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Trends in smoking-attributable mortality in Spain: 1990–2018

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Background: This study sought to analyse the trend in smoking-attributable mortality (SAM) in Spain among the population aged ≥35 years across the period 1990–2018. **Methods:** SAM was estimated by applying a prevalence-independent method, which uses lung cancer (LC) mortality as a proxy of tobacco consumption. We sourced observed mortality from the National Institute of Statistics (Spain), LC mortality rates in smokers and never smokers from the Cancer Prevention Study I–II, and relative risks from 5 US cohorts. Estimates of annual SAM by cause of death, sex and age are shown, along with crude and annual standardised SAM rates. The trend in standardised all-cause and LC rates was analysed using a joinpoint regression model. **Results:** Tobacco caused 1 717 150 deaths in Spain in the period 1990–2018. Among men, cancers replaced cardiovascular diseases–diabetes mellitus (CVD–DM) as the leading group of tobacco-related cause of death in 1994. Among women, CVD–DM remained the leading cause of death throughout the period. Trend analysis of standardised SAM rates due to all causes and LC showed a decrease in men and an increase in women. **Conclusions:** The tobacco epidemic in Spain across the period 1990–2018 has had an important impact on mortality and has evolved differently in both genders. SAM is expected to increase dramatically in women in the coming years. SAM data highlight the importance of including a gender perspective in SAM analyses, in designing more effective and comprehensive public health interventions and in developing gender-specific tobacco control policies to curb tobacco consumption.

Introduction

The effects of tobacco consumption on people's health have long been, and indeed continue to be, a highly relevant research topic. In the 50 years between the publication of the Surgeon General's first report in 1964[1] and the latest report, causal relationships between tobacco consumption and more than 20 diseases have been established.[2] Among these diseases, three major groups can be discerned, namely, cancers, cardiovascular diseases (CVD) and respiratory diseases. According to the National Statistics Institute (NSI—Spain), in 2020, these three disease groups accounted for 22.8%, 24.3% and 8.6% of total deaths in Spain, respectively.[3]

In Spain, before 2005, different legislative measures in tobacco control were implemented. Nevertheless, the greatest advance came in 2006 with the implementation of the Law 28/2005 on health measures against smoking and regulating the sale, supply, consumption and advertising of tobacco products.[4] This regulation was incomplete, and tobacco consumption was allowed in the hospitality sector under certain assumptions.[4,5] In 2010, a comprehensive regulation, the Law 42/2010, amended the Law 28/2005 extending the smoking ban to hospitality venues with no exception.[6]

Various indicators can be used to ascertain the impact of tobacco consumption on people's health: the most commonly used is the prevalence of smoking. National Health Surveys, which provide information on the prevalence of tobacco consumption nationwide, have been conducted in Spain since 1987. Notwithstanding this, no year-on-year data are available and the periodicity of such surveys has been irregular. Prevalence data is derivable for 12 years, sourced from both the National Health Survey and the European Health Survey in Spain.[7,8] Nonetheless, data for 18 of the 28 years included in the period 1990–2018 is missing, making it impossible to form an accurate picture of the trend in the tobacco epidemic in Spain. Another alternative indicator is the smoking-attributable mortality (SAM). Lopez et al.,[9] proposed a model based on the monitoring of prevalence and SAM to analyse the trend in the tobacco epidemic in a given population. The method generally used to estimate SAM is based on the prevalence of tobacco consumption and is known as 'prevalence-dependent method'. Yet, the lack of data on the prevalence of annual tobacco consumption means that an alternative, prevalence-independent method, must be used.[10]

The aim of this study was to analyse the trend in SAM in Spain among the population aged ≥35 years across the period 1990–2018, by applying a prevalence-independent method.

Methods

Method of estimation

To estimate SAM, we used a prevalence-independent method of tobacco consumption, developed by Peto et al., which uses lung cancer (LC) mortality as a proxy of tobacco consumption.[10]

LC SAM was estimated on the basis of observed mortality (OM) due to LC and the difference between the LC mortality rate overall and in never smokers among the study population, year on year, across the period 1990–2018.[11]

To estimate SAM to the remaining causes associated with tobacco consumption, the smoking impact ratio (SIR) was calculated as follows:

$$\mathrm{SIR} = \frac{C_{\mathrm{LC}} - N_{\mathrm{LC}}}{S^{*}_{\mathrm{LC}} - N^{*}_{\mathrm{LC}}}$$

where C_{LC} and N_{LC} are overall and never smokers LC mortality rates in the study population, respectively. S^{*}_{LC} and N^{*}_{LC} are the LC mortality rates among smokers and never smokers in a reference population, respectively.

