Occupational Burden of Asbestos-related Cancer in Argentina, Brazil, Colombia, and Mexico

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ABSTRACT

Background: An estimate at the national level of the occupational cancer burden brought about by the industrial use of asbestos requires detailed routine information on such uses as well as on vital statistics of good quality. A causal association with asbestos exposure has been established for mesothelioma and cancers of the lung, larynx, and ovary.

Objectives: The aim of this study was to provide estimates of the occupational burden of asbestos-related cancer for the Latin American countries that are or have been the highest asbestos consumers in the region: Argentina, Brazil, Colombia, and Mexico.

Methods: The burden of multifactorial cancers has been estimated through the approach suggested for the World Health Organization using the population attributable fraction. The following data were used:

- Proportion of workforce employed in each economic sector
- Proportion of workers exposed to asbestos in each sector
- Occupational turnover
- Levels of exposure
- Proportion of the population in the workforce
- Relative risk for each considered disease for 1 or more levels of exposure

Data on the proportion of workers exposed to asbestos in each sector are not available for Latin American countries; therefore, data from the European CAREX database (carcinogen exposure database) were used.

Findings: Using mortality data of the World Health Organization Health Statistics database for the year 2009 and applying the estimated values for population attributable fractions, the number of estimated deaths in 5 years for mesothelioma and for lung, larynx, and ovary cancers attributable to occupational asbestos exposures, were respectively 735, 233, 29, and 14 for Argentina; 340, 611, 68, and 43 for Brazil; 255, 97, 14, and 9 for Colombia, and 1075, 219, 18, and 22 for Mexico.

Conclusions: The limitations in compiling the estimates highlight the need for improvement in the quality of asbestos-related environmental and health data. Nevertheless, the figures are already usable to promote a ban on asbestos use.

Key Words: asbestos, burden of disease, Latin America, neoplasms, occupation

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INTRODUCTION

The purpose of this study was to tentatively estimate the asbestos occupational burden of cancer in Argentina, Brazil, Colombia, and Mexico, in the frame of scientific cooperation activities envisaged by the Italian National Asbestos Project. The project aimed at developing collaborations with Latin America countries where asbestos use is still permitted or only recently banned, as discussed by Marsili et al.[1]

Neoplasms causally associated with asbestos are mesothelioma of pleura, peritoneum, pericardium, and tunica vaginalis testis and cancer of the lung, larynx, and ovary.[2] Asbestos is the only recognized cause of mesothelioma, together with some asbestiform mineral fibers. In industrialized countries such as Italy, more than two-thirds of all mesothelioma cases are associated with documented

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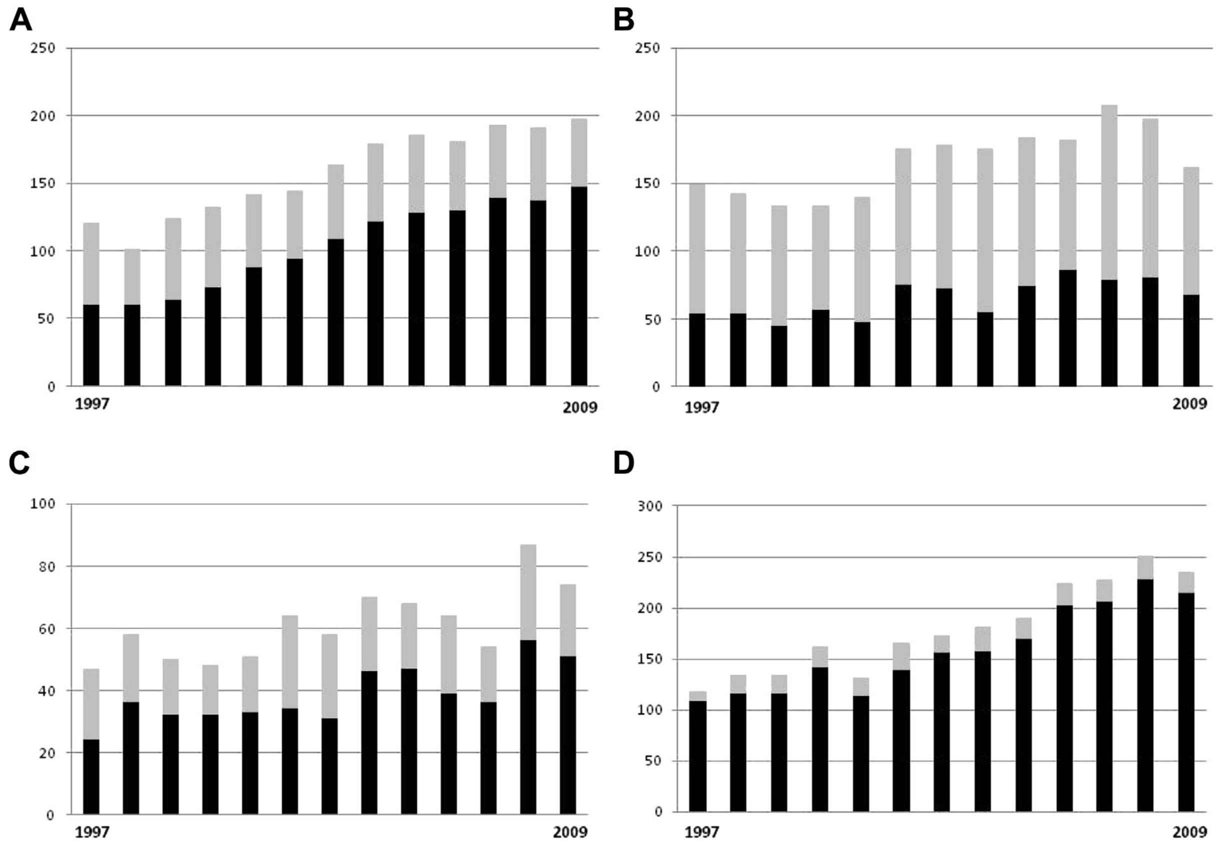

