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ORIGINAL ARTICLE / *ARTÍCULO ORIGINAL*

Mortality attributed to tobacco consumption in Brazil, 2016

Mortalidad atribuida al consumo de tabaco en Brasil, 2016

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ABSTRACT: ***Objective:*** To update the estimation of tobacco attributable mortality (AM) in the Brazilian population aged 35 years old and older. ***Methods:*** A prevalence-dependent analysis was applied based on the population attributed fraction. This method estimates the tobacco AM taking into account the mortality observed in Brazil (source: Brazilian Mortality Information System – 2016); the prevalence of smokers, former smokers, and never smokers (National Health Survey Brazil – 2013) and the excess of risk of death (relative risk) of smokers and former smokers in comparison to never smokers (derived from 5 North American cohorts). Estimates of overall AM are shown by gender, age group (35–54; 55–64; 65–74; and 75 years old and older) and 3 groups: malignant tumors, cardiometabolic diseases, and respiratory diseases. ***Results:*** In 2016, tobacco consumption caused 163,831 deaths in Brazil, 67% (109,369) were in men and four out of ten (62,791) occurred before the age of 65. Without differences by gender, 42% of the AM is associated with cardiometabolic diseases, followed by respiratory diseases (34%) and malignant tumors (24%). ***Conclusion:*** During 2016, 14% of the deaths occurred in the Brazilian population aged 35 years old and older were attributed to tobacco consumption. Periodic tobacco AM estimations are mandatory to assess and strengthen smoking control strategies and policies.

Keywords: Tobacco. Mortality. Cardiovascular diseases. Pulmonary disease, chronic obstructive. Lung neoplasms. Brazil.

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RESUMEN: ***Objetivo:*** Actualizar la estimación de la mortalidad atribuida al consumo de tabaco en Brasil en población de 35 y más años. ***Métodos:*** Se aplicó un método dependiente de prevalencia, basado en la fracción atribuida poblacional. Este método estima la mortalidad atribuida a partir de la mortalidad observada en Brasil (fuente: Sistema de Información de Mortalidad del Sistema Único de Salud de Brasil-2016); de las prevalencias de fumadores, exfumadores y nunca fumadores (Encuesta Nacional de Salud de Brasil-2013) y del exceso de riesgo de morir (riesgo relativo) que tienen los fumadores y exfumadores en comparación con los nunca fumadores (5 estudios de cohortes norteamericanos). Se presentan estimaciones de mortalidad atribuida globales, por sexo, grupo de edad (35–54; 55–64; 65–74 y 75 años en adelante) y 3 grupos de enfermedades: tumores malignos, enfermedades cardiometabólicas y respiratorias. ***Resultados:*** En 2016, el consumo de tabaco causó con 163.831 muertes en Brasil, el 67% (109.369) fue en hombres y cuatro de cada diez (62.791) sucedieron antes de los 65 años. El 42% de la mortalidad atribuida se asocia a enfermedades cardiometabólicas, seguidas de respiratorias (34%) y tumorales (24%), sin diferencias por sexo. ***Conclusión:*** El 14% de las muertes que sucedieron en Brasil durante 2016 en población de 35 y más años se atribuye al consumo de tabaco. Realizar de forma periódica estimaciones de MA es necesario para valorar y fortalecer las leyes de control de tabaquismo implantadas.

Palabras clave: Tabaco. Mortalidad. Enfermedades cardiovasculares. Enfermedad pulmonar obstructiva crónica. Neoplasias pulmonares. Brasil.

INTRODUCTION

Tobacco use is considered the preventable risk factor that causes the most deaths in the world[1]. It is responsible for approximately one million deaths per year in the Latin American and Caribbean Regions[2].

