ORIGINAL ARTICLE

Mortality due to pneumoconioses in macro-regions of Brazil from 1979 to 1998*

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Pneumoconioses make up a group of lung diseases related to exposure to mineral dusts in work environments. They represent a public health problem, considering that such diseases could already have been eradicated from Brazil, if control measures had been taken in such environments. The aim of this research was to map the distribution of deaths due to pneumoconioses in the different geographical areas and states of Brazil, by means of an ecological survey carried out in the working population older than 15 years. The preliminary results of this investigation in the Brazilian macro-regions from 1979 to 1998 are presented. This study used mortality data provided by the Mortality Information System of Datasus – Data Processing Department of the Unified Health System, using the codes of the ICD (International Classification of Diseases) 9 and ICD 10. The results showed an increase in the mortality coefficient due to pneumoconioses per 1 million inhabitants per year along the studied period of time. By shifting from ICD 9 to ICD 10, the frequency of deaths doubled. We concluded that the mortality coefficients due to pneumoconioses do not reflect the problem properly, thus masking the transcendence and magnitude of the disease. In order to obtain more representative indicators, the actually exposed population and the territorial distribution of the disease have to be known. (***J Pneumol*** *2003;29(2):82-8)*

Key words – Mortality. Pneumoconiosis. Asbestosis. Silicosis.

Acronyms and abbreviations used in this work

Cenepi (Centro Nacional de Epidemiologia) – National Center for Epidemiology
CESTEH (Centro de Estudos da Saúde do Trabalhador e Ecologia Humana) - Center for Workers' Health Studies and Human Ecology
ICD – International Classification of Diseases
Datasus – SUS (Unified Health System) Data Processing Department
ENSP (Escola Nacional de Saúde Pública) - National Public Health School Fiocruz – Oswaldo Cruz Foundation
IBGE (Instituto Brasileiro de Geografia e Estatística) - Brazilian Institute of Geography and Statistics
MS (Ministério da Saúde) – Health Ministry
WLO – World Labor Organization
WHO – World Health Organization
PNES (Programa Nacional de Eliminação da Silicose) – National Program for the Elimination of Silicosis
SIM (Subsistema de Informação de Mortalidade) – Mortality Information Subsystem
SUS (Sistema Único de Saúde) – Unified Health System

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INTRODUCTION

The history of diseases caused by mineral dusts goes back a long way. They were named pneumoconioses by Zenker, in 1866, and silicosis was given its specific name by Visconti, in 1870(1). In 1900, the Londoner pathologist Montague Murray described what we know now as asbestosis(2), and, in 1906, Fahr reported the presence of asbestoid bodies or feruginous bodies in workers who had been exposed to asbestos or amianthus(3).

In Brazil, the main pneumoconioses are: silicosis, asbestosis, mixed-dust pneumoconiosis, talcosis, caused by heavy metals, by coal, silicatosis, siderosis, baritosis, stannosis. Silicosis is more frequent and more relevant, folowed by asbestosis. According to Algranti(4), in the 1990's it was estimated that there were 6,600,000 workers who were exposed to silica, 500,000 of which in mining, 2,300,000 in the transformation industry, and 3,800,000 in civil construction. For amianthus there are no published exposure estimates, but 240,000 exposed workers are admitted to exist in the fibrocement and brake industries alone. Such information enhances the importance of studying these diseases by using already existing data, even if they do not represent all events focused.

This paper is a communication of partial results of an ongoing investigation at the Centro de Estudos da Saúde do Trabalhador e Ecologia Humana (Center for Workers' Health Studies and Human Ecology) (CESTEH/ENSP/Fiocruz). It is a geographically countrywide-based study, that has been carried out so far by geographic macro-regions of Brazil. The main objective of this research is to establish a relationship between mortality due to pneumoconioses and the presence of productive activities usually associated with exposure to the inorganic dusts which cause the above mentioned diseases. The resulting knowledge will bring a contribution to the fields of pneumology and of epidemiology. Regarding the latter, it can provide a basis for environmental and occupational vigilance programs and actions, and programs for the control of morbidity due to preventable causes. It can also provide support to the Unified Health System (SUS) in the monitoring of workers in their work environments, and for the planning of medical attention to be given to the diseased by its medical assistance network.