Figure 1. Mortality from "mesothelioma" (C45 in the 10th revision of the International Classification of diseases - ICD) and "pleural cancers excluding mesothelioma" (C38.4 10th ICD) in Argentina (A), Brazil (B), Colombia (C), and Mexico (D) during 1997-2009. Yearly number of C45 deaths in black, number of C38.4 deaths in grey. Data from the WHO Health statistics database (http://www.who.int/healthinfo/statistics/mortality_rawdata/en/index.html).

asbestos exposure in the workplace.[3] In general terms, the number of mesothelioma cases within a population can be directly retrieved from mortality data, if reliable, or from pathology registries, where available. This figure, furthermore, also can be indirectly estimated from data on asbestos consumption in the population of interest.[4]

Contrary to mesothelioma, the etiology of pulmonary, laryngeal, and ovarian cancers is multifactorial. For each outcome, the number of cases that would be prevented if exposure to asbestos were eliminated can be estimated by using the population attributable fraction (PAF). Within a project on occupational carcinogens commissioned by World Health Organization,[5] a multistep approach to estimate national PAFs from data on the workforce and a number of assumptions regarding exposure were established. Additionally, limited to lung cancer, PAF can also be estimated using a reasonable ratio between mesothelioma and occupational lung cancer cases. This ratio is time- and place-specific and is largely determined by the effectiveness of antismoking campaigns and by the type of asbestos used. In the United Kingdom, it has been estimated that for every mesothelioma death, between two-thirds and one asbestos-related lung cancer death occur.[6] A more recent meta-analysis of occupational cohort studies concluded that all types of asbestos, except crocidolite, kill at least twice as many people through lung cancer than through mesothelioma.[7] However, for chrysotile, still widely consumed today, the number of asbestos-related lung cancers cannot be robustly estimated from few mesothelioma deaths.

Both approaches have been used in the present study. A major problem in Latin America is the quality of mortality statistics regarding mesothelioma, whose diagnosis may be problematic. Worldwide, a sizable number of pleural mesotheliomas (C45.0 code in the 10th revision of the International Classification of Diseases) are wrongly certified as "pleural cancers excluding mesothelioma," corresponding to the C38.4 code.[8,9] A few studies performed in Brazil[10] and Mexico[11] suggested that the recognition of deaths caused by mesotheliomas in those countries is far from being satisfactory. Changes in time of the absolute number of death from C45 and C38.4 in the countries of interest are described in Figure 1.

METHODS

As stated earlier, the methodological approach was derived from an earlier study.[5] The number of cases of a given disease due to a given exposure is the product between the PAF for the given exposure and the total number of cases of that disease.