Consumption prevalence has decreased over the last 20 years in industrialized countries, although this decrease is not homogeneous in South America as a whole[3]. In Brazil, where 210 million people live[4], *i.e.*, a third of the South American population, the prevalence of tobacco consumption among the adult population has decreased since the end of the 1980s, from 35% in 1989 to 15 % in 2003[5], and later stabilizes. In 2013, the prevalence was stable at 14.7%, which translates into approximately 22 million smokers[6]. Different studies estimated the attributable mortality (AM) of tobacco consumption for Brazil; the most recent, from 2013, estimated that tobacco caused 132,928 deaths[7]. In addition, there are AM estimates in specific areas of the country[8] and for selected causes[9]. Calculating AM, specifically related to tobacco consumption, allows the evaluation of individual situations, as well as the planning and management of health policies aimed at curbing the impact of tobacco on the health of the population.

The objective of this work was to update the 2016 estimate on AM for tobacco consumption in Brazil in the population aged 35 years old and older using the best evidence available.

METHODS

To estimate tobacco consumption AM in Brazil, a dependent method of prevalence of tobacco consumption was applied, based on the calculation of the population attributed fraction (PAF)[10]. This method estimates AM as the product of observed mortality (OM) and PAF, calculated from the prevalence and excess risk of dying (RR: relative risk) of smokers (S) and former smokers (FS) compared to never smokers (NF). The PAF was estimated according to Equation 1:

$$\frac{[P0 + P1RR1 + P2RR2] - 1}{[P0 + P1RR1 + P2RR2]} \quad (1)$$

Where:
p = the prevalence of tobacco use;
RR = the excess risk that smokers (1) and former smokers (2) have of dying from diseases related to tobacco use, taking as a reference the group of never smokers (0).

The OM for the year 2016 comes from the data of the Mortality Information System of the Brazilian Unified Health System (*Sistema de Informação de Mortalidade do Sistema Único de Saúde* – SIM-SUS), which has information on the basic cause of death, coded as declared by the certifying physician, according to the standards established by the World Health Organization, using the Tenth Revision of the International Classification of Diseases (ICD-10)[11]. The causes of death associated with tobacco consumption[12] were analyzed in detail (individually) and subsequently grouped into three groups of diseases: malignant tumors (lip-oral cavity-pharynx, esophagus, pancreas, larynx, trachea-lung-bronchi, cervix, urinary bladder, kidney-renal pelvis, stomach, liver cells, colon and rectum, and acute myeloid leukemia), cardiometabolic (ischemic heart disease, other heart diseases, cerebrovascular disease, atherosclerosis, aortic aneurysm, other arterial disease, diabetes mellitus), and respiratory diseases (pneumonia-influenza, tuberculosis and chronic obstructive pulmonary disease — COPD) (for detailed information, please refer to Supplementary Table 1).

The prevalence of S, FS, and NS by gender and age group (35–54; 55–64; 65–74; and 75 years old and older) was estimated from the microdata of the National Health Survey (*Pesquisa Nacional de Saúde* – PNS), Module P — Lifestyles, carried out by the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* – IBGE) in 2013. This survey is the latest one available where the prevalence of tobacco consumption represents the Brazilian population according to their tobacco consumption status: NS, S, and FS. The S category includes daily and occasional smokers (Supplementary Table 2)[6].

The RR applied came from the follow-up of 5 cohorts including 956,756 participants: the National Institutes of Health -AARP Diet and Health Study, the American Cancer Society's

CPS-II Nutrition Cohort, the Women's Health Initiative (WHI), the Nurses' Health Study, and the Health Professionals Follow-Up Study[13].

Approval from the Ethics Committee was not necessary in order to carry out this research as it worked with secondary free-access databases; in this sense, the study does not represent an ethical risk for people nor for the environment.

The results presented below are the estimates of AM in global terms, by gender, age group (35–54, 55–64, 65–74, and 75 years older and older) and 3 groups of diseases: malignant tumors, cardiometabolic, and respiratory. The calculations were performed with Stata 14 and Epidat 4.2.

