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The next mesothelioma wave: Mortality trends and forecast to 2030 in Brazil

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A R T I C L E I N F O

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Background: There are limited data on mesothelioma mortality in industrializing countries, where, at present, most of the asbestos consumption occurs.
Objectives: To analyze temporal trends and to calculate mortality rates from mesothelioma and cancer of the pleura in Brazil from 2000 to 2012 and to estimate future mortality rates.
Methods: We retrieved records of deaths from mesothelioma (ICD-10C45) and cancer of the pleura (ICD-10C38.4) from 2000 to 2012 in adults aged 30 years and over. Crude and age-standardized mortality rates (ASMR) were calculated. Rate ratios of mean crude mortality for selected municipalities were compared to the Brazilian rate. A regression was carried out of the annual number of deaths against asbestos consumption using a Generalized Additive Model (GAM). The best model was chosen to estimate the future burden and peak period of deaths.
Results: There were 929C45 and 1379 C38.4 deaths. The ratio of men to women for C45 was 1.4. A positive trend in C45 numbers was observed in Brazil ($p = 0.0012$), particularly in São Paulo ($p = 0.0004$) where ASMRs presented an increasing linear trend ($p = 0.0344$). Selected municipalities harboring asbestos manipulation presented 3.7–11 fold rate ratios of C45 compared to Brazil. GAM presented best fits for latencies of 34 years or more. It is estimated that the peak incidence of C45 mortality will occur between 2021 and 2026.
Conclusions: The observed ASMRs and the gender ratio close to 1 suggest underreporting. Even so, deaths are increasing and mesothelioma clusters were identified. Compared to industrialized countries Brazil displays a 15–20 year lag in estimated peak mesothelioma mortality which is consistent with the lag of asbestos peak consumption in the country.

1. Introduction

Utilization of asbestos in Brazil started in the 1940s. Asbestos production, namely chrysotile mining and consumption rose steeply in the 1970s and consumption peaked between 1985 and 1991. Brazil is ranked among the top countries in the world for asbestos production, consumption and exportation [1]. The State of Goias holds the only asbestos mine in operation which has produced around 300,000 metric tons of chrysotile per year in the last four years [2]. Anthophyllite was mined in the State of São Paulo and marketed in the country from the 1960s to 1990 at a fairly constant rate of 2600 t/year. After 1980, 3900 metric tons of crocidolite and amosite were imported from South Africa [3] for the production of asbestos-cement pipes. Consumption of amphiboles has been forbidden since 1991. At present, less than 10,000 workers are engaged in the asbestos industry, i.e., mining and milling, transportation and manufacturing of products containing asbestos and an unknown number are exposed at construction sites, vehicle repair shops, industrial maintenance and others [4]. Available consumption data from 1961 to 2012 allows us to estimate that more than 6,000,000 t of asbestos remain in the country as raw fibers, transformed products containing asbestos, materials and debris [5,6]. The production and consumption of products containing asbestos were mostly concentrated in the Southeast Region,

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particularly in the State of São Paulo, where half of the typical asbestos industries settled [7].

Over 98% of internal consumption is used for the manufacture of asbestos-cement products, mainly roofing materials. It is estimated that around 40–50% of Brazilian dwellings have asbestos-cement products installed [8]. The production of asbestos-cement materials is shared by seven industry groups. The Brazilian Eternit group accounts for 100% of Brazilian chrysotile mining, 100% of exports and 50% of asbestos transformation in the country [9].

Mesothelioma is a fingerprint of asbestos exposure. It is a rare cancer associated with occupational and environmental asbestos exposure in over 80% of cases [10]. The true magnitude of the mesothelioma epidemics at the global level is still unknown, mostly due to the lack of data from industrializing countries [11] and recent estimates argue that the epidemic is not fading [12]. At present, the burden of asbestos utilization is concentrated in the BRICS group (in Brazil, Russia, India and China), with the exception of South Africa. No information on mesothelioma mortality was reported to the World Health Organization (WHO) by Russia, China and India [13].

Until now, mesothelioma cases have remained hidden in parts of Brazil because of the relatively low incidence rate, long latency period, differences in regional economic profiles and poor awareness on the part of health professionals in suspecting and identifying the disease. Nonetheless, there has been a steady increase in the number of deaths from mesothelioma plus cancer of the pleura and previous studies have shown that Southeastern States presented the highest number of deaths [7,14].

Based on the asbestos consumption pattern we hypothesized that mesothelioma deaths should be on the rise. The objective of this paper is to examine mortality trends and calculate mortality rates from mesothelioma and cancer of the pleura in Brazil in the period from 2000 to 2012. Additionally, we aim to estimate the future burden of mortality through asbestos consumption.