The formula used to calculate the PAF considering different levels of exposure is:

$$PAF = \sum((Pi * RRi) - 1)/\sum(Pi * RRi)$$

where Pi is the proportion of the exposed population in the exposure category i. RRi is the risk for the disease in the exposure category i relative to the risk in the reference exposure category (i.e., the population not exposed).

Exposures to asbestos may occur as direct occupational, indirect occupational, environmental occupational, extra-occupational in living environments, environmental-residential.[12] For occupational settings, it is possible to estimate the proportion of workers exposed in the workplace in different economic sectors. The PAF for cancers of the lung, larynx, and ovary associated with asbestos occupational exposures has been estimated using the following data:

- Proportion of the workforce employed in each sector
- Proportion of workers exposed to asbestos in each sector
- Occupational turnover
- Levels of exposure
- Proportion of the population in the workforce
- Relative risk for each considered disease for different levels of exposure (when available)

Proportion of the Workforce Employed in Each Sector

Data from the ILOSTAT database of the Intenational Labour Organization were used (Table 1).

Proportion of Workers Exposed to Asbestos in Each Economic Sector

No estimates are available for the countries of interest. For western European and North American countries, data are available from the CAREX (carcinogen exposure) database, which estimated the workforce exposed to a number of carcinogens in different occupational sectors in 1990 to 1993.[13,14] The proportions of the CAREX database for asbestos exposure (Table 2) have been applied to Argentina, Brazil, Colombia, and Mexico, under the assumption of an overall similarity of working procedures in today's Latin American and yesterday's European countries. This assumption is essentially based on the knowledge of asbestos consumption trends in western Europe and in Latin American countries. In western Europe, asbestos consumption began in the first decades of the 20th century and the asbestos industry reached its greatest expansion in the 1960s; although in Latin American countries, asbestos consumption began in the early 1960 reaching its greatest consumption in the 1980s, 1990s.[15] This corresponds to a lag time that can be generally assumed in 20 to 30 years.

Occupational Turnover

The interval between start of exposure and mesothelioma onset is measured in decades. Risk persists well after exposure ceases and well after the minimum latency is reached. For any job position, a turnover of people occurs also for reasons not necessarily related to health. Therefore, at any time, people at risk for developing cancer caused by a certain exposure are all those who have been exposed in the past and have met the minimum latency period. Direct calculation of the turnover is not straightforward and varies depending on the age of the individuals, the annual turnover in each sector, and the life expectancy of population in the country. A turnover factor of 4 was previously proposed[16] and adopted.[17] The same has been adopted as the factor to be multiplied by the present proportions of individuals considered at risk.

Levels of Exposure

The intensity of exposure differs within and between different economic sectors. To the best of our

Table 1. Proportion of Workers by Economic Sector, Total, and Women: Argentina, Brazil, Colombia, Mexico, 2006

Economic Sector ISIC 2.0*	Argentina		Brazil		Colombia		Mexico	
	Total	Women	Total	Women	Total	Women	Total	Women
Agriculture, hunting, forestry, and fishing	0.007	0.003	0.084	0.022	0.123	0.039	0.081	0.022
Mining and quarrying	0.005	0.002	0.005	0.001	0.006	0.002	0.006	0.002
Manufacturing	0.145	0.088	0.163	0.108	0.120	0.133	0.193	0.180
Electricity, gas, and water	0.006	0.002	0.007	0.003	0.004	0.003	0.007	0.003
Construction	0.072	0.008	0.052	0.005	0.045	0.005	0.088	0.009
Wholesale and retail trade and restaurants and hotels	0.184	0.148	0.192	0.174	0.219	0.254	0.219	0.225
Transport, storage, and communication	0.068	0.022	0.048	0.018	0.066	0.029	0.054	0.018
Financing, insurance, real estate, and business services	0.090	0.084	0.087	0.080	0.061	0.061	0.062	0.071
Community, social, and personal services	0.420	0.641	0.362	0.589	0.191	0.332	0.280	0.461
Activities not adequately defined	0.003	0.003	—	—	0.165	0.142	0.010	0.009

*Main categories of the International Standard Industrial Classification of All Economic Activities.

