseases, not only work-related ones, there might also be an increasing

the number of WRD in certain industries, such as food and health care.

Although our estimates of fatal communicable diseases were based on downward-adjusted AFs, they are still overestimations. A range is hard to find because the attributable fraction used for communicable diseases was based on the study of Nurminen and Karjalainen (2001),⁶ which was the only one that could be found at the time. In the case of communicable diseases, it is also hard to know if a disease is truly work-related; this may be especially true in developing regions.³⁶ Another aspect that affects not only communicable diseases but all WRD is the change associated with work and leisure-time, e.g., physical exercise and healthy eating habits. Exercise and healthy diet assist the recovery from work as well as increase resistance.

Methodological Discussion

There are a number of methodological limitations to our study that should be considered. The WHO global burden data covers all diseases, not only WRD. Its use is justified because it is the only global data available. Another limitation is that the attributable fraction we used was based on exposure estimates from an industrialized country, Finland. Fractions were adjusted to the whole world, which of course causes errors, especially with the figures for developing areas, even though the attributable fractions in some regions were adjusted. Fractions were taken directly from the main disease groups, not separate diseases, which also weakens the estimated numbers because the distribution of diseases is different in different countries. In the case of communicable diseases, the attributable fraction used is questionable. This fraction was developed based on tuberculosis in health care workers and an association between pneumococcal disease and environmental tobacco smoke. In Finland, communicable diseases are rare. Deaths because of work-related communicable diseases form a bigger part of all deaths caused by communicable diseases than in developing regions, where communicable diseases are a major disease group, and only a smaller part of these common diseases and deaths are work-related.

The attributable fraction for communicable diseases was adjusted downward in some regions where the number of all diseases is very high, notably in the case of the AFRO region. Attributable fractions were not revised for regions such as AMRO, SEARO, EURO A, EMRO, and WPRO, partly because most of them are developing countries and the social structure and, consequently, the disease structure is gradually changing to follow the patterns in industrialized countries. However, there are no studies for attributable fraction in developing countries, and the values used for industrialized countries are relatively high, because the existence of infectious diseases in the general population is low; in fact, many of these occur in the health and transport sectors, and as such are caused by work. In developing countries, it is very likely that most infectious diseases are not of occupational origin. For example, malaria is a compensated occupational disease in industrialized countries—leading to high attributable fraction—but practically never in developing countries.

Despite limitations, we found Nurminen and Karjalainen's attributable fractions to be most appropriate for this study. Other studies giving an attributable fraction for occupational diseases can be found, but they are also for industrialised countries. In addition, attributable fractions published in studies do not cover all the main WRD groups. In addition, other studies gave only a combined attributable fraction,³⁷ either combined or separate fractions for men and women,³⁸ or a limited attributable fraction.³⁹ Another reason we chose to use Nurminen and Karjalainen's attributable fractions is that they are based on several sub-group fractions, depending on the disease.⁶ For malignant neoplasms, more specific fractions can be found. Steenland et al. calculated the attributable fraction for nine separate cancers that form the attributable fraction of the whole cancer group,³⁸ while Rushton et al. calculated the attributable fraction for six separate cancers.¹⁴ Nurminen and Karjalainen calculated the attributable fraction for cancer by combining 28 different cancer groups.⁶ Also the attributable fractions for asthma, chronic obstructive pulmonary diseases (COPD), and pneumoconiosis were included. In addition, other studies generally do not give attributable fractions for communicable work-related diseases. While Nurminen and Karjalainen's attributable fractions are usually higher than the fractions of other studies, the matching subgroup fractions are close to each other and the AFs are covering a much more limited range in other studies.

CONCLUSION

Overall, it is very hard to reliably estimate the number of fatal WRD. Epidemiological studies of WRD are typically expensive and time consuming, and the results may not be generalized to the global population. Work-

places have different kinds of exposures and the combination of these is difficult to study. Globally, scientific studies are mainly conducted in developed countries, and the information produced is used also for developing regions. WRD are often influenced also by genetic background: Not all people exposed to similar conditions, even serious hazards, become ill. Equally, exposure levels, time, and possibly other associated and combined exposures or conducive factors will have an impact. To obtain the best global estimates of fatal WRD in the future, attributable fractions based on exposures and individual disease data for each country should be used. At least, attributable fractions should be calculated for regions that are expected to have similar structures of industries and exposure patterns. However, the problem is that such disease data is lacking, or missing even, in developed regions.

From the global perspective, changes in social structure such as corporate mergers, outsourcing, and shift of production to developing countries have caused impacts, both in developed and developing regions, on the number of occupational accidents and work-related diseases, although this is difficult to demonstrate.⁴⁰ At times, work materials and processes are dangerous and the environment may be dirty and infested with pests and microbes. Also, problems with space, lighting, ventilation, or noise may be prevalent. Dangerous chemicals may be handled without precautions.^{41,42} All of these will affect the number of work-related injuries and illnesses in the future.