RESULTS

In 2016, tobacco use was responsible for 163,831 deaths among the population aged 35 years old and older in Brazil (Table 1); 66.8% (109,370) of the AM occurred in men; 38.3% of the attributed deaths were premature (62,791), that is, they occurred before the age of 65, 40% in men and 36.1% in women.

Cardiometabolic diseases represent the greatest burden in AM (42.6% of total AM in men and 41.0% in women); followed by respiratory (32.3 and 36.6%, respectively) and malignant tumors (25.0 and 22.4%).

COPD is the disease with the highest attributed mortality (33,490 deaths in both genders). Taking into account gender, the two causes with the highest AM burden are COPD and ischemic heart disease. In men, ischemic heart disease is the cause with the highest mortality (21,532 deaths) followed by COPD (20,321 deaths); in women, the order is reversed and the first cause is COPD (13,169 deaths) and the second is ischemic heart disease (9,789 deaths). COPD and lung cancer are associated with 33.6% of AM. In those older than 74 years, respiratory diseases, specifically COPD, are the main cause of AM.

In ischemic heart disease, PAF ranges between 20 and 44% in men and between 12 and 44% in women, according to age groups, with higher figures for the younger age groups (between 35 and 54 years). For any age, both in men and in women, the PAF associated with lung cancer stands out (close to 80 and 70% respectively, with slight variations depending on the age group).

Overall, as age increases, AM also increases. Respiratory diseases, whose mortality ratio for the age group of 65 years old and older compared to those under 65, exceed the value of 2 (2.3 in men and 2.5 in women), while for cardiometabolic diseases and malignant tumors, AM is below 1.5.

Regardless of the age group, the male/female mortality ratio is 2 and varies depending on the specific causes. The maximum value of the male/female mortality ratio is observed in "Other cancers", in which it takes a value of 3.4, and the minimum values are seen in COPD and lung cancer (ratios 1.5 and 1.6 respectively).

DISCUSSION

In 2016, tobacco use caused 163,831 deaths in Brazil, representing approximately 450 deaths per day, 12.5% of the total mortality in the country and 14% of the deaths occurred in the population aged 35 years old and older. Tobacco AM is higher in men and, globally, 4 out of 10 attributed deaths occur before 65 years of age. The two highest specific causes of death with PAF are COPD and lung cancer, which cause 1 in 3 deaths attributed to tobacco use.

In 2004, a report by the World Health Organization, based on the application of an independent prevalence method, estimated that, in Brazil, tobacco had produced 116,094 deaths[14]. More recent estimates, applying a prevalence-dependent method, reflect an increase since 2004, and in 2011 the AM was estimated at 147,072 deaths and then decreased in 2013 to 132,928[7,9]. In 2016, AM is estimated at 163,831 deaths, which represents an increase in

Table 1. Attributed mortality and population attributed fraction to tobacco use, according to cause of death and gender, in individuals aged 35 years old and older. Brazil, 2016.

				Trachea, bronchi, and lung cancer	Other cancers[a]	Ischemic heart disease	Other heart diseases[b]	Cerebrovascular disease
Males		Total		**13,364**	**14,018**	**21,532**	**7,512**	**9,428**
	Age group (years)	35–54	AM	1,207	2,115	4,725	1,344	1,349
			PAF	0.78	0.19	0.44	0.24	0.24
		55–64	AM	3,391	3,563	6,005	2,159	2,898
			PAF	0.84	0.24	0.39	0.35	0.35
		65–74	AM	4,538	4,606	6,254	2,129	2,897
			PAF	0.88	0.30	0.35	0.25	0.22
		≥ 75	AM	4,228	3,734	4,549	1,879	2,284
			PAF	0.83	0.25	0.20	0.12	0.10
Females		Total		**8,138**	**4,070**	**9,789**	**3,929**	**4,538**
	Age group (years)	35–54	AM	1,068	511	2,173	645	872
			PAF	0.78	0.07	0.44	0.17	0.17
		55–64	AM	2,277	1,433	2,087	640	912
			PAF	0.79	0.19	0.29	0.15	0.15
		65–74	AM	2,488	1,122	2,734	826	1,395
			PAF	0.77	0.13	0.25	0.12	0.14
		≥ 75	AM	2,305	1,004	2,795	1,818	1,359
			PAF	0.66	0.08	0.12	0.08	0.05

Continue...