Table 2. Proportion of Workers Exposed to Asbestos by Economic Sector: CAREX Database, Countries of the European Union 1990-1993

Economic Sector ISIC 2.0*	Proportion of Workers Exposed to Asbestos
Agriculture, hunting, forestry, and fishing	0.012
Mining and quarrying	0.102
Manufacturing	0.006
Electricity, gas, and water	0.017
Construction	0.052
Wholesale and retail trade and restaurants and hotels	0.003
Transport, storage, and communication	0.000684
Financing, insurance, real estate, and business services	0.003
Community, social, and personal services	0.012
Activities not adequately defined	—

Available at: http://www.ttl.fi/en/chemical_safety/carex/countries/pages/default.aspx. Accessed May 1, 2014.
*Main categories of the International Standard Industrial Classification of All Economic Activities.
Source: FIOH (1998). CAREX database. Helsinki, Finnish Institute of Occupational Health.[13]

knowledge, in the past, the production of data on asbestos concentration in work settings in the 4 countries of interest has been extremely limited if not negligible. The levels of asbestos exposure that have been assumed in the present exercise were previously presented[17] on the basis of national indicators of human development. Two levels of exposure have been introduced (high and low) assuming that 50% were highly exposed and 50% lowly exposed.

Proportion of the Population in the Workforce

The size of the economically active population is available from administrative data sources. In the present approach, a single value that is the economically active population for the whole population (men and women combined) aged 15 years or older has been used.

In 2009, the proportion of the population in the workforce was 0.55 for Argentina, 0.63 for Brazil, 0.59 for Colombia, and 0.57 for Mexico. These data were obtained from the previously mentioned ILOSTAT database dividing the employed population over age 15 by the total population over age 15. Considering only women in order to compute estimates for ovary cancers, the corresponding proportions were 0.44 in Argentina, 0.52 in Brazil, 0.46 in Colombia, and 0.41 in Mexico.

Relative Risk of Each Considered Disease for Each Level of Exposure

The relative risks due to asbestos exposure for cancers of the lung, larynx, and ovary have been retrieved from the scientific literature, in particular from metanalyses (Table 3).

For each of the 4 countries taken into consideration, the total numbers of deaths from mesothelioma and lung cancer in 2009 were retrieved from the WHO health statistics database (http://www.who.int/healthinfo/statistics/mortality_rawdata/en/index.html). For lung cancer, the number of cases attributable to asbestos also has been estimated using the proportion mesothelioma to lung cancer as 1:1 and 1:2. This exercise is focused on occupational exposures, therefore the estimate of asbestos attributable lung cancers has been reduced by one-third on the basis of evidence from industrialized countries, such as Italy,[3] showing that nonoccupational mesothelioma cases, including those related to environmental and domestic exposures, and those with limited or no exposure information, can sum to about 30%.

RESULTS

For each country of interest and for each cancer site, the number of cases attributable to asbestos exposure in the

Table 3. Relative Risk (RR) for Asbestos-related Cancers Other than Mesothelioma

Site of cancer	High Exposures			Low Exposures			Any Exposure			Source
	RR	LCI*	UCI†	RR	LCI*	UCI†	RR	LCI*	UCI†	
Lung	1.48	1.44	1.52	1.18	1.13	1.23				Goodman et al 1999[18]
Larynx							1.44	1.19	1.64	IOM 2006[19]
Ovary	1.77	1.37	2.28							Camargo et al 2011[20]

*Confidence interval, lower limit.
†Confidence interval, upper limit.

Table 4. Number of Mesothelioma Deaths (C45, 10th ICD) and Estimated Cases of Lung, Larynx, and Ovary Cancers Attributable to Asbestos in 5 y in Argentina, Brazil, Colombia, and Mexico*

Country	Cancer	Estimated Deaths in 5 y†	PAF	Attributable Cases in 5 y Computed with PAF	Lung Cancer Attributable Cases in 5 y Using Mesothelioma:Lung Cancer Ratios 1:1; 1:2
Argentina	Mesothelioma	735			
	Lung	44,735	0.0052	233	490; 980
	Larynx	4175	0.007	29	
	Ovary	5630	0.0024	14	
	Total			276	
Brazil	Mesothelioma	340			
	Lung	105,345	0.0058	611	227; 453
	Larynx	17,450	0.0039	68	
	Ovary	14,815	0.0029	43	
	Total			722	
Colombia	Mesothelioma	255			
	Lung	19,490	0.005	97	170; 340
	Larynx	2080	0.0068	14	
	Ovary	3555	0.0025	9	
	Total			120	
Mexico	Mesothelioma	1075			
	Lung	32,750	0.0067	219	717; 1433
	Larynx	3925	0.0045	18	
	Ovary	8625	0.0026	22	
	Total			259	

