Social inequalities in male mortality, and in male mortality from smoking: indirect estimation from national death rates in England and Wales, Poland, and North America

Prabhat Jha, Richard Peto, Witold Zatonski, Jillian Boreham, Martin J Jarvis, Alan D Lopez

Summary

Background There are substantial social inequalities in adult male mortality in many countries. Smoking is often more prevalent among men of lower social class, education, or income. The contribution of smoking to these social inequalities in mortality remains uncertain.

Methods The contribution of smoking to adult mortality in a population can be estimated indirectly from disease-specific death rates in that population (using absolute lung cancer rates to indicate proportions due to smoking of mortality from certain other diseases). We applied these methods to 1996 death rates at ages 35–69 years in men in three different social strata in four countries, based on a total of 0·6 million deaths. The highest and lowest social strata were based on social class (professional *vs* unskilled manual) in England and Wales, neighbourhood income (top *vs* bottom quintile) in urban Canada, and completed years of education (more than *vs* less than 12 years) in the USA and Poland.

Results In each country, there was about a two-fold difference between the highest and the lowest social strata in overall risks of dying among men aged 35–69 years (England and Wales 21% *vs* 43%, USA 20% *vs* 37%, Canada 21% *vs* 34%, Poland 26% *vs* 50%: four-country mean 22% *vs* 41%, four-country mean absolute difference 19%). More than half of this difference in mortality between the top and bottom social strata involved differences in risks of being killed at age 35–69 years by smoking (England and Wales 4% *vs* 19%, USA 4% *vs* 15%, Canada 6% *vs* 13%, Poland 5% *vs* 22%: four-country mean 5% *vs* 17%, four-country mean absolute difference 12%). Smoking-attributed mortality accounted for nearly half of total male mortality in the lowest social stratum of each country.

Conclusion In these populations, most, but not all, of the substantial social inequalities in adult male mortality during the 1990s were due to the effects of smoking. Widespread cessation of smoking could eventually halve the absolute differences between these social strata in the risk of premature death.

Lancet 2006; 368: 367–70

Published Online July 14, 2006 DOI:10.1016/S0140-6736(06)68975-7

See Comment page 341

Centre for Global Health Research, St Michael's Hospital, Public Health Sciences, University of Toronto, Toronto M5C1N8, Canada (P Jha MD); **Clinical Trial Service Unit and Epidemiological Studies Unit, University of Oxford, Oxford, UK** (Prof R Peto FRS, J Boreham PhD); **The Maria Sklodowska-Curie Memorial Cancer Center and Institute of Oncology, Warsaw, Poland** (Prof W Zatonski MD); **Department of Epidemiology and Public Health, University College London, London, UK** (Prof M Jarvis DSc); **and School of Population Health, University of Queensland, Brisbane, Australia** (Prof A Lopez PhD)

Correspondence to: Dr Prabhat Jha **prabhat.jha@utoronto.ca**

Introduction

There are still substantial social inequalities in adult male mortality in many countries.[1–3] Although male mortality from smoking has recently started to decrease in Europe and North America, in the 1990s smoking still accounted for about one-third of all male deaths in middle age, here defined as ages 35–69 years.[4–6] In many countries, male smoking is far more common in lower than in higher social strata, whether these strata are defined by education, income, or occupation.[7] In this report we quantify the approximate contribution of smoking to the social inequalities in adult male mortality in England and Wales, the USA, Canada, and Poland in 1996.

Methods

The approximate contribution of smoking to adult mortality in a European or North American population can be estimated indirectly from the disease-specific death rates in that population, using the absolute lung cancer rates to indicate the proportions due to smoking of the mortality from certain other diseases.[4–6]

Mortality data for three social strata in each country

We obtained 5-year age, sex, and disease-specific 1996 mortality data for three different social strata in England and Wales, urban Canada (the metropolitan areas, which include 60% of the Canadian population), the USA, and Poland. Causes of death were based on the routine official coding of death certificates, which in 1996 was based on the ninth revision of the International Classification of Diseases.[8] The definitions of the three social strata differed by country. In England and Wales, the strata were based on the National Statistics Socio-Economic Classification of occupations,[9] grouped into social classes I or II (professional, managerial, and technical), III or IV (other non-manual and skilled or semi-skilled manual), and V (unskilled manual). In Canada, the strata were based on area of residence, sub-divided by quintiles of neighbourhood income[10] into the top 20%, middle 60%, and bottom 20%. For the USA[11] and Poland,[12] the strata were based on completed years of education (more than 12, 12, and less than 12). The analyses in this report are for ages 35–69 years only, as causes of death are better classified in middle age than in old age.[13]

Indirect estimation of smoking-attributable deaths

Even in countries where no direct evidence is available about the effects of smoking on mortality, indirect methods can be used that are based just on the national age-specific death rates for lung cancer and for various