Table 1. Continuation.

				Other vascular diseases[c]	Diabetes *mellitus*	Pneumonia, flu, tuberculosis	COPD	Total
Males		Total		**3,186**	**4,961**	**15,048**	**20,321**	**109,370**
	Age group (years)	35–54	AM	197	814	3,032	521	**15,304**
			PAF	0.24	0.24	0.50	0.50	
		55–64	AM	482	1,993	4,769	2,537	**27,797**
			PAF	0.35	0.35	0.81	0.81	
		65–74	AM	1,230	1,882	2,708	5,605	**31,848**
			PAF	0.61	0.24	0.35	0.89	
		≥ 75	AM	1,277	272	4,539	11,658	**34,421**
			PAF	0.43	0.03	0.20	0.83	
Females		Total		**1,741**	**2,341**	**6,747**	**13,169**	**54,461**
	Age group (years)	35–54	AM	94	488	1,400	400	**7,651**
			PAF	0.17	0.17	0.48	0.45	
		55–64	AM	116	757	2,421	1,397	**12,039**
			PAF	0.15	0.15	0.68	0.57	
		65–74	AM	588	842	668	3,924	**14,588**
			PAF	0.44	0.10	0.11	0.87	
		≥ 75	AM	943	254	2,258	7,448	**20,184**
			PAF	0.28	0.01	0.08	0.66	

[a,b,c]: see Supplementary Table 1 for more information; AM: attributed mortality; PAF: population attributed fraction; COPD: chronic obstructive pulmonary disease.

relation to previous estimates. It should be noted that the comparison of the results should not be done directly due to methodological differences between the 3 studies: thus, in the 2016 study, estimates of prevalence and specific RR are used in 4 age groups, while in previous studies, only 2 groups are assessed; in addition, the 2016 study includes 4 causes of death not previously considered in the estimate. In Spain, a study that analyzed the change in the estimate associated with these two aspects quantified the percentage of increase in AM by 12%[15].

As in the studies conducted in 2011 and 2013, COPD continues to be the main cause of tobacco AM in Brazil and no changes have been observed in the attribution of lung cancer mortality[7,9]. The mortality rate attributed to tobacco use due to malignant tumors is lower than that observed in European countries or North America, where they are the group of causes

with the highest burden of AM. The different age structure could explain these differences, since Brazil, compared to the United States, Canada or Europe, has a less aged population.

The decline observed in the prevalence of tobacco use in Brazil since the late 1980s and its stabilization in recent years does not seem to be reflected in AM. AM would be expected to have decreased, since the decrease in prevalence is reflected in the OM approximately 3 decades later[16-18]. The first estimate available for Brazil is from 1985[19]. To differentiate the impact of the prevalence decline in OM from population aging on this point is difficult. In the last 30 years, OM in Brazil in the population aged 35 years old and older has increased; for example, in 1996, the number of deaths was 695,909, in 2006 it was 861,061, and in 2016, 1,148,330. However, even though the prevalence of tobacco use has decreased and its decline has had an impact on OM, the aging of the population or improvements in registry coverage may explain why there are observed no decreases in AM.