PAF, population attributable fraction.
*Estimates have been produced both using the PAF and (limited to lung cancer) assuming that two-third of all mesotheliomas are related to occupational exposure and applying the 1:1 and 1:2 ratio between the number of occupational mesotheliomas and the number of occupational lung cancers.
†Estimates computed using mortality data from the World Health Organization health statistics database for 2009.

workplace was obtained by multiplying the specific PAF by the total number of cases (Table 4). For mesothelioma, the estimated number of deaths in 5 years was based on the official mortality figure provided by the WHO. These figures includes all 4 topographic sites, pleura (the great majority), peritoneum (up to about 10% of total cases), pericardium, and tunica vaginalis testis (extremely rare).[3]

For mesothelioma, the absolute number of cases reasonably can be considered as an indicator of asbestos burden of disease. For the other neoplasms, lung, larynx, and ovary cancers, the estimated number of deaths in 5 years is based on the WHO 2009 figure, whereas the number of attributable cases is modeled with PAF method and, only for lung cancer, with the mesothelioma-to-lung cancer ratio method.

The difference between the estimates of the number of occupational lung cancer deaths obtained and the 2 methods are difficult to interpret. In Brazil, the PAF method led to estimates somewhat higher than those produced by the ratio method whereas the reverse occurred in the other 3 countries (with differences up to 5-fold in Mexico). An effect of the weaknesses of both methods and intercountry differences in the reliability of the background statistics cannot be excluded. However, the peculiarity of the estimates in Brazil also might reflect the limited use of amphiboles, which were been made in that country.[1] It is known that the differential in carcinogenic potency between amphiboles and chrysotile is greater for mesothelioma than for lung cancer.[7]

DISCUSSION

Estimating the occupational burden of asbestos-related cancer at the national level is a worthwhile exercise. However, when applied to the countries considered in the present study, these estimations must rely on a number of assumptions open to debate. Furthermore, in Latin American countries, the databases required for this exercise are limited or nonexistent and they have not been submitted to adequate control in terms of quality and exhaustiveness. Despite its limitations, the present study suggests that a sizable number of occupational asbestos-related cancers (in the order of a few to several hundreds per 5 years) occur in each country. As shown in the study, these numbers are almost certainly underestimated.

Two conclusions appear to be warranted in light of this exercise. One is the urgent need for remediation of asbestos contamination of the environment (and a national asbestos ban in Brazil, Colombia, and Mexico). The other is the improvement of the quality of asbestos-related environmental and health data.

The approach[5] that we adopted in this study has not been applied, as far as we know, to countries that have extensively produced and used asbestos. This may depend, presumably, on the fact that political decisions on the ban of asbestos use had been taken before 2004, the year of publication of Driscoll et al.'s work,[5] on the basis of the existing available evidence. Basic figures to be used in burden-of-disease computations are reported in the literature for mesothelioma and lung cancer. Most population-attributable fractions for lung cancer following occupational asbestos exposure ranged in between 2 and 10, with peak values of 20 to 50, in the male population of European countries;[21] the occurrence of mesothelioma cases is well monitored, and annual incidence rates of 1 to a few cases per 100,000 are generally estimated,[12] indicatively one order of magnitude over those of Latin American countries. Figures of time trend of asbestos consumption in countries where its use is still legal supports the notion of future outbreaks of mesothelioma and other asbestos-related diseases.

The estimates provided in this study must be considered as exploratory, but they also intend to stimulate the construction of "local" databases regarding the extent to which asbestos is or was present in the occupational environment.

The proportion of the workforce exposed to asbestos in different occupational contexts applied to the present case study are those of the CAREX database, which provide prevalence of exposure to asbestos by economic sector for western European countries. In each economic sector, prevalence of exposure may be specific in Latin American countries and may have been different form those in western European countries in the 1990s because of differences in industrial cycles and in use of asbestos products. Therefore, it would be preferable and desirable to have such proportions estimated through surveys implemented in each country. Estimates of the PAFs in the countries of interest would greatly benefit by more precise data on the proportion of workers exposed to asbestos in each productive sector, on the occupational turnover, and on levels of exposure.

Methodological advances in case ascertainment and exposure assessment might improve the validity of the modeled estimates, thus providing a more solid input to decision-making processes aimed at preventing asbestos-related disease.

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