The population attributable fraction (PAF) for each associated disease is calculated as follows:

$$\mathrm{PAF} = \frac{\mathrm{SIR}\ (\mathrm{RR} - 1)}{1 + \mathrm{SIR}(\mathrm{RR} - 1)}$$

where RR refers to the risk posed to smokers of dying of tobacco-related diseases with respect to never smokers.

Lastly, SAM for each cause is obtained as the product of OM multiplied by the PAF.

Data sources

OM was obtained for each year of the period 1990–2018 by sex, age and cause of death from the NSI.[3] Cause of death information was extracted between 1990 and 1998 following the coding of the 9th revision of the International Classification of Diseases (ICD) and since 1999 following the coding of the 10th revision of ICD. The codes were harmonized according to the recommendations of Anderson et al.[12] The causes of death are divided into three major groups: cancers, cardiovascular diseases-diabetes mellitus (CVD-DM) and respiratory diseases. Detailed information on the causes included in each major group accompanied by their ICD-9 and ICD-10 codes can be found in Supplementary table S1.

The LC mortality rates in the Spanish population were estimated for each year, taking the population resident on 1 July of each year as reference.[13]

The LC mortality rates in the reference population for smokers and never smokers and the LC mortality rates for never smokers in the study population were drawn from the Cancer Prevention Study Phases I and II.[14]

Relative risks (RRs) by cause, sex and age group (35–54, 55–64, 65–74, ≥75 years), were obtained from a joint analysis of five cohort studies conducted in the USA.[2]

Analysis

The following analyses were performed: annual SAM for the period 1990–2018, by sex and cause of death; and annual crude SAM rates, by sex, for 4 causes of death [LC, cancers (including LC), CVD–DM, and respiratory diseases].

Annual SAM rates were standardised by age using the direct method, and calculated for each sex and age group (35–64, ≥65 years). The Eurostat Task Force European standard population was used for rate adjustment.[15] We analysed the trend in annual standardised SAM rates using joinpoint regression models, assuming variance to be constant, and setting a maximum of 3 cutpoints (joinpoints) and a significance level of 5%. The annual percentage change (APC) with its 95% confidence interval (CI) was calculated.

Analysis was performed with the statistical package Stata v16.1 and the Joinpoint regression software v4.8.[16]

Results

In Spain, active smoking caused 1 717 150 deaths between 1990 and 2018 in population aged ≥35 years, accounting for 12.7% of total deaths in this period (22.3% in men and 2.3% in women). Of the total SAM, 1 563 706 deaths occurred in men and 404 174 in population aged <65 years, which accounted for 24.8% of total mortality in the same age group during the study period; 31.7% in men and 8.6% in women. Of the total SAM, 42.6% was due to cancers (60.4% due to LC), 35.8% due to CVD–DM (35.1% and 0.7%, respectively), and 21.6% due to respiratory diseases (88.4% due to chronic obstructive pulmonary disease). Among men, the principal group of causes of death comprised cancers (43.6%), followed by CVD–DM (35.1%) and respiratory diseases (21.4%). Among women, CVD–DM (43.2%) was the group of causes with the greatest impact on SAM, followed by cancers (32.5%) and respiratory diseases (24.3%) (tables 1 and 2).

Among men, a downward trend in crude SAM rates was observed in all causes. The crude SAM rate for CVD–DM fell from 239.1 to 105.1 cases per 100 000 population between 1990 and 2018 and was replaced by cancers in 1994. In respiratory diseases, there was a fall in crude SAM rates from 1999 onwards. The crude SAM rates for LC drew level with those for CVD–DM in 2013. Among women, there was a rising trend in crude SAM rates for all causes. In the initial years of the study period, the crude SAM rates for CVD–DM showed wide variability but from 2001 these displayed a rising trend (figure 1). In cancers, an increase was likewise observed in crude SAM rates, going from 1.5 to 31.0 cases per 100 000 population between 1990 and 2018. When the trend was analysed in individualised causes rather than in large groups, LC was observed to be the cause of death with the highest crude SAM rate in men across the period and that which registered the greatest increase in the crude SAM rate in women from 1990 to 2018 (Supplementary tables S2 and S3).