Though extensive industrialization causes work-related accidents and diseases, it can also increase consciousness of occupational safety and health issues. One motivation for developing countries is that better safety and health can increase competitiveness. Those countries in which competitiveness is highest are developed, industrialized countries.^{43,44} Competitiveness requires political and economic stability as well as a well-trained labor force.⁴⁵ Many enterprises in high-income countries are relocating their work to low-income countries that offer more political and economic stability. In these countries (e.g., the Republic of Korea, Malaysia, Chile, and Thailand), productivity and competitiveness have increased and they have gained from globalization.⁴⁵ Also, in many former socialist countries, competitiveness has increased.⁴³ Both at the national and company levels, investment in safety and health has decreased the number of WRD, and at the same time, increased employees' job satisfaction, commitment to the company, and productivity.

References

1. Driscoll T, Takala J, Steenland K, Corvalan C, Fingerhut M. Review of estimates of the global burden of injury and illness due to occupational exposures. *Am J Ind Med*. 2005;48:491-502.
2. Leigh J, Macaskill P, Kuosma E, Mandryk J. Global Burden of Disease and Injury Due to Occupational Factors. *Epidem*. 1999; 10:626-31.

3. Leigh JP, Wachrer G, Miller TR, McCurdy SA. Costs differences across demographic groups and types of occupational injuries and illnesses. *Am J Ind Med.* 2006;49:845-53.
4. Niu S. The ILO list of occupational diseases. *Afr News Occup Health Saf.* 2002;12:48-50.
5. An ILO Codes and Practice. Recording and notification of occupational accidents and diseases. Geneva: International Labour Office; 1996. p. 1-4.
6. Nurminen M, Karjalainen A. Epidemiologic estimate of the proportion of fatalities related to occupational fraction in Finland. *Scand J Work, Environ Health.* 2001;27:161-213.
7. Australian Government, Australian Safety and Compensation Council. [cited 2008 Sep 9]. Available from: www.ascc.gov.au/ascc/AboutUs/Publications/StatReports/CompendiumofWorkersCompensationStatistics.htm
8. Eurostat. 8.6% of workers in the EU experienced work-related health problems. Statistics in focus 63/2009. European Communities; 2009. p.12.
9. United States Department of Labor, Bureau of Labour Statistics. [cited 2008 Sep 9]. Available from: www.bls.gov/iif/home.htm
10. Weevers HJA, van der Beek AJ, Anema JR, van der Wal G, van Mechelen W. Work-related diseases in general practice: a systematic review. *Fam Pract.* 2005;14:1-8.
11. Driscoll T, Nelson DI, Steenland K, et al. The global burden of disease due to occupational carcinogens. *Am J Ind Med.* 2005;48:419-31.
12. Doll R, Peto R. The Causes of Cancer. Oxford: Oxford University Press; 1981. p. 1197-1312.
13. O'Neill R, Pickvance S, Watterson A. Burying the evidence: How Great Britain is prolonging the occupational cancer epidemic. *Int J Environ Health.* 2007;13:428-36.
14. Rushton L, Hutchings S, Brown T. The burden of cancer at work: Estimation as the first step to prevention. *Occup Environ Med.* 2008;65:789-900.
15. Driscoll T, Nelson DI, Steenland K, et al. The global burden of non-malignant respiratory disease due to occupational airborne exposures. *Am J Ind Med.* 2005;48:432-45.
16. Blanc PD, Toren K. 1999. How much adult asthma can be attributed to occupational factors? *Am J Med.* 1999;107:580-87.
17. Wang J, Adair C, Patten S. Mental health and related disability among workers: A population-based study. *Am J Ind Med.* 2006;49:514-22.
18. Chatterji P, Alegria M, Lu M, Takeuchi D. Psychiatric disorders and labour market outcomes: Evidence from the national Latino and Asian American study. *Health Econ.* 2007;16:1069-90.
19. Choi BK, Clays E, De Bacquer D, Karasek R. Socioeconomic status, job strain and common mental disorders—An ecological (occupational) approach. *Scand J Work Environ Health.* 2008;(supp 6):22-32.
20. Wang J, Afifi TO, Cox B, Sareen J. Work-family conflict and mental disorders in the United States: Cross-sectional findings from the national comorbidity survey. *Am J Ind Med.* 2007;50:143-49.