The results of the study are presented as mortality tendencies due to these pneumopathies, during the period going from 1979 to 1998, by geographic macro-region. The epidemiological discussion is based on these tendencies and on their relationship with the exposure opportunities which exist in the regional and nationwide productive system. Its development is presented as a guideline for a more in-depth study or as a hypothesis. In this case, it was not yet possible to associate specific risks with work processes existing in the regions and municipalities. We hope, however, that this will be a starting point for states and municipalities to have an opportunity to deepen and articulate the information regarding exposure *versus* mortality, establishing the relationship between the pneumoconiosis-generating processes in place in municipalities with mortality rates informed by the Mortality Information Subsystem (SIM)(5).

MATERIAL AND METHOD

An ecological analysis model was adopted in view of the current status of studies on pneumoconioses. Mortality was distributed based on geography, so as to enable us to associate it progressively with the presence of regional activities and companies whose labor processes involve exposure to dusts which are potential causes of these pneumoconioses.

Conditions of information on pneumoconioses: Information on morbidity due to pneumoconioses is very scarce in Brazil. As a consequence, data on these diseases are insufficient for an adequate view of the health problem they represent to the country's population. The information shown to be more adequate and favorable to get an idea about the distribution of pneumoconioses in Brazil is the one regarding mortality. Collected and organized by the Mortality Information Subsystem (SIM)/Cenepi/MS(5), it comprises information about the deaths recorded in Brazil from 1979 to 1998, and was therefore the adopted option.

From 1979 through 1995, deaths were coded according to the rules of the 9th Revision of the International Classification of Diseases. From 1996 on, the coding followed the rules of the 10th Revision of the International Classification of Diseases, Injuries and Health-Related Problems. As long as the 9th Revision was effective, the use of three-digit codes was the most appropriate way of selecting deaths due to pneumoconioses, including codes 500, 501, 502, 503, 504, and 505 of chapter 08 of the 9th Revision for all pneumoconioses.

When the 10th Revision became effective (1996-1998), codes J60, J61, J62, J63, J63.1, J63.2, J63.3, J63.4, J63.8, J64, and J65 from chapter 10 of that Revision were included for all pneumoconioses.

Population: To calculate the coefficients, we used the population over 15 years of age, as informed by the IBGE: from the General Censuses of 1980 and 1991, and from the estimates made for the inter-census years. For the year 1979, it was estimated by using the demographic growth rate for the decade of 1980. The exclusion of individuals under 15 years of age from the denominator was due to the fact that in the lower age brackets the presence of pneumoconioses is very rare. Although this procedure has the disadvantage of including a large contingent of non-exposed populations and of producing very low coefficient values, when that population is considered as a whole, the real number of exposed individuals is not available. In order to reduce this problem that makes it more difficult to measure the expression of those diseases, the mortality coefficients were calculated per 1,000,000 inhabitants/year.

Data analysis: Data were analyzed by statistical methods of the *Microsoft Excel 2000* software: arithmetic mean, mean deviation, standard deviation, and regression. For regression, the sequential 1-20 variation, representing the 20 years of the period, was taken as the independent variable X, and, as the independent variable Y, the values used were those of the mortality coefficients of the sequence of the studied years. Regressions were made for the series of coefficients of the North-Eastern, South-Eastern, and Southern regions. From this function were obtained: the *angular coefficient*, and the R^2 statistics for the study of the tendency of the presented values and for the verification of the adequacy of the regression model for the study.

RESULTS

The focus of this paper is the analysis of the tendency observed for the mortality coefficient due to pneumoconioses, obtained by regressions and their respective tendency lines. Mortality coefficients per 1,000,000 inhabitants/year, calculated for the greater geographic regions and Brazil, are presented in Table 1, that also shows angular coefficient and R^2 statistics. No regressions were performed for the Northern and Midwestern regions, because data for that period were not continuous.