The analysis of the annual standardised SAM rates for all causes revealed opposite scenarios according to sex. Since 1990, the standardised SAM rate independently of age decreased in men and increased in women. The joinpoint model identified three downward periods in men aged 35–64 years. The first change point occurs in 1999, with an APC lower than the second and third periods [APC 1990–99 = −1.1 (95% CI −1.6 to −0.7); APC 1999–2008 = −3.0 (−3.5 to −2.5); APC 2008–18 = −3.8 (−4.2 to −3.5)]. In men aged ≥65 years, two periods with a downward trend were identified, with the APC for the second period being higher than that for the first [APC 1990–98 = −0.1 (−0.9 to 0.7); APC 1998–2018 = −2.6 (−2.8 to −2.4)]. Among women aged 35–64 years, there were two upward periods: the first until 2001 (change point), with a percentage increase in SAM rates which quadrupled that of the second period [APC 1990–2001 = 25.0 (20.3–29.9) and APC 2001–18 = 6.1 (4.1–8.3)]. Among women aged ≥65 years, a single period with a rising trend was identified without any change point [APC 1990–2018 = 7.1 (5.7–8.6)]. The APC differ between sexes, being higher in women and especially in younger women in the first period set by the joinpoint (figure 2 and Supplementary table S4).

Related to the annual standardised SAM rates for LC, a slightly rising trend was observed in the initial years of the study period among men aged 35–64 and ≥65 years, with this being more marked

Table 1 Smoking-attributable mortality (SAM) and its percentage of total SAM in men ≥35 years, by cause of death: Spain, 1990–2018

	Men												
	Cancers				**Cardiovascular diseases–diabetes mellitus**				**Respiratory diseases**				**Total**
	Lung cancer[a]		**All remaining cancers**[a]		**Cardiovascular diseases**[b]		**Diabetes mellitus**		**COPD**		**Other respiratory diseases**[c]		
	SAM	**%**	**SAM**	**%**	**SAM**	**%**	**SAM**	**%**	**SAM**	**%**	**SAM**	**%**	**SAM**
1990	11 094	22.5	7388	15.0	20 429	41.5	478	1.0	8715	17.7	1113	2.3	49 218
1991	11 529	22.7	7651	15.1	21 066	41.5	460	0.9	9104	17.9	979	1.9	50 789
1992	12 033	23.5	8000	15.6	20 837	40.7	438	0.9	8849	17.3	983	1.9	51 139
1993	12 477	23.4	8481	15.9	21 278	39.9	459	0.9	9563	17.9	1040	2.0	53 299
1994	12 855	24.2	8684	16.3	20 815	39.1	456	0.9	9410	17.7	986	1.9	53 206
1995	13 204	24.0	8822	16.1	21 005	38.2	475	0.9	10 405	18.9	1030	1.9	54 941
1996	12 948	23.6	8598	15.7	20 925	38.2	439	0.8	10 867	19.8	1020	1.9	54 797
1997	13 127	24.0	8886	16.3	20 500	37.5	413	0.8	10 729	19.6	1027	1.9	54 683
1998	13 608	24.0	9013	15.9	20 992	37.0	447	0.8	11 637	20.5	1073	1.9	56 770
1999	14 048	23.9	9309	15.8	21 227	36.1	443	0.8	12 147	20.7	1628	2.8	58 802
2000	13 865	25.0	9205	16.6	19 851	35.7	425	0.8	10 804	19.5	1381	2.5	55 532
2001	14 602	26.0	9759	17.4	20 023	35.7	415	0.7	9995	17.8	1345	2.4	56 139
2002	14 301	25.5	9395	16.8	19 529	34.8	411	0.7	11 035	19.7	1401	2.5	56 072
2003	14 801	25.7	9669	16.8	20 097	34.8	424	0.7	11 245	19.5	1435	2.5	57 670
2004	14 871	26.8	9754	17.6	18 971	34.2	413	0.7	10 241	18.4	1262	2.3	55 511
2005	14 832	26.0	9558	16.7	19 123	33.5	430	0.8	11 586	20.3	1589	2.8	57 117
2006	15 032	27.9	9587	17.8	18 149	33.6	391	0.7	9507	17.6	1300	2.4	53 967
2007	15 278	27.5	9714	17.5	18 353	33.0	396	0.7	10 411	18.7	1427	2.6	55 578
2008	15 199	28.2	9619	17.8	17 527	32.5	377	0.7	9779	18.1	1476	2.7	53 977
2009	15 291	28.3	9694	17.9	16 910	31.3	349	0.6	10 413	19.3	1387	2.6	54 044
2010	15 257	28.7	10 010	18.8	16 300	30.7	327	0.6	10 153	19.1	1134	2.1	53 181
2011	15 410	28.9	10 085	18.9	15 980	29.9	327	0.6	10 295	19.3	1278	2.4	53 375
2012	15 542	28.5	10 283	18.8	16 168	29.6	318	0.6	10 936	20	1333	2.4	54 580
2013	15 415	29.4	10 118	19.3	15 497	29.6	285	0.5	9888	18.9	1223	2.3	52 425
2014	15 032	29.4	9672	18.9	14 976	29.3	301	0.6	9919	19.4	1286	2.5	51 186
2015	15 050	28.6	9676	18.4	15 450	29.3	302	0.6	10 768	20.4	1436	2.7	52 681
2016	15 375	29.7	9826	19.0	15 333	29.6	298	0.6	9585	18.5	1415	2.7	51 831
2017	14 999	29.3	9557	18.7	15 172	29.6	295	0.6	9712	19	1482	2.9	51 217
2018	14 888	29.8	9328	18.7	14 775	29.6	274	0.5	9113	18.2	1599	3.2	49 978
Total	411 963	26.3	269 343	17.2	537 260	34.4	11 267	0.7	296 809	19	37 065	2.4	1 563 706