2. Methods

2.1. Mortality data

We retrieved retrieved anonymously microdata from public databases. containing underlying and contributing causes of death coded as malignant mesothelioma (ICD-10C45) and cancer of the pleura (ICD-10C38.4) in adults 30 years and over, during the period 01/01/2000 to 31/12/2012 stratified by States of the Federation and in selected municipalities in the State of São Paulo [15]. The reason for using ICD 38.4 lies in the fact than many true mesothelioma cases are hidden under this code. Age-standardized mortality rates (ASMR) were calculated for age classes 30–49, 50–69 and 70 plus, using as standard the Brazilian population from the national census of 2010 of 30 years and over [16]. Rate ratios of mean crude mortality rates for the period 2000–2012 in selected municipalities from the State of São Paulo where compared to Brazil using the mean population, as denominators, drawn from intercensitary data [16,17]. These municipalities where selected according to a criteria of having asbestos-cement industries settled for fifty years or more. We opted for using crude rates because standardizing a small number of deaths by age would artificially inflate or deflate rates.

2.1.1. Asbestos consumption

Data from asbestos production, imports and exports from 1961 to 1974 were obtained from the US Geological Service [1,5] and for the period 1975–2012 from the Brazilian Department of Mineral Production at the Ministry of Mining and Energy [6]. Apparent asbestos consumption was calculated by summing production and imports minus exports. Annual per capita consumptions were calculated by dividing estimates of annual consumption by the estimated population.

2.1.2. Statistical analysis

Analyses were conducted separately for C45, C38.4 and the sum. Temporal trends for number of deaths and for ASMR were calculated by linear regression. Rate ratios of mean 13-year crude mortality rates were calculated for selected municipalities in the State of São Paulo against Brazil. The relationship between annual number of deaths as the dependent variable, and asbestos consumption in kg/capita/year were analyzed using Generalized Additive Models (GAM). The model consists of a non parametric regression, assuming that the number of deaths has a Poisson random distribution and allows for accommodation of non-linear independent variables [18,19]. We tested models lagged in three periods: asbestos consumption in the periods 1961–1973, 1966–1978 and 1971–1983, for latencies of 39 years or more, 34 years or more and 29 years or more, respectively. The smoothing parameters of the models were assessed using analyses of covariance to obtain the coefficient of determination R^2 and the Generalized Cross Validation (GCV) method. GCV values with $p > 0.05$ (null hypothesis of no seasonal trend) indicates that the model fit is significant. The best fitting model was used to estimate future mortality. We used the SAS software 9.2 for analysis.

3. Results

Between January 2000 and December 2012, the information mortality system registered 929 and 1379 underlying causes of deaths from C45 and C38.4, respectively, for adults aged 30 years and over. Brazilian 2010 census showed a population of 30 years and over of 93,483,031, being 44,390,356 men and 49,092,675 women [16]. Table 1 shows the number of deaths by sex and age groups and the gender ratios. Codes C45 and C38.4 were cited as contributing causes of death, in a further 79 and 201 death certificates, respectively.

The frequency of deaths from C38.4 was higher in women in all age groups and in older men. For C45 gender ratio was higher in men. The State of São Paulo, with a population of 21,669,897, representing 23.2% of the Brazilian population of 30 years and over, registered 44.6% of all C45 deaths and was the only State where C45 deaths were higher than C38.4 deaths during the period under observation.

Pleural (ICD-10C45.0) plus unspecified (ICD-10C45.9) mesothelioma accounted for 77.1% of the cases, including 82.9% in men and 68.7% in women. Table 2 shows the frequency and relative percentages of mesothelioma topographies.

Fig. 1 shows annual asbestos consumption in kilograms per capita from 1961 to 2012 and number of C45, C38.4 and C45 + C38.4 deaths for adults over 30 from 2000 to 2012. Peak consumption was around 1.6 kg/capita in the period 1987–1992, decreasing to less than 0.6 kg/capita in 2003. Since then, it has shown an increasing trend.

Table 1
Number of underlying causes of deaths from mesothelioma (C45), cancer of the pleura (C38.4) and sum by age group, gender and gender ratio, Brazil, 2000–2012.

Age group	Men			Women		
	C45	C38.4	C45 + C38.4	C45	C38.4	C45 + C38.4
30–49	100	68	168	64	102	166
50–69	256	275	531	164	280	444
70+	192	308	500	153	346	499
Total	548	651	1199	381	728	1109
Ratio M/W	1.4	0.9	1.1			