A pronounced variability of the mortality coefficient values was observed, which is in agreement with the same characteristic already observed regarding the number of deaths recorded yearly. This fact occurred in all regions of the country, and also in Brazil as a whole. This variability, explained by the low death frequency due to these diseases, recommends a critical appreciation of the statistical results obtained, where it is important to enhance mainly the epidemiological characteristics of the pneumoconioses studied.

TABLE 1
Mortality coefficient due to pneumoconioses, per 1,000,000 inhabitants/year, in Brazil and its geographic regions (1979-1998)

Year	Brazil	North	North-East	South-East	South	Midwest
1979	1.451	0	0.208	0.871	1.430	0
1980	0.865	0	0.101	1.202	1.398	0.222
1981	0.955	0.266	0.198	1.523	1.048	0.236
1982	1.076	0	0.001	0.954	1.420	0
1983	1.041	0.239	0.140	1.425	1.699	0
1984	0.854	0	0.182	1.097	1.361	0.624
1985	1.201	0	0.222	1.806	1.037	1.400
1986	1.074	0	0.434	1.331	1.671	0.385
1987	1.2	0	0.169	1.805	1.212	0
1988	1.158	0.386	0.165	1.793	1.400	0.900
1989	0.959	0.186	0.324	1.494	1.031	0.348
1990	0.959	0	0.278	1.821	1.082	0.169
1991	1.055	0	0.465	1.274	1.659	0.491
1992	1.117	0.164	0.416	1.628	1.225	1.104
1993	1.399	0.171	0.489	1.755	2.139	2.038
1994	1.54	0.501	0.631	2.155	1.668	1.687
1995	1.229	0	0.550	1.601	1.206	1.505
1996	2.632	1.898	1.459	3.156	3.323	2.947
1997	2.205	1.563	1.372	2.387	1.667	6.161
1998	1.804	0.694	1.697	2.499	0.705	1.207
Angular c.	0.049188	–	0.064	0.072	0.022	–
R^2	0.404104	–	0.644	0.598	0.488	–

Source: coefficients calculated based on frequency of deaths recorded by SIM/Cenepi/MS and populations informed by IBGE and estimated.

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For *Brazil*, regression analysis showed a positive, low-value angular coefficient, indicating a non-pronounced growth of mortality due to pneumoconioses over that period of time (Figure 1). The low mortality coefficient values reflect the effect of using the whole population over 15 years of age as a denominator, which, in the case of a coefficient with an aggregation level of the entire country, also suffers the influence of other factors, as it occurs in regions where the prevalence of these diseases is low, or is not informed as underlying cause of death, due to lacking diagnosis.

For R^2 the value found was 0.484; this is a test for measuring how adequate the regression model is to explain the variation displayed by the data, indicating that almost 50% of the variation were within the tendency established by the graph. However, its value also suffers the influence of the variation in the recorded frequency, which occurred due to the low number of deaths and to the use of the criteria of the 10^{th} Revision of the International Classification of Diseases, which doubled the frequency of deaths during the last three study years. This effect was due to the revision of definition criteria for the underlying cause of death, so as to attribute this code to the disease which led the individual to death, classifying diseases or conditions which aggravate the underlying disease as contributing causes.

The regional differences regarding socioeconomic conditions and degree of development of productive activities and institutions seem to be reflected by the regional results for mortality due to pneumoconioses, where the influence of the mentioned factors is evident, ultimately determining the transcendence of a health problem.

In the *Northern region*, no record of death due to pneumoconioses occurred in all the years of the study period. It seems likely that the influence of lacking diagnosis for pneumoconioses brought about an important under-record of this morbidity in that region, since risk-offering productive activities, such as mining, are possible there. The alternating death records did not allow to apply statistical analysis methods to those data.

Mortality coefficient data and regression results indicate that the *Northeastern region* also presents an increasing tendency for mortality due to pneumoconioses. The positive angular coefficient confirms this statement. Although its value seems low, this is due to the equally low values of the coefficients. In practice, the mortality coefficient due to pneumoconioses in that region nearly tripled during the studied period. R^2 indicates that about 65% of the variation found can be explained by the tendency presented in Figure 2.