COPD: Chronic obstructive pulmonary disease.

a: All remaining cancers: include lip, oral cavity and pharynx, oesophagus, stomach, colon and rectum, liver and intrahepatic bile ducts, pancreas, larynx, cervix uteri, urinary bladder, kidney-renal pelvis and acute myeloid leukaemia.

b: Cardiovascular diseases: include ischaemic heart disease, rheumatic heart diseases, cardiopulmonary diseases, other types of heart disease, cerebrovascular disease, atherosclerosis, aortic aneurysm and other arterial diseases.

c: Other respiratory diseases: include influenza–pneumonia–tuberculosis.

in the 65-year-and-over group. Among women, a rising trend was observed across the period in both age groups; 35–64 and ≥65 years. In younger women (35–64 years old), joinpoint detected two periods; the first (1990–2002) with an APC that was four times higher than that for the second period. In women aged ≥65 years, no change points were detected (Supplementary figure S1 and Supplementary table S4).

Discussion

In Spain, tobacco consumption caused 1 717 150 deaths in population aged ≥35 years across the period 1990–2018. Although SAM was higher in men throughout the study period, the greater change in SAM figures was observed in women, with an increase of over 10 000 deaths between the first and last years of the series. The principal group of causes of death consisted of cancers in men from 1994 onwards and CVD–DM in women across the study period. LC remained the leading cause of death in men throughout the whole series and in women from 2009 onwards. The standardised SAM rates displayed a downward trend in men and an upward trend in women.

The results obtained in this study reflect the trend in the tobacco epidemic in Spain across the stages proposed by Lopez et al.[9] Spanish men started smoking during the Spanish Civil War (1936–39) and its prevalence started to decrease since the 1970s[17] and continue to decrease until today.[7,8] In women, it is observed that smoking prevalence started to increase in the 1960s[17] and decrease in 2006, although this decline has been very slight until the current prevalence data.[5,7,8] This places men and women at different stages in the evolution of the tobacco epidemic with men currently at phase IV and women at late phase III.[9]

In our study, a peak in SAM figures was observed in men in 1999. However, among women, there was an increase in SAM figures across all the series studied. These results are similar to those found by a systematic review of SAM undertaken in Spain, which reported a decrease in SAM figures among men in 2001, and an increase among women ever since the first estimate in 1978.[18]

According to the Global Burden of Disease study (GBDS),[19] the percentage change between the number of deaths attributed to tobacco consumption from 1990 and 2019 in Spain was 1.86%, while in our study it was 23.9%. This difference can be explained by the methodology used in each study. The GBDS uses a methodology based on the current prevalence of tobacco consumption and our study based on the LC mortality rates. The percentage change between smoking prevalence in Spain used by the GBDS between 1990 and 2019 is −23.6% in women and −39.6% in men.[19] However, the percentage change between 1990 and 2018 LC mortality rates was 151.7% in women and −12.1% in men.[3] The higher percentage change for women and lower for men between LC mortality rates may explain why we observe such differences. Moreover, the GBDS

Table 2 Smoking-attributable mortality (SAM) and its percentage of total SAM in women ≥35 years, by cause of death: Spain, 1990–2018