	Social stratum*			Ratio of rates (low/high)	Difference in rates (low–high)	Proportion of total difference in rates attributed to smoking
	Low	Middle	High			
England and Wales, stratified by social class						
Yes	6·98	3·58	1·24	5·6	5·74	59%
No	9·25	6·93	5·34	1·7	3·91	
Total	16·23	10·51	6·58	2·5	9·65	
	(7346)	(48 619)	(18 391)			
USA, stratified by years of education						
Yes	5·34	4·81	1·37	3·9	3·97	58%
No	7·83	7·88	4·90	1·6	2·93	
Total	13·17	12·69	6·27	2·1	6·90	
	(102 497)	(155 008)	(109 938)			
Canada (urban), stratified by neighbourhood income						
Yes	4·39	2·51	1·89	2·3	2·50	51%
No	7·28	5·37	4·91	1·5	2·37	
Total	11·67	7·88	6·80	1·7	4·87	
	(5867)	(11 977)	(3097)			
Poland, stratified by years of education						
Yes	8·81	3·51	1·81	4·9	7·00	65%
No	10·81	7·57	6·96	1·6	3·85	
Total	19·62	11·08	8·77	2·2	10·85	
	(82 334)	(14 884)	(4668)			

*Annual death rates per 1000 men aged 35–69 years (standardised to uniform age distribution, so 3/1000 yields a 35-year risk of 10%), together with the stratum-specific numbers of such deaths in 1996 (in parentheses).

Table: **Male death rates attributed to smoking (Yes) and not attributed to smoking (No), by social class, education, or neighbourhood income**

other diseases. These methods have been described previously in detail[4] and have been widely utilised.[5–6,14–16] Briefly, the absolute age-specific lung cancer rates at ages 35–69 years for each social stratum were calculated first. Second, the above lung cancer rates were matched to the lung cancer rates in a mixture of smokers and non-smokers in a large prospective study conducted in the 1980s of 1 million Americans.[3,17,18] Third, for the mortality in such a mixture of smokers and non-smokers from various other causes of death (upper aerodigestive cancer, other cancer, chronic obstructive lung disease, other respiratory disease, vascular disease, and certain other diseases; no deaths from cirrhosis or from non-medical causes are attributed to smoking), the proportion attributed to smoking was used as a guide (with adjustments as described earlier[4]) to estimate the smoking-attributed proportion of the mortality from those other diseases in that stratum.

These methods were originally devised to estimate death rates from smoking in entire countries.[4] We are now using them to estimate social-stratum-specific death rates from smoking. These indirect methods have the advantage of not requiring any knowledge of current or past smoking patterns in the target population. The only requirements are the age-specific mortality rates in each stratum for lung cancer and for a few groups of causes other than lung cancer.

Rates and risks at ages 35–69 years

The tabulated death rates at ages 35–69 years are standardised to a uniform age distribution (by averaging the age-specific death rates for the seven 5-year age groups within this 35-year age range). If the average annual death rate in this age range is R per 1000, then at these age-specific death rates the probability that a 35-year-old man will die within the next 35 years (ie, at age 35–69 years) can be shown to be $1–exp(–35R/1000)$.[4,5] For example, if the average annual death rate in this age range is three per 1000, then the probability of a 35-year-old dying at ages 35–69 years would be 0·10 (ie, 10%).

Role of the funding source

The sponsors of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

A total of 564 626 male deaths at age 35–69 years were analysed in the four countries (table). The table gives, for the three social strata (low, middle, high) in each country, the estimated male death rates attributed to smoking and the estimated male death rates not attributed to smoking, which together add up to the total annual death rate per 1000 men aged 35–69 years. There was about a two-fold difference in the total death rate between the lowest and the highest social strata (with the death rate ratios for the lowest *vs* the highest social strata ranging from 1·7 in Canada to 2·5 in England and Wales). The proportional differences between social strata in smoking-attributed mortality were, however, considerably more extreme than this (with the death rate ratios ranging from 2·3 in Canada to 5·6 in England and Wales). This was because the proportion of total mortality attributed to smoking was substantially greater in the lower than in the higher social strata. Indeed, in the lowest social stratum in each country, smoking-attributed mortality accounted for about 40% of total male mortality in middle age (with the proportion of the death rates in the lowest stratum attributed to smoking ranging from 38% [4·39/11·67] in Canada to 45% [8·81/19·62] in Poland).

In contrast, the proportional differences between these social strata in non-smoking-attributed mortality were much less extreme (with the death rate ratios ranging from 1·5 in Canada to 1·7 in England and Wales). Hence, smoking-attributed mortality accounted for more than half (range 51–65%) of the absolute difference between these social strata in the total male mortality rates at ages 35–69 years.