The *Southeastern region* also presents a positive angular coefficient and, consequently, a growth in mortality. However, the straight-line angular coefficient is very low. This indicates a variation in the growing tendency, yet smaller than in the Northeastern region. The value of R^2 indicates an explaining power of about 60% for the regression model for the tendency presented in Figure 3.

The *Southern region* was the one with the smallest mortality growth tendency, represented by the lowest angular coefficient of all regions, although still positive. Since the Southern region has high mortality coefficients, lower only than those of the Southeastern region, it is indisputably the one where its smallest growth occurred. The 0.488 value of R^2 indicates that about 50% of the variation found in the mortality coefficient due to pneumoconioses in this region are located on the tendency line presented in Figure 4, also being influenced by the fact that mortality kept a continuous growth over the period, but abrupt at its end.

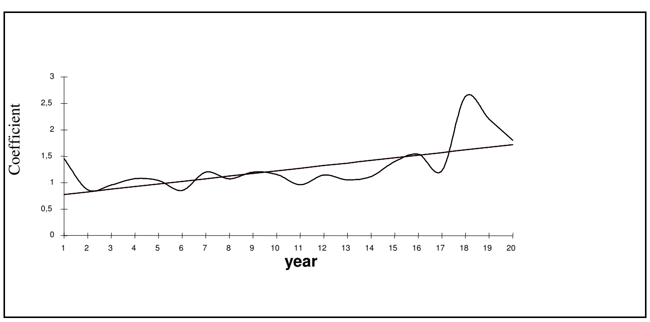

***Figure 1** – Mortality coefficient due to pneumoconiosis, per one million inhabitants/year, Brazil, 1979-1998*

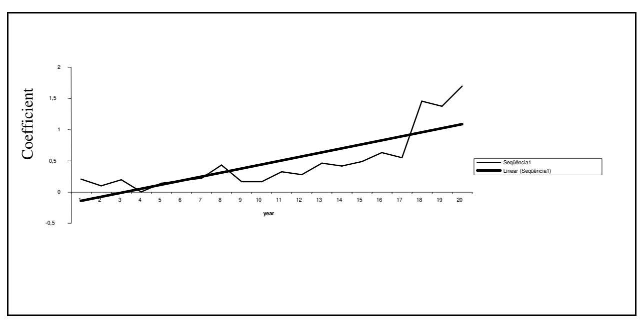

***Figure 2** – Mortality coefficient due to pneumoconiosis, per one million inhabitants/year, North-East, 1979-1998*

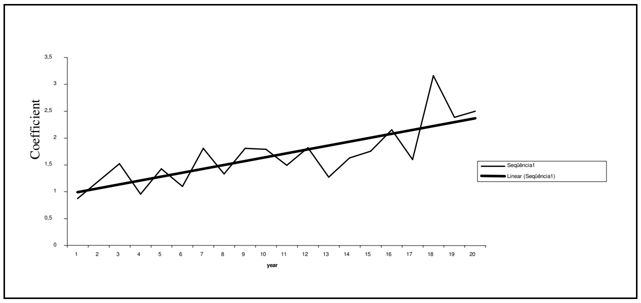

Figure 3 – *Mortality coefficient due to pneumoconiosis, per one million inhabitants/year South-East, 1979-1998*

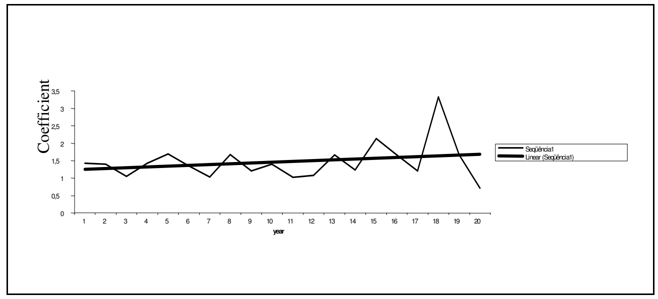

Figure 4 – *Mortality coefficient due to pneumoconiosis, per one million inhabitants/year, South, 1979-1998*

The *Midwestern region* only presented deaths on a regular basis from 1988 on. Therefore, statistical analysis was limited as compared to the other regions, as it only became possible during the period from 1988 through 1998. During this period, it showed an expressive growth of mortality. The angular coefficient obtained by regression was 0.324, the highest of all regions, alerting to a possible expansion of the disease in that area. The low R^2 value, 0.407, was strongly influenced by the variability of the mortality coefficient values, although a clear growth tendency was found for this indicator.