	Women												Total
	Cancers				Cardiovascular diseases–diabetes mellitus				Respiratory diseases				
	Lung cancer		All remaining cancers[a]		Cardiovascular diseases[b]		Diabetes mellitus		COPD		Other respiratory diseases[c]		
	SAM	%	SAM	%	SAM	%	SAM	%	SAM	%	SAM	%	SAM
1990	68	5.0	77	5.7	695	51.6	11	0.8	470	34.9	26	1.9	1347
1991	103	9.1	94	8.3	528	46.5	18	1.6	371	32.7	21	1.9	1135
1992	81	10.5	75	9.7	337	43.6	13	1.6	254	32.9	14	1.8	773
1993	111	5.4	128	6.2	1051	51.3	15	0.7	703	34.3	41	2.0	2050
1994	123	15.7	111	14.2	308	39.4	19	2.5	207	26.4	15	1.9	783
1995	176	9.2	154	8.0	891	46.4	22	1.1	640	33.3	39	2.0	1922
1996	137	10.9	114	9.1	550	43.9	16	1.2	408	32.5	30	2.4	1254
1997	223	11.6	172	8.9	847	44.1	23	1.2	610	31.7	47	2.4	1922
1998	290	9.8	226	7.6	1379	46.5	29	1.0	966	32.6	75	2.5	2965
1999	311	12.0	222	8.6	1082	41.9	29	1.1	842	32.6	95	3.7	2582
2000	379	15.4	238	9.7	1059	42.9	30	1.2	666	27.0	94	3.8	2466
2001	408	17.9	251	11.0	982	43.2	33	1.5	525	23.1	75	3.3	2274
2002	538	15.9	346	10.2	1468	43.3	42	1.2	872	25.7	121	3.6	3387
2003	651	15.0	428	9.9	1942	44.8	48	1.1	1113	25.7	154	3.6	4337
2004	797	18.1	503	11.4	1931	43.8	52	1.2	985	22.3	147	3.3	4413
2005	792	16.3	511	10.5	2107	43.3	55	1.1	1208	24.8	193	4.0	4865
2006	924	20.0	562	12.1	2005	43.3	56	1.2	911	19.7	169	3.7	4626
2007	1049	18.7	661	11.8	2447	43.5	65	1.2	1187	21.1	211	3.8	5620
2008	1259	18.6	828	12.2	2991	44.2	73	1.1	1343	19.8	275	4.1	6770
2009	1301	20.7	824	13.1	2577	40.9	73	1.2	1255	19.9	263	4.2	6292
2010	1584	22.0	1037	14.4	2905	40.3	80	1.1	1370	19.0	237	3.3	7213
2011	1684	19.9	1189	14.1	3525	41.7	82	1.0	1646	19.5	333	3.9	8459
2012	1891	20.8	1269	14.0	3729	41.0	80	0.9	1780	19.6	335	3.7	9083
2013	2157	21.4	1503	14.9	4204	41.7	92	0.9	1767	17.5	370	3.7	10 092
2014	2083	21.9	1409	14.8	3825	40.1	93	1.0	1750	18.4	368	3.9	9529
2015	2372	21.9	1596	14.8	4395	40.6	101	0.9	1911	17.7	437	4.0	10 812
2016	2541	22.9	1718	15.5	4485	40.4	100	0.9	1793	16.1	468	4.2	11 106
2017	2811	22.1	1924	15.2	5259	41.4	114	0.9	2027	16.0	558	4.4	12 693
2018	2893	22.8	1936	15.3	5206	41.1	115	0.9	1885	14.9	639	5.0	12 673
Total	29 734	19.4	20 105	13.1	64 709	42.2	1576	1.0	31 467	20.5	5853	3.8	15 3444

COPD: chronic obstructive pulmonary disease.

a: All remaining cancers: include lip, oral cavity and pharynx, oesophagus, stomach, colon and rectum, liver and intrahepatic bile ducts, pancreas, larynx, cervix uteri, urinary bladder, kidney-renal pelvis and acute myeloid leukaemia.

b: Cardiovascular diseases: include ischaemic heart disease, rheumatic heart diseases, cardiopulmonary diseases, other types of heart disease, cerebrovascular disease, atherosclerosis, aortic aneurysm and other arterial diseases.

c: Other respiratory diseases: include influenza–pneumonia–tuberculosis.

estimated that the percentage of SAM over the total OM in men in 2019 was between 25% and 29% and in women between 5% and 10%.[19] In our study, these percentages were 23.3% and 6.0% (data not shown) in men and women in 2018, respectively. In terms of other European countries, France and Italy are in the same range of percentages of SAM in women as Spain, while other European countries such as Portugal have lower percentages and the UK, Denmark and The Netherlands have higher percentages.[19,20] In men, it seems that Spain is one of the countries with the highest percentage of SAM, above countries such as France, Italy, the Netherlands, Denmark or the UK,[19,20] where the tobacco epidemic started years earlier than in Spain.[21]

In Spain, estimates of SAM are available for certain years. In all cases, the methodology applied was prevalence-dependent.[18] Using a prevalence-independent method, this study has allowed us to observe the pattern described by the trend in SAM over 28 years. It should, however, be borne in mind that previous studies which compared SAM estimates by applying both methods found that the prevalence-independent method yielded higher SAM estimates than the prevalence-dependent method.[22–27]