Because the death rates in the table are standardised to a uniform age distribution, they can be used directly to calculate the probabilities, at 1996 rates, of death in middle age from smoking, and the probabilities of death in middle age from any cause (see Methods). The inequalities between these social strata in mortality from any cause were clearly apparent in these risks (figure) as they were for the age-standardised death rates (table). In each country, there was about a two-fold difference between the highest and the lowest social strata in the risks of dying at age 35–69 years (England and Wales 21% *vs* 43%, USA 20% *vs* 37%, Canada 21% *vs* 34%, Poland 26% *vs* 50%). When these probabilities were averaged across the four countries, the four-country mean was 22% for the highest versus 41% for the lowest. This corresponds to an absolute difference of 19% between the highest and the lowest social strata in the all-cause probability of death at ages 35–69 years. Most, but not all, of this difference in stratum-specific mortality involves differences in the risks of being killed at these ages by smoking (England and Wales 4% *vs* 19%, USA 4% *vs* 15%, Canada 6% *vs* 13%, Poland 5% *vs* 22%). On average across these four countries, the probabilities of being killed at ages 35–69 years by smoking were 5% for the highest versus 17% for the lowest social strata. This corresponds to an absolute difference of 12% between the highest and the lowest social strata in smoking-attributed mortality. Most of those killed at these ages by smoking would otherwise have survived to beyond age 70 years, but a minority (shaded areas above the dotted lines in the figure) would have died before age 70 years anyway.

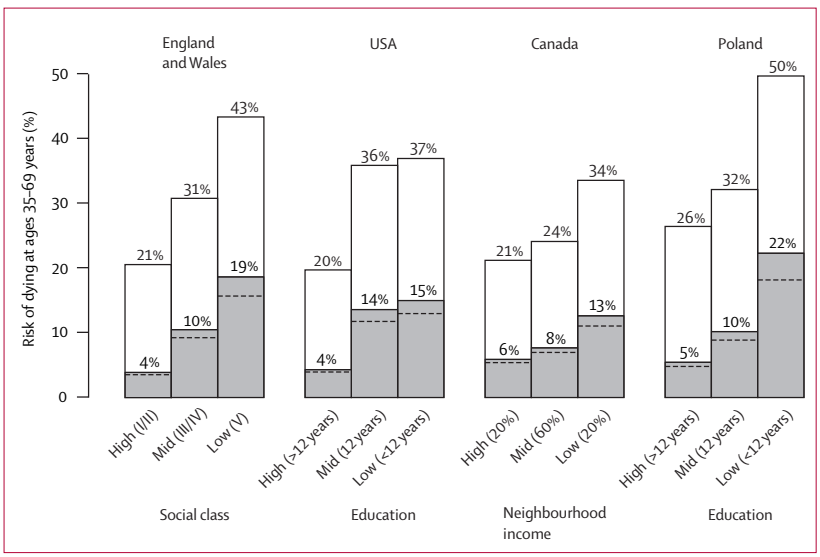

Figure: **Social inequalities in male mortality in 1996 from smoking (shaded) and from any cause**
Percentages of 35-year-old men dying at ages 35–69 years from smoking (shaded) or from any cause (shaded and white), if the population death rates of 1996 were to remain unchanged. Most of those killed at these ages by smoking would otherwise have survived to beyond age 70 years, but a minority (shaded areas above dotted lines) would have died before age 70 years anyway.

Discussion

Although the methods of estimation that we have used are indirect, the uncertainties inherent in them affect all social strata similarly and cannot, therefore, account for the great differences between the social strata in smoking-attributed mortality in these four diverse countries in 1996. These differences are due partly to substantial absolute differences in smoking-attributed lung cancer mortality[19] and partly to even greater absolute differences in smoking-attributed mortality from other diseases.[20,21] In each of these countries smoking is a cause of the large majority of all lung cancer deaths, and the lung cancer death rates (and hence the lung cancer death rates from smoking) differ greatly between different social strata. In prospective studies that relate the smoking patterns of individuals to the causes of death of those same individuals, however, smoking causes substantially more deaths from other diseases than from lung cancer.[4–6,13,17,18] Thus, it is reasonable to expect that it would do likewise in each of the different social strata, and hence that the absolute difference between strata in overall smoking-attributable mortality would be much greater than the absolute difference between strata in lung cancer mortality. Similarly, a recent analysis of differences in mortality by years of education among eight western European countries also found that the absolute mortality differences between strata were greater for causes other than lung cancer than for lung cancer.[1]

There are many factors other than smoking that differ between different social strata in these four countries, perhaps involving both the causes and the diagnosis and treatment of some of the chronic diseases of middle age.[22] Indeed, our results suggest that even among non-smokers, male death rates in middle age would be about 1·6 times as great in the lowest as in the highest social strata in this study. As smoking interacts with other risk factors (generally increasing their effects),[13] the hazard for the individual smoker must also be expected to be greater in the lower than in the higher strata. In addition, the prevalence[7] and the intensity[23,24] of smoking is generally greater in lower than in higher social strata.

