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Smoking-attributable deaths and potential years of life lost from a large, representative study in China

Jingmei Jiang,[1] Boqi Liu,[2] Freddy Sitas,[3] Junyao Li,[2] Xianjia Zeng,[1] Wei Han,[1] Xiaonong Zou,[2] Yanping Wu,[2] Ping Zhao[2]

[1]Department of Epidemiology and Biostatistics, Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences, Beijing, China [2]The Cancer Institute/Hospital, Chinese Academy of Medical Sciences, Beijing, China [3]Cancer Epidemiology Research Unit, The Cancer Council NSW, Australia

Correspondence to
Boqi Liu, National Cancer Institute, Chinese Academy of Medical Sciences, 17 Pan Jia Yuan Nan Li, Beijing (100021), China; wangjbo@263.net

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ABSTRACT

Objectives To provide a more accurate estimate of early smoking-attributable mortality and potential years of life lost using data from a representative study of 103 study areas in China.

Methods Two datasets were employed as follows. Firstly, retrospective national mortality survey data, which included a population of 67 million in 103 study areas, and about 1 million adults who died in 1986–1988; secondly, nationally representative case-control comparative data was extracted from the survey data to measure the effect of smoking on age trends in smoking-attributable mortality. Potential years of life lost, and sex differences in life expectancy in smokers and non-smokers in the total population aged 35 and over were also estimated.

Results Tobacco caused 11.2% (16.0% of men and 3.7% of women) of total deaths in 1987, and more than two-thirds of these excess deaths occurred between the ages of 50 and 74 years, but only less than 5% excess deaths occurred at ages under 50. Although life expectancies varied with region or sex differences, the years of life lost attributable to smoking was almost the same. Smokers at age 35 lost about 3 years of life expectancy in comparison with never smokers. The study also confirmed that more than 50% of the sex difference in life expectancy was accounted for by smoking.

Conclusion Fully understanding the consequences of smoking in relation to mortality can clarify its effects on the health and longevity of the entire population.

INTRODUCTION

One of the most important measures for ascertaining the impact of tobacco on a population is the estimation of the mortality attributable to its use. To measure this, a number of indirect methods of quantification are available, yet several limitations and questions regarding the procedures have been noted in the literature.[1–4] First, the calculations are based on relative risk of death for smokers and non-smokers obtained from a non-random sample of a given population, mainly derived from developed countries. Second, most studies concentrate on only the four most common smoking-related causes of death, but many persons die from other smoking-related diseases.[5–8] Third, the calculation of excess or smoking-attributable deaths alone do not measure potential years of life lost and life expectancy, estimates which can help guide policy makers in planning public health interventions.[9]

In this study, we employed and extended the method proposed by Rogers *et al*,[4] which combines the influence of smoking prevalence and population size on smoking-attributable mortality, to calculate excess deaths and potential years of life lost in Chinese adults as a result of smoking. We employed a national mortality survey dataset and national representative case-control comparative data, which were obtained from the same survey. We attempted to avoid some of the problems noted above by the following: (1) use of a representative national sample; (2) consideration of all causes of death rather than some specific causes; and (3) measurement of the effect of smoking on trends in death rates, potential years of life lost and on sex differences in life expectancy.

METHODS

National mortality survey data and case-control comparative data

In 1989–1991, a nationwide retrospective mortality survey was conducted in China which involved 67 million of a population in 103 study areas (24 urban and 79 counties), and about 1 million adult deaths from all causes during the years 1986–1988.[6] We obtained information on the base population and nearly 90% of deceased subjects from the local Population Administrative Offices (PAO), which had the records of all residents (alive or dead) who lived in the study areas, and included name, sex and address, as well as other items of personal information. Data on cases were extracted from the PAO records and controls were from the population of surviving spouses who were identified from the deceased persons' addresses in the PAO dataset. Thus, in this design, all deceased persons were taken as cases and sex-matched surviving spouses of the deceased were taken as controls to assess smoking history and mortality risk. We assumed that sex matching essentially removes any shared environments between couples.

To obtain information on the smoking history of case and control populations, we interviewed informants (spouses or other relatives) of all deceased persons, according to the address provided by the PAO. The interviewees described their own smoking habits as well as those of their deceased family members. The data was used to determine whether people had ever smoked before 1980, a period of time prior to the onset of their disease.

Smoking status, the key predictor variable in this study, was defined as a binary variable (smoker and never smoker), because the proportion of former smokers in China was low.[6 10 11] A never smoker was defined as a person who had never smoked during his life or had only smoked infrequently at a young age.