In Spain, in 2016 and 2017 SAM was estimated with the prevalence-dependent method, using the same source of RRs and causes of tobacco-related mortality.[28,29] Comparing the results of both studies against those obtained in our study, overall the prevalence-independent method has yielded estimates of SAM that were 12% higher in 2016 and 19% higher in 2017. Among men, the variations are smaller, never exceeding 13% in any of the years. The greatest differences are seen in women, particularly in 2017, when the prevalence-independent method estimated 53% more deaths due to tobacco consumption (independent: 12 693 deaths vs. dependent: 8306 deaths). Broken down by cause of death, CVD–DM display the greatest variability between methods, with differences of 24% and 27% in men and 50% and 105% in women in 2016 and 2017, respectively.[28,29] The fact that the prevalence-independent method tends to estimate a higher SAM for CVD–DM could be due to the use of LC mortality as a proxy of tobacco consumption. Thus, the epidemiology of tobacco is being assessed as it was decades earlier, whereas the prevalence-dependent method uses prevalences contemporary with OM. Hence, the precedence in time of the exposure variable, tobacco, is avoided. This in turn means that, if prevalence decreases, SAM will also decrease, without taking into account the nature of previous exposures. The fact that the prevalence-independent method relies on the LC mortality rate may mean that, for diseases such as CVD, the time lag of the epidemic might be longer than necessary. As a result of this, the SAM estimates would vary by so much.

In studies that analysed the difference between the two SAM estimation methods, one report small differences[22] while others greater

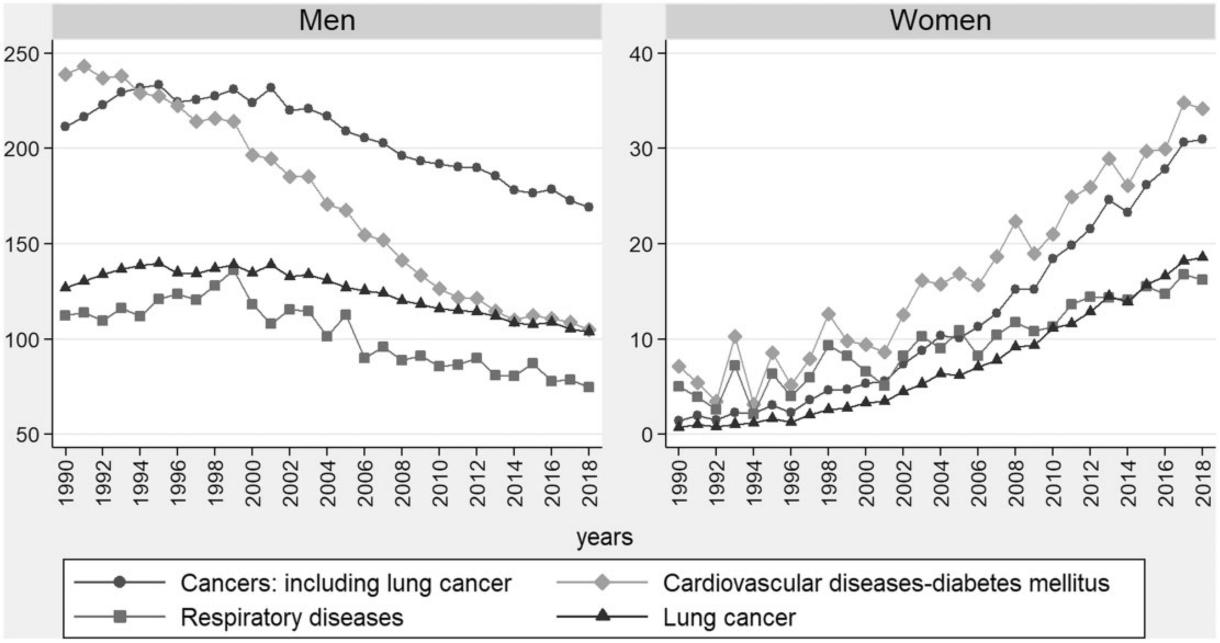

Figure 1 Crude rates of smoking-attributable mortality in Spain per 100 000 population ≥35 years across the period 1990–2018, by sex and cause of death.