21. Ha M, Park J. Shiftwork and metabolic risk factors of cardiovascular disease. *J Occup Med.* 2005;47:89-95.
22. Bøggild H, Suadicani P, Hein HO, Gyntelberg F. Shift work, social class, and ischemic heart disease in middle aged and elderly men: A 22-year follow up in the Copenhagen male study. *Occup Environ Med.* 1999;56:640-45.
23. Chen JD, Cheng TJ, Lin YC, Hsiao ST. Job categories and acute ischemic heart disease: A hospital-based, case-control study in Taiwan. *Am J Ind Med.* 2007;50:409-14.
24. Hämäläinen P, Takala J, Saarela KL. Global estimates of occupational accidents. *Saf Sci.* 2006;44:137-56.
25. Hämäläinen P, Takala J, Saarela KL. Global estimates of fatal work-related diseases. *Am J Ind Med.* 2007;50:28-41.
26. Hämäläinen P, Saarela KL, Takala J. Global trend according to estimated number of occupational accidents and fatal work-related diseases at region and country level. *J Safety Res.* 2009;40:125-39.
27. Nelson D, Concha-Barrientos M, Driscoll T, et al. The global burden of selected occupational diseases and injury risks: Methodology and summary. *Am J Ind Med.* 2005;48:400-18.
28. Murray CJL, Lopez AD, editors. The Global Burden of Disease. A comprehensive assessment of mortality and disability from diseases, injuries, and risk fraction in 1990 and projected to 2020. Volume I. Harvard School of Public Health, World Health Organization, World Bank; 1996. p. 990.
29. WHO. Global burden of disease (GBD) 2002 Estimates. [cited 2005–2006]. Available from: www.who.int/healthinfo/bodgbd2002revised/en/index.html (accessed 2005–2006).
30. Dewa CS, Lesage A, Goering P, Cavee M. Nature and prevalence of mental illness in the workplace. *Healthc Papers.* 2004;5:12-25.
31. Sroujian C. Mental health is the number one cause of disability in Canada. *Insurance J.* 2003;7:8.
32. Marras WS, Cutlip RG, Burt SE, Waters TR. National occupational research agenda (NORA) future directions in occupational musculoskeletal disorder health research. *Appl Ergonomics.* 2009;40:15-22.
33. Spreeuwers D, de Boer AGEM, Verbeek JHAM, et al. Sentinel surveillance of occupational diseases: A quality improvement project. *Am J Ind Med.* 2008;51:834-42.
34. Blandin MC, Kieffer C, Lecoanet C. Survey on under-reporting of occupational diseases in Europe. Paris: Eurogip 2002. Eurogip-03/E. p. 28.
35. The World Health Report. Primary Health Care—Now More Than Ever. Geneva: World Health Organization; 2008. p. 119.
36. Negash D. Work-related diseases. *Afr News Occup Health Saf.* 2002;12:51-54.
37. Leigh JP, Markowitz SB, Fahs M, Chin C, Landrigan PJ. Occupational injury and illness in the United States—Estimates of costs, morbidity, and mortality. *Arch Intern Med.* 1997;157:1557-68.
38. Steenland K, Burnett C, Lalich N, Ward E, Hurrell J. Dying for work: The magnitude of US mortality from selected causes of death associated with occupation. *Am J Ind Med.* 2003;43:461-82.
39. Morrell S, Kerr C, Driscoll T, Taylor R, Salkeld G, Corbett S. Best estimate of the magnitude of mortality due to occupational exposure to hazardous substances. *Occup Environ Med.* 1998;55:634-41.
40. Hämäläinen P. The effect of globalization on occupational accidents. *Saf Sci.* 2009;47:733-42.
41. Glodstein G, Helmer R, Fingerhut M. Mobilizing to protect worker's health: The WHO global strategy on occupational health and safety. *Afr News Occup Health Saf.* 2001;11:56-60.
42. Phoon W. Impact of globalization on small enterprises and the informal sector. *Asian-Pacific News.* 2001;8:64-65.
43. Hämäläinen P. The effect of competitiveness on occupational safety. In: Helander M, Xie M, Jiao R, Tan KC, editors. Proceedings of the IEEE International Conference on Industrial Engineering and Engineering Management IEEM2007, December 2–5, 2007, Singapore. CD-ROM, ISBN 1-4244-1529-2.
44. Decent Work—Safe Work. XVIIth World Congress on Safety and Health at Work. Geneva: International Labour Office; 2005. p. 48. Available from: <http://www.ilo.org/public/English/bureau/inf/download/safework.pdf>.
45. Lopez-Claros A, Altinger L, Blanke J, Drzeniek M, Mia I. The global competitiveness index: Identifying the key elements of sustainable growth. In: Schwab K, editor. The global competitiveness report 2005-2006. Geneva: World Economic Forum; 2006. pp. 3-50.