Table 1 Number of deceased people and surviving spouses, and smoker to non-smoker mortality ratios for urban and rural Chinese aged 35 years and over

Categories	Deceased people n (% of smokers)	Surviving spouses n (% of smokers)	Adjusted risk ratios*	95% CI	Deaths attributed to smoking, %
Urban					
Males	401 050 (62.6)	71 316 (57.1)	1.26	1.24 to 1.28	15.9
Females	335 032 (21.9)	163 039 (17.6)	1.31	1.30 to 1.34	5.0
Rural					
Males	179 571 (68.1)	30 275 (64.0)	1.22	1.19 to 1.25	16.2
Females	144 151 (12.3)	43 223 (8.6)	1.32	1.27 to 1.38	3.2

*Adjustment for age (5-year age groups) and the areas of residence.

Calculation of excess deaths due to smoking

The number of excess deaths (ED) as a result of smoking in the base population was calculated by equation 1. As proposed by Rogers *et al*,[4] we calculated EDs in three steps based on the two datasets described above. First, to determine the number of base population by smoking status (smoke or never smoke); second, to calculate the excess death rates for smokers relative to never smokers for the base population; and third, to calculate the excess deaths within that population. All calculations are given in equations 1—3.[4 6]

$$ED = \sum_x \left[\mathrm{Prev}_x \times Pop_x \times \left(M_{x,s} - M_{x,n}\right)\right] \quad (1)$$

$$M_{x,n} = \frac{M_x}{1 + (RR_x - 1)\times prev_x} \quad (2)$$

$$M_{x,s} = RR_x \times M_{xn} \quad (3)$$

Where x denotes age group (x ranges from 35 to 80+, in 5-year age groups); Prev_x is the prevalence of smokers at age x (calculated from the control group); Pop_x is the population size at age x in the base population; $M_{x,s}$ denotes annual death rates at age x for smokers and $M_{x,n}$ is annual death rates at age x for never smokers. We calculated $M_{x,s}$ and $M_{x,n}$ using equations 2 and 3,[6] where M_x denotes the total death rates at age x for the whole of the base population (10% reduction in the population estimate for the same proportion of missing death certification) irrespective of whether the smoking habits were ascertained, RR_x is the relative risk for smokers and non-smokers at age x estimated by the OR using unconditional logistic regression adjusted for the areas of residence.

Life expectancy by smoking status

Based on annual deaths from all causes and the relevant mean populations in 1987, we calculated abridged life tables for the base population stratified by sex and region, using age 35 as the starting point for the youngest persons included in the life table. We made a 10% reduction in the local population estimates in the calculation to account for the fact that only 90% of deaths were available in the survey. The life expectancies by smoking status were also calculated using basic life tables, which excluded some missing data (about 6%) on smoking status, and with the assumption that the same proportion of missing data occurred in the study population. The difference in life expectancy between smokers and never smokers was interpreted as the reduction in life expectancy caused by smoking.

RESULTS

There was a total of 1 059 804 deceased persons (cases) (69.5% urban, 30.5% rural) and 307 853 surviving spouses (controls) (76.1% urban, 23.9% rural) aged 35 years and over. The mean ages (SD) for cases and controls, respectively, were 67.1 (11.3) and 62.8 (12.1) years for males, and 70.4 (12.8) and 60.4 (10.8) years for women.

Table 1 presents the RRs of deaths from all causes for smokers compared to never smokers, stratified by sex and region. Women had higher relative risks than men although men experienced higher mortality and were more likely to smoke. Overall, tobacco smoking caused an estimated 11.2% of deaths (16.0% of all male deaths and 3.7% of all female deaths) in 1987. The proportion was much lower in women than in men because few women were smokers in China.