Cancers: include trachea-bronchus-lung, lip, oral cavity, pharynx, oesophagus, stomach, colon and rectum, liver and intrahepatic bile ducts, pancreas, larynx, cervix uteri, urinary bladder, kidney-renal pelvis and acute myeloid leukaemia. Cardiovascular diseases–diabetes mellitus: include ischaemic heart disease, rheumatic heart diseases, cardiopulmonary diseases, other types of heart disease, cerebrovascular disease, atherosclerosis, aortic aneurysm, other arterial diseases and diabetes mellitus. Respiratory diseases: include influenza–pneumonia–tuberculosis and chronic obstructive pulmonary disease

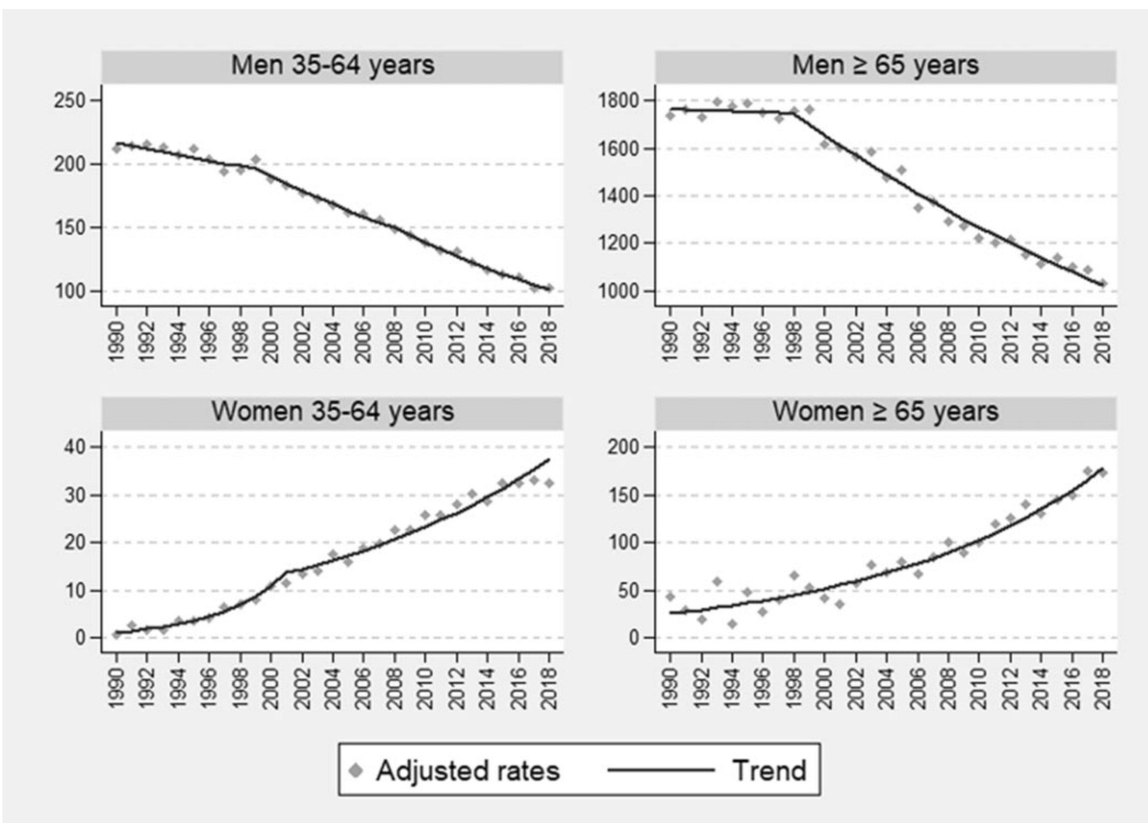

Figure 2 Trends in smoking-attributable all-cause mortality rates adjusted with the joinpoint regression model, by sex (men and women) and age group (35–64 and 65 years and over) across the period 1990–2018 in Spain: rates per 100 000 population

than those found it in Spain.[23,24,26] In Spain, as in Korea, Italy, Canada and the USA,[22,24–26] the most important changes in SAM took place in women, with the prevalence-independent method being the one that estimated higher figures. However, in a study conducted in Lithuania, the greatest variation was observed in men.[23] By the cause of death, CVD in both men and women, and respiratory diseases in women displayed the greatest differences between methods. Similar results were also observed in studies undertaken in Lithuania, the USA and Vietnam.[23,24,27]