DISCUSSION

Statistical data analysis enabled us to find a way to approach the epidemiological behavior of mortality due to pneumoconioses. In view of the ecological character of this study, the approaches at both the nationwide and the regional levels provided different insights. In the first case, evidence can be obtained regarding the difficulties which still exist to obtain precise knowledge and offer a certain degree of coping with health problems which, although severe, are more specific of certain segments of the population.

At the regional level, it becomes possible to establish a certain degree of approximation and articulation of this specific mortality and regional productive activities with a potentially pneumoconiosis-generating work process. Information on mortality also provided a favorable substrate for analysis, that was best in those regions where the Mortality Information Subsystem showed its best performance, and the resources available for health care allowed better diagnoses of the underlying cause of death.

The dismembering of the different pneumoconioses and the new coding rules introduced by the 10^{th} Revision of the ICD also had an influence on the frequency of deaths due to these diseases. Thus, a more frequent record of the underlying disease as cause of death was favored. Regarding deaths caused by diseases like the pneumoconioses, which frequently occur due to a worsening of the underlying disease – acute respiratory failure, pneumonia, etc. – the new rules displace them to the status of contributing causes. This reduces their under-recording which, although actually not a fact of epidemiological significance, represents a major contribution to the better knowledge of the epidemiological reality of pneumoconioses. Moreover, it can serve as an alert (sentinel event) of the presence and relevance of these diseases in each region, state, and the whole country of Brazil.

The matters mentioned above are those actually analyzed. Nationwide, we can say that the mortality data for pneumoconioses showed that some steps have to be taken in Brazil, so as to obtain information and organize it according to geographic distribution criteria, linked to the country's political and administrative organization. This model supplies data for each state and can be linked to the geographic distribution of the polluting processes. This is a model that contributes to the implementing of essential actions for the control and prevention of these diseases in the work environment.

This is a study of the ecological type, which has so far shown the relevance of the problem and will ultimately provide us with new scientific bases for the design and development of environmental vigilance actions, involving sanitary pneumology and workers' health. It thus contributes to making the risk control and elimination measures more effective, mainly in the field of health promotion and prevention.

Among the identified problems, we point out, as a starting point implemented by this study, the mapping of deaths and productive processes, looking for a geographic and epidemiological association between them. Secondly, some essential elements are stressed, which should be searched for and recognized, so as to make it possible to carry out studies directly relating exposed populations and specific, determined and measurable exposures. What becomes immediately evident is the need to know the exposed populations and their respective exposures, as well as the movements of these populations, which, under the current Brazilian circumstances, represent an obstacle to their knowledge and to any prevention and control action regarding these diseases.

Still nationwide, it was also found that the existing studies, some published and others represented only by service reports for the State Health Departments, show a number of correspondences with the mortality data presented here. It should, however, be stated that almost all of them are based on outpatient diagnoses of pneumoconiosis, made by focal services, not expressing the real morbidity picture, which may still be better represented by the recorded deaths due to these diseases.

The studies on focal, and sometimes regional, realities can be presented as drafts for a mapping that is being implemented. There is, however, the wish to evolve toward a context in which it will be possible to make a territorial and populational demarcation where productive processes exist involving exposure to polluting agents of greater interest, and thus to have access to the determinants of the process by which the resulting morbidity and mortality develop. This will not be an easy task because, although some cities and regions with economic activities involving workers' exposure to pneumoconiosis-causing pollutants are well known, most of them are unknown. Thus, deaths due to pneumoconioses work as signalers of regions and cities where they occur. The results obtained so far by this approach will be discussed by macro-region of the country.