The prevalence of smoking among surviving spouses interviewed in about 1990 was regarded as a substitute exposure rate of the base population. The prevalence of smoking in men was high and higher in rural than urban areas, but in women it was low and lower in rural than urban areas (figure 1).[6] These spouse-based prevalences were highly consistent with those in the 1984 and 1996 nationwide surveys of smoking prevalence.[11—13] At ages 35—69 the prevalence of smoking remained fairly constant among males, but among women it was much lower at 35—39 than at 50—69. Over the past few decades young women, particularly in cities, have become much less likely to start smoking. The proportion who started to smoke before the age of 25 was 10% of all urban women born before 1940, but only 1% for those born in 1950—1964. For rural women the prevalence was 4% for those born before 1940 and 2% for those born in 1950—1964. These unexpected decreases are statistically reliable.[6]

Age trend in the numbers of smoking-related deaths

From the age-specific annual death rates by smoking status, smoking prevalence rates and population distributions, the age-

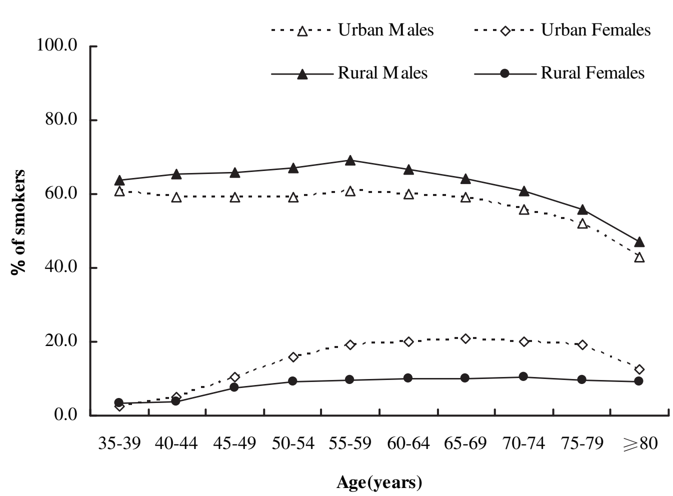


Figure 1 Smoking prevalence in 1990 among interviewees whose spouses had died in 1986—1988.

specific number of excess deaths from smoking was estimated under the assumption that all observed excess mortality among smokers was the result of smoking. Overall, if the smokers had the same death rates as never smokers, we would expect to see 46 239 fewer deaths (71.5% for urban areas, 28.5% for rural areas) in the base populations in 1987. When the estimation was stratified by age group, the estimated number of excess deaths increased disproportionately with the increase in age. Figure 2 displays a curvilinear pattern with age, and there were few excess deaths in young adults, a larger number of excess deaths in middle and early old age adults, and the number of excess deaths decreased again at older ages. Overall, if everyone could assume the mortality risk of never smokers, 69% of male excess deaths (72% in urban areas, 63% in rural areas) and 67% of female excess deaths (67% in urban areas, 69% in rural areas) would be avoided between the ages of 50 and 74 years, but only 1% of male and 5% of female excess deaths would be avoided at ages under 50.

The contribution of smoking to reduction in life expectancy

Figure 3 presents survival curves by smoking status according to sex and urban/rural status. The y-axis standardises all smoking status groups to 100 000 persons at age 35 and follows their survival through old age, based on the smoking status death rates calculated within 5-year age groups. Overall, the survival curves were shallow initially and the differences between smokers and never smokers were not significant at the earlier ages, but the differences became larger at around age 60. In urban and rural areas, female never smokers had the highest survival rates. For instance, 45% of all urban and 42% of all rural women never smokers at age 35 can expect to be alive at age 80, compared with 34% and 30% of urban and rural women smokers, 1.3 and 1.4 times, respectively, as many never smokers as smokers surviving to this age. There was a similar trend for men, although the survival curves in urban and rural areas were both lower than those for women; 38% of urban and 34% of male rural never smokers can survive to age 80, compared with 25% and 21% of smokers, 1.5 and 1.6 times as many never smokers as smokers surviving to this age.

The risk can also be quantified in 'years of life lost'. Although the impact of sex and regional differences in life expectancies can be seen, never smokers can expect to live longer than smokers. For example, at ages 35 years, the actual life expectancy was an extra 41.3 years for women and 37.5 years for men; but the life expectancies were 42.0 and 39.9 years, respectively, for non-smokers and 38.8 and 36.8 years, respectively, for smokers. There was a similar reduction in the life lost irrespective of region and sex difference. Smokers at age 35 can lose about 3 years of life in comparison with never smokers, thus smoking remains a very important predictor of premature adult mortality.

Sex difference in life expectancy

Table 2 summarises the contribution of smoking to the male—female difference in life expectancy at ages 35 and over. The total life expectancy was divided into two components: attributable to smoking and attributable to other factors. The difference in life expectancy decreased, on average, by 0.5 years in urban areas and by 0.6 years in rural areas over the periods between age 35 and age 75. However, the proportion attributable to smoking increased. For example, the difference in life expectancy at age 35 years in urban areas was 3.8 years, with 47% of this difference attributable to smoking, in comparison with a difference of only 1.8 years at age 75 years, but with 56% of this difference attributable to smoking. The figures and trend in the sex difference was also similar in rural areas. This is partly due to the higher smoking-attributable mortality in men, and partly due to the relatively small sex difference attributable to other factors with increasing age.