According to data sourced from the NSI mortality register,[3] over the last 30 years (1990–2018) in Spain, the percentage difference between OM due to cancers and CVD with respect to total annual OM, dropped from 14.8% in 1990 (cancers: 24.0% vs. CVD: 38.8%) to 1.9% in 2018 (cancers: 26.4% vs. CVD: 28.3%). The breakdown by sex shows that among men cancers ranked as the leading cause of death since 2000, surpassing CVD, and that the differences between the two causes were small. Among women, the changes in the percentage of OM due to cancers and CVD were more evident, going from a difference between the two causes of 25.7% in 1990 (cancers: 19.8% vs. CVD: 45.5%) to 9.6% in 2018 (cancers: 21.8% vs. CVD: 30.7%).[3] These data are reflected in the trend in figures obtained by our study for SAM due to cancers and CVD. These changes in both OM and SAM are mainly due to the decline in CVD mortality. This decrease can be explained by some reasons; one of the most important is the improvement in secondary prevention of CVD with earlier diagnosis and improved treatment, and to a lesser extent, due to better control of cardiovascular risk factors. Moreover, this decrease can also be explained by differences in the induction time of CVD vs. cancers, in that the time required for tobacco consumption to induce a CVD is less than that required to induce a cancer.[30,31]

In our study, LC was the cause with the greatest SAM burden in men throughout the period and in women since 2009. These results coincide with what was observed in estimates made in Spain using the prevalence-dependent method.[18] These changes in SAM are closely related to the trend in prevalences of tobacco consumption among men and women in previous years. According to NSI data, LC is the leading cause of cancer-related death in men, while in women it is the second leading cause after breast cancer. Among women, it is noteworthy that the percentage difference between OM due to breast cancer and LC with respect to total annual cancer-related OM steadily diminished from 1990 to 2018, going from 13.1 percentage points in 1990 (lung: 4.3% vs. breast: 17.4%) to 3.6 in 2018 (lung: 11.1% vs. breast: 14.7%).[3] This increase in LC-related deaths can be accounted for the increase in tobacco consumption among Spanish women.

The SAM estimates obtained in this study are subject to some limitations which have to be identified.[32] In Spain, LC mortality rates according to tobacco consumption are not available. Therefore, we are forced to use data from other countries such as the USA and assume that their LC mortality rates for never smokers are the same as in Spain. Another limitation relates to the use of RRs drawn from US cohorts, since the trend in the tobacco epidemic in the USA is different regarding Spain. Due to the lack of risks derived from the follow-up of cohorts in southern Europe, the RRs are derived from 5 contemporary US cohorts since they are the best evidence available to date.[2,33] Although the RRs were not adjusted for potential confounding factors, the variation in estimates on applying adjusted RRs is small.[34,35] Using LC as a tobacco marker implies assuming that the time of induction of cancers, CVD–DM and respiratory diseases is the same.

This study also exhibits strengths, such as the estimation of SAM across a span of almost 30 years, which enables us to see how the tobacco epidemic has evolved in Spain. Furthermore, although Peto et al.'s method has limitations, it also has strengths. One of the most important is that it respects the criterion of causality of temporal precedence which must exist between exposure to a given risk factor and the effect. This is so because it uses LC as a 'marker' of the tobacco epidemic, which reflects tobacco consumption in the population in previous decades. Furthermore, the second leading risk factor for LC, defined by the World Health Organization as being exposure to radon, has a largely irrelevant causal effect at a national level,[36] thereby making the use of LC as a marker of the tobacco epidemic that much more reliable. A further strength is that, in the absence of prevalences, it allows for the estimation of SAM.

Tobacco consumption caused more than 1.7 million deaths in Spain across the period 1990–2018. The tobacco epidemic in Spain during this period evolved differently in both sexes: whereas in men there was a fall in SAM figures for all tobacco-related causes, in women the opposite scenario was to be seen. The breakdown by major groups of causes shows that, among men, cancers replaced CVD–DM as the leading group of cause of death due to tobacco consumption in 1994. Among women, while CVD–DM comprised the principal group of cause of death across the entire series, the differences with respect to SAM for cancers became smaller with the passage of years. The trend in standardised SAM rates also displays opposite scenarios in the two sexes, both in the joint analysis of all causes and in LC. Thus, while the standardised rates were observed to fall among men, they were seen to rise among women. Therefore, a substantial increase in women's SAM figures is expected in the coming years. All data related to SAM highlight the importance of including a gender perspective in the analyses of SAM, in the design of more effective and comprehensive public health interventions and in the development of tobacco control policies to curb tobacco consumption. These policies should consider a gender-specific approach to achieve a higher effectiveness.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request

Conflict of interest

None declared

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Key points

- Little research is available on the impact of tobacco mortality for a long time span.
- We have used a methodology independent of the prevalence of tobacco use.
- Through 28 years, tobacco use caused 1 717 150 deaths in Spain.
- Attributable mortality differed by sex. Decreases in men and increases in women.

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