In the *Northern region*, there is a very high percentage of deaths included in the group of codes of chapter "Ill-defined Causes", reaching over 40% of the records. Those deaths correspond most frequently to patients who received no medical attention. Therefore, no diagnosis was made of the underlying disease causing the death. In addition to that, there is a known tendency not to include diseases of specific risk groups in diagnostic hypotheses, when no action is taken to spread information about such pathologies among the physicians of general assistance networks. Such lack of information contributes to the under-recording of deaths, even in patients with access to medical assistance.

In the *Midwestern region*, the mortality coefficient found was not high, but with a tendency to increase from 1995 through 1998, probably due to the improvement of the SIM and to the new coding rules of the 10th Revision of the ICD. In this region the same problems occurred as seen in the Northern region, although the percentage of deaths assigned to the chapter of "Ill-defined Causes" was lower. The coincidence of problems suggests the same line of propositions to solve them, namely the identification of polluting productive processes and of exposed populations. It is preliminarily recorded that the main areas of exposure to mineral dusts in this region are connected to mineral extraction activities and to civil construction.

The *Northeastern region* presented the most evident tendency to a rising mortality coefficient due to pneumoconioses, as it tripled during the studied period. The deaths occurred scattered all over the states, even though there are areas of concentration. This might be explained by a regional characteristic regarding the origin of those diseases, related to a peculiar well-digging activity for water consumption and to the mineral extraction model [6,7].

This region also presents under-recording problems and deficiencies in the diagnosis of the underlying cause of death. Nevertheless, their values are among the highest, as compared to the other regions. Likewise, there is little knowledge regarding other polluting productive processes.

Mortality data from the *Southeastern region* reflect both the effects of the industrial and the mining process, both present in states of that region. It should be noticed, however, that in São Paulo and Rio de Janeiro morbidity and mortality due to pneumoconioses are predominantly the result of industrial productive processes, whereas, in Minas Gerais, they originate mostly from mining processes [8-15].

In this study, the linear regression parameters leave no doubt about the growing tendency of the mortality coefficient due to pneumoconioses. However, the abrupt increase during the years after 1995, which probably occurred in the already discussed regions as a result of the rules of the 10th Revision of the ICD, was not observed. It can be assumed that, in this region, where the diagnostic and medical assistance conditions are better, a good part of the cases and deaths due to those diseases were already diagnosed and reported [16-20].

It is possible that in the states of the Southeastern region, where the productive processes are better listed in the public registers, under-recording also occurs, but to a smaller degree, for the same reasons as mentioned regarding the other regions.

In the states of the Southern region, the mortality information subsystem is among the best developed in Brazil, presenting a good performance during the studied period, and contributing to the reduction of under-information of the underlying causes of death. So, their data are reliable, which also applies to the diagnoses made in that region, favoring the mapping work as an indicator of areas with potentially disease-generating activities [18,20].

Concluding the epidemiological approach of pneumoconioses, as far as information and studies are concerned, the picture is still one of dispersion. This indicates that some steps have to be taken in Brazil, so as to obtain, centralize and organize the information which is necessary for designing and implementing actions to control and prevent these diseases in the work environment. Forming work groups on occupational pneumopathies was a favorable measure taken by the Health Ministry to guide the work of knowing more about these diseases.

The existing data indicate a reality generated by the consequences of workers' exposure to mineral dusts, culminating now with a liability represented by sick workers who are unable to work in any other line of activity, due to their poor health condition. They thus expose a dramatic public health picture, the outcome of which is the patients' usually early death.

Among the control policies for pneumoconioses, an outstanding one is the National Silicose Elimination Program (PNES) set up in Brazil, in accordance with WLO/WHO. This program is crucial for the prevention and eradication of pneumoconioses, where the control of the work environment is the main focus.

Attention to pneumoconioses implies measures to strengthen the field of pneumological assistance targeted to that purpose, taking responsibility for diagnosis, follow-up and rehabilitation of the diseased, as well as follow-up of exposed, but still healthy workers. Workers should be periodically submitted to X-rays and spirometric tests, according to the safety rules for work environments in force in Brazil.

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