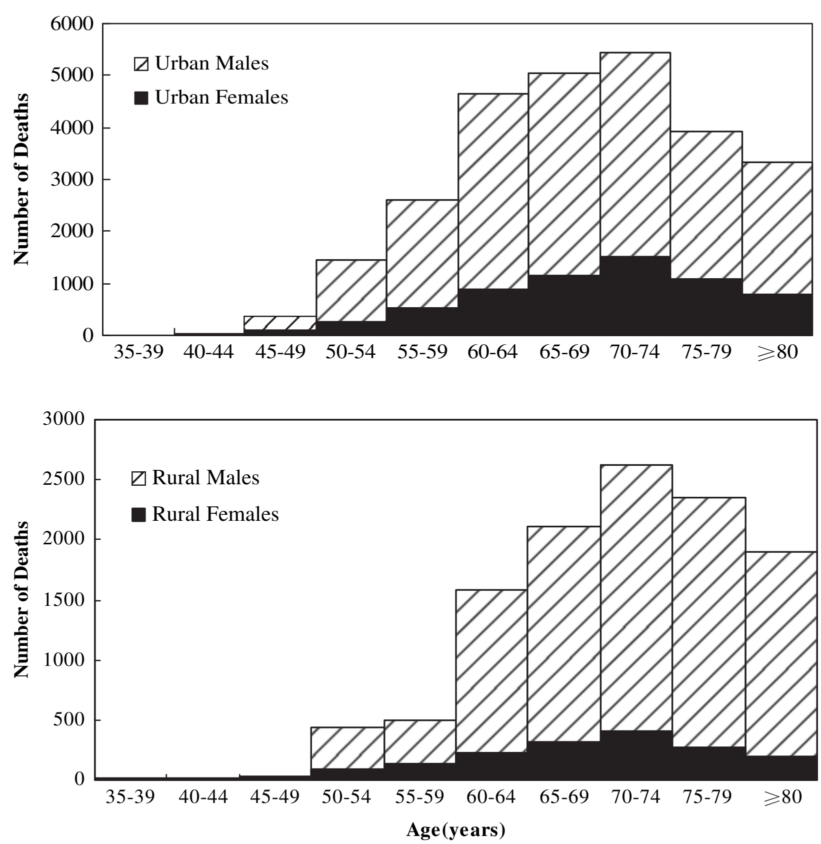
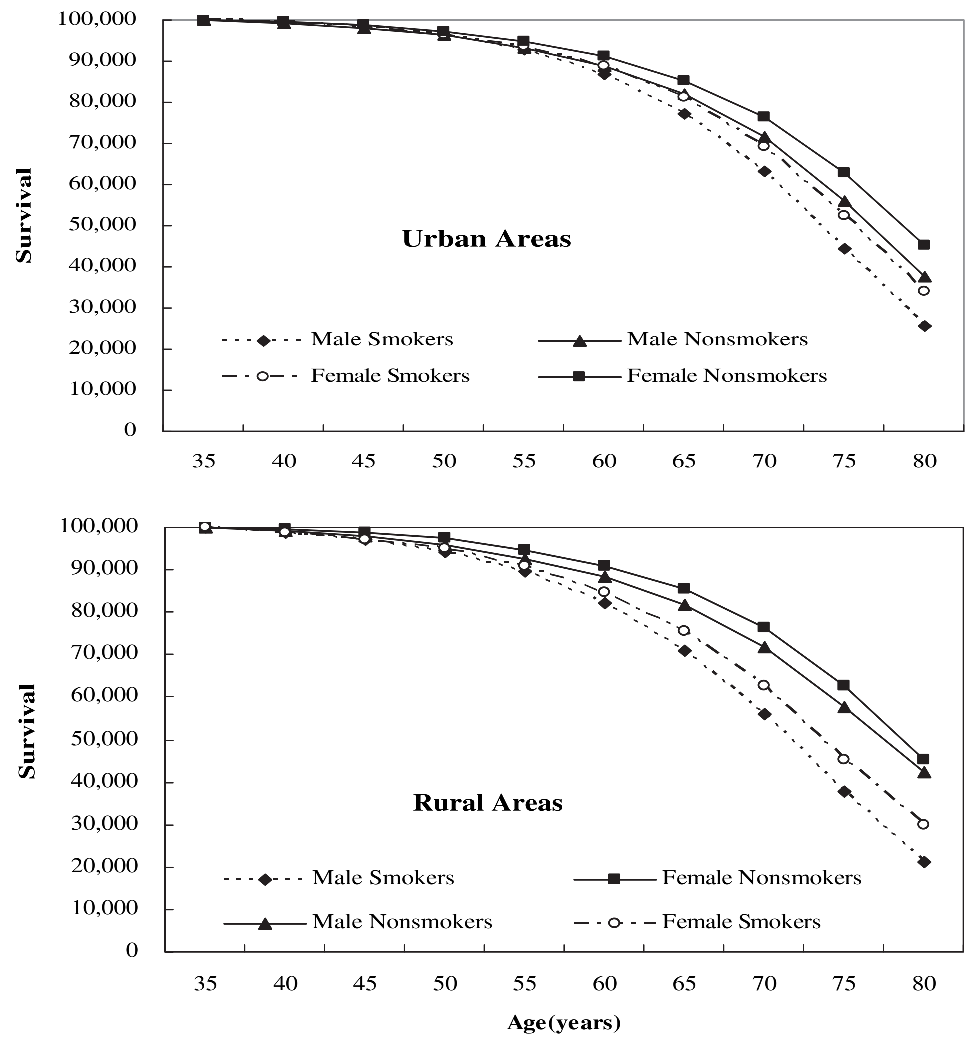