In Brazil, 40% of deaths attributed to tobacco use, in both men and women, occur before the age of 65. In European countries, the burden of mortality is concentrated among those over 64 years of age. For example, in Spain, 25% of tobacco AM occur before the age of 65, with important differences based on gender; thus, this percentage is 23% among men and 35% in women due to the impact that malignant tumors have among young women, which is reflected in a mortality ratio of 1 when comparing the two age groups. In the specific case of respiratory diseases, it stands out that in Spain the mortality ratio presents values of 11.5 and 4.9, in men and women respectively, when the age group of 65 and over is compared with those under 65; in Brazil, these values are 2.3 and 2.5. The lower aging of the population or differences in the health system may explain the burden of mortality in those under 65 years of age[20].

This work presents the usual limitations of any work that estimates AM. Among them are those linked to the calculation process and data sources[10]. In relation to OM, the quality and coverage of the mortality registry must be taken into account. The quality of the Brazilian mortality registry has improved in recent years. Thus, it must be taken into account that in 2005 it was classified as of medium quality[21]. In the 2000-2011 period, the presence of junk codes was estimated at 21%, *i.e.* mortality coded as "Symptoms, signs, and abnormal clinical and laboratory findings, not classified elsewhere", in the Brazilian Mortality Registry[22], although in 2014, poorly defined causes corresponded to 8%[23]. Based on data from the Brazilian mortality registry, it is estimated that the percentage of deaths in the population aged 35 years old and older classified as "Symptoms, signs, and abnormal clinical and laboratory findings, not classified elsewhere", has decreased with time, from 16.4% in 1996 to 5.6% in 2017. Another factor to take into account is the underreporting of mortality estimated for 2009 at 9%[7].

The improvement in the quality of the mortality registry led the World Health Organization to point out that the quality of mortality available since 2017 is high[24]; nonetheless, some authors use corrections in the mortality data that would correct the under-registration and the junk or non-specific codes data[9]. These corrections have not been applied in this work due to the uncertainty that a global correction for mortality could entail. The decrease in

junk codes, *i.e.* the mortality coded under the rubric "Symptoms, signs and abnormal clinical and laboratory findings, not classified elsewhere" may have caused an increase in OM from causes associated with tobacco use, with the consequent increase in the estimation of the AM. In relation to the prevalence of consumption, it should be taken into account that the target population of the survey from which the prevalence estimates are derived does not include residents of households located in special census sectors, which could affect the global estimate of prevalence.

Limitations in common with other studies, such as those linked to the use of prevalence of tobacco consumption temporarily concurrent with the observed mortality, to self-declaration of prevalences[25] or to the extrapolation of mortality risks derived from North American populations and not adjusted for confounders[9,26,27] are present. The temporal proximity between the year of the estimate of prevalence of consumption and that of the OM does not guarantee a correct temporal precedence of the exposure compared to the effect. This may lead to an underestimation of AM, associated with the decrease in the prevalence of tobacco use in Spain in recent decades.

This study also has a number of advantages. AM was estimated globally using the best available evidence, which makes it possible to measure the burden of mortality associated with tobacco use in Brazil and to help shape policies aimed at tobacco control. Having the microdata from the survey made it possible to estimate the prevalence in the same age groups as the risks.

In conclusion, 14% of the deaths occurred in Brazil during 2016 in the population aged 35 years old and older are attributed to tobacco use. The impact of tobacco on mortality is greater in men. One out of 3 deaths attributed to tobacco is due to COPD or lung cancer.

Brazil, along with Uruguay and Panama, has been a continental leader in tobacco control; and it has progressively implemented tobacco control policies since 1980[7,28] that have resulted in a significant decrease in the prevalence of consumption, although they are not reflected in a decrease in attributed mortality. To assess this decrease in AM, it is necessary to estimate, using the same methodology, the evolution of AM in Brazil in recent years and to make periodic estimates in order to be able to assess and strengthen the impact of smoking control strategies and policies.

SUPPLEMENTARY MATERIAL

Additional material to this article can be consulted on the causes of death associated with tobacco use (Supplementary Table 1) and the prevalence of tobacco use in Brazil, 2013 (Supplementary Table 2).

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