Figure 2 Estimated smoking-attributable deaths by age and region, Chinese adults at ages 35 and over, in 1987.

Figure 3 Survival curves by smoking status for urban and rural Chinese adults ages 35 years and over in 1987.



DISCUSSION

Using the datasets from a national mortality survey and representative case-control comparative data, we have estimated smoking-attributable deaths for all causes and potential years of life lost for an entire population in 103 study areas in China. Our results revealed that more the two-thirds of excess deaths occurring between the ages of 50 and 74 years were attributable to smoking. The very important finding in our study is that although life expectancy was higher in urban than in rural areas, and in women than in men, the reduction in life expectancy attributable to smoking was almost the same irrespective of the regional or sex differences. Smokers at age 35 can lose about 3 years of life in comparison with never smokers. Our study also confirmed the major influence of smoking on sex differences in life expectancy, more than 50% of the sex difference was accounted for by smoking.

Tobacco smoking in China is highly prevalent, especially among men, and is associated with substantially high costs of morbidity, mortality and associated health expenditure.[6 11 12] A recent national cohort study[13] showed the prevalence of tobacco smoking remaining high in adult men and the average age of smoking initiation dropping. Studies such as this one point to continued strengthening of smoking prevention and cessation programs in China.

To refine calculations on tobacco attributed mortality, we used the sex-matched surviving spouses as the reference population to calculate the mortality risk rate. The merits of such a selection of reference group are: (1) its practicality and feasibility; (2) we may estimate smoking-related deaths for all causes, which may offer a more precise estimate of the harm of tobacco smoking on a given population; and (3) surviving spouses were regarded as a sample representative of the study population, and the prevalence of smoking among them could directly translate into the distribution of smoking in the study population. This made it possible to estimate the effect of smoking on the life expectancy

Table 2 Female—male difference (years) in life expectancy at different ages, attributable and not attributable to smoking in 1987 in urban and rural areas

	Life expectancy (years) at ages				
Categories	**35**	**45**	**55**	**65**	**75**
Urban					
Difference in life expectancy	3.8	3.6	3.3	2.8	1.8
Smoking attributable	1.8	1.8	1.7	1.4	1.0
Not attributable to smoking	2.0	1.8	1.6	1.4	0.8
Percentage smoking attributable	47	50	52	50	56
Rural					
Difference in life expectancy	4.2	4.0	3.7	2.8	1.8
Smoking attributable	1.4	1.7	1.8	1.8	1.6
Not attributable to smoking	2.8	2.3	1.9	1.0	0.2
Percentage smoking attributable	33	43	49	64	89

on the whole of the study population. Prospective studies, however, take years to mature, whereas the retrospective methods such as this one require much less time.

Three aspects have been considered with regard to the validity of our results: first, the validity of surviving spouses as a reference group has been assessed by two recent studies, and the results were found to be highly comparable compared to what one would expect from choosing controls using classical methods.[14 15] Moreover, as mentioned previously, the prevalence of smoking in the reference group was almost the same as that estimated from national studies indicating the relative risk analyses will not exaggerate the hazard of tobacco. Second, smoking status was treated as a binary variable in our study, the reasons for which were: (1) there were few former smokers in China; (2) considering the information on smoking was retrospectively obtained in this study, we checked the response on the main variables of smoking history among different categories and found consistency in the response between spouses and other relatives was satisfactorily fulfilled on the broad categories of exposure information; however, any diversity became larger with more detailed information; and (3) one possible bias might be introduced by non-response rates of 6% for dead subjects and 1% of surviving spouses regarding smoking information. However, this misclassification could be very limited if the responses were at random between smoking and non-smoking status and among deceased people and surviving spouses. Third, we compared actual life expectancies calculated from our original data with published values of life expectancy in China,[16] and agreement was near perfect indicating that the estimate of the years of life lost attributable to smoking, which was based on actual life expectancy, had validity.

It should be noted that the estimates of smoking-attributable adult mortality varied with differences in methodologies, time period, subpopulations and assumptions. It is difficult to develop a common standard for comparative purposes. For instance, our results suggest that 11% of all deaths (16.0% in men and 3.7% in women) in adults (≥35 years) can be attributed to smoking, which is lower than the 13% obtained in a national study from South Africa,[8] a little higher (13.0% in men, 3.0% in women) than our previous study where the excess deaths were estimated with the proportional mortality method,[6] and also a little higher (13.0% in men, 3.1% in women) than a recent nationally cohort study.[13] In general, our estimates of smoking-attributable adult mortality revealed a lower value than some other studies from developed countries.[17–22] Apart from the reasons noted above, the most probable explanation may be that in China the main increase in cigarette smoking is too recent to fully assess the entire future impact of this exposure on the health of the population. Hence, the potential importance of the association between tobacco smoking and mortality may be underestimated. Moreover, our results reveal that more than two-thirds of adult smoking-related deaths occurred in middle and early old age, and only a small proportion occurred at ages under 50. This trend is very similar to that found in a national study in the US,[4] where three-quarters of these averted deaths fall between ages 40 and 79, only 6% fall between 20 and 39. This is unlike many health conditions, such as cancers, functional disabilities and Alzheimer's disease, which have high prevalence rates and higher associated mortality at older ages. Tobacco smoking has its highest prevalence and, because the addiction tends to be cumulative, its highest intensity in middle age. This fact emphasises the importance of preventing the initiation of smoking at young ages and also of quitting smoking at middle age. Furthermore, like some other studies from Europe,[23 24] our study has also confirmed that women who smoke run a relatively higher risk in terms of reduced life expectancy although the prevalence among Chinese women is much lower compared to that in Europe.

There were some limitations to our study. First, only 90% of deaths in the study base were included, thus selection bias may have had some effect on our results. Second, there was no ex-smoker information (although its proportion is low, 9.5% of ever smokers[11]) in this study, which might limit interpretations about the temporal nature of the association. Third, no direct adjustment for socioeconomic status was made in the analysis although our analyses were stratified by age, sex and region. Some studies[25] have argued that the method of estimating 'smoking-attributable' death adjusts for age and sex, but fails to consider the lower socioeconomic and educational status, occupational and other risk factors of smokers, and would exaggerate the burden of mortality attributable to smoking, while other studies[17] have indicated that estimates of deaths caused by smoking are not substantially altered by adjustments for behavioural and demographic factors associated with smoking, beyond the current adjustment for age and sex.

In conclusion, our findings suggest that fully understanding the consequences of smoking on mortality can clarify its effects on the prospects for health and longevity of the population.

What this paper adds

- Tobacco caused 16% of deaths in men and 4% of deaths in women using the method proposed by Rogers *et al*.[4] More than two-thirds of these excess deaths occurred between the ages of 50 and 74 years. This fact emphasises the importance of preventing the initiation of smoking at a young age.
- Although life expectancy was higher in urban than in rural areas, and was higher in females than in males, the years of life lost which were attributable to smoking, were almost the same irrespective of the region or sex differences. Smokers at age 35 lost about 3 years of life expectancy in comparison with never smokers.
- On average, more than 50% of the sex difference in life expectancy was accounted for by smoking: women who smoke ran a relatively higher risk in terms of reduced life expectancy, although the prevalence of smoking among women was much lower than among men.

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The lighter side