Our indirect methods are obviously crude, and the presentation in our table and figure of apparently precise numbers should not be taken to suggest otherwise. The major pattern in these populations is, however, clear: smoking-attributed mortality accounts for more than half of the difference between these social strata in male mortality in middle age.

Higher taxes, warning labels, and other tobacco control interventions have already been shown to help increase smoking cessation rates, with higher taxes being particularly effective at raising cessation rates among less educated or poorer groups.[25,26] Widespread cessation has already greatly reduced national mortality rates in countries such as the UK and USA, and these decreases in the national mortality rates are continuing. Still, however, in the present decade about a quarter of all deaths in middle age in these countries are due to

smoking.[6] These remaining hazards disproportionately affect individuals in lower social strata. Irrespective of whether these differences between strata in smoking-attributable mortality chiefly involve differences in the prevalence of smoking, differences in the intensity of smoking, differences in various co-factors, or differences in treatment, a substantial increase in cessation could approximately halve these 1996 social inequalities in adult male mortality.

Contributors

P Jha, R Peto, and M Jarvis planned the paper. R Peto and A D Lopez devised the indirect estimation method used here. W Zatonski obtained data for Poland. P Jha, J Boreham, and R Peto conducted statistical analyses. All authors participated in interpreting the data and writing the manuscript.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgments

External funding was from the Fogarty International Centre (grants R01 TW05991–01 [PJ] and R01 TW05993-02 [RP]), the Canadian Institute of Health Research (grant EG-53506), Cancer Research UK, and the UK Medical Research Council (Clinical Trial Service Unit direct support). P Jha is supported by the Canada Research Chair programme. We thank Samira Asma and Russell Wilkins for assistance in obtaining data.

References

1 Huisman M, Kunst AE, Bopp M et al. Educational inequalities in cause-specific mortality in middle-aged and older men and women in eight western European populations. *Lancet* 2005; **365:** 493–500.

2 Adler NE, Ostrove JM. Socioeconomic status and health: what we know and what we don't. *Ann N Y Acad Sci* 1999; **896:** 3–15.

3 Steenland K, Henley J, Thun M. All-cause and cause-specific death rates by educational status for two million people in two American Cancer Society cohorts, 1959–1996. *Am J Epidemiol* 2002; **156:** 11–21.

4 Peto R, Lopez AD, Boreham J, Thun M, Heath C Jr. Mortality from tobacco in developed countries: indirect estimation from national vital statistics. *Lancet* 1992; **339:** 1268–78.

5 Peto R, Lopez AD, Boreham J, Thun M, Heath C Jr. Mortality from smoking in developed countries, 1950–2000. Oxford: Oxford University Press, 1994.

6 Peto R, Lopez AD, Boreham J, Thun M. Mortality from smoking in developed countries, 1950–2000. 2nd edn. http://www.deathfromsmoking.net, http://www.ctsu.ox.ac.uk/~tobacco (accessed June 1, 2006).

7 Bobak M, Jha P, Nguyen S. Poverty and smoking. In: Jha P, Chaloupka FJ, eds. Tobacco control in developing countries. Oxford: Oxford University Press, 2000: 41–61.

8 WHO. International statistical classification of diseases and related health problems, 9th revision. Geneva: World Health Organisation, 1978.

9 Office of National Statistics. Mortality statistics: general—DH1 series. London: HM Stationery Office, 1998.

10 Wilkins R, Berthelot JM, Ng E. Trends in mortality by neighbourhood income in urban Canada from 1971 to 1996. http://www.statcan.ca/english/freepub/82-003-SIE/2002001/pdf/82-003-SIE2002007.pdf (accessed June 1, 2006).

11 Peters KD, Kochanek KD, Murphy SL. Deaths: final data for 1996. *Nat Vit Stat Rep* 1998; **47:** 1–100. http://www.cdc.gov/nchs/data/nvsr/nvsr47/nvs47_09.pdf (accessed June 1, 2006).

12 Central Statistical Office. Rocznik statystystyczny demografii [Statistical yearbook of demography]. Warsaw: Central Statistical Office, 1998.

13 Doll R, Peto R. The causes of cancer: quantitative estimates of avoidable risks of cancer in the United States today. *J Natl Cancer Inst* 1981; **66:** 1191–308.

14 Mackenbach JP, Huisman M, Andersen O, et al. Inequalities in lung cancer mortality by the educational level in 10 European populations. *Eur J Cancer* 2004; **40:** 126–35.

15 Ezzati M, Lopez AD. Regional, disease-specific patterns of smoking-attributable mortality in 2000. *Tob Control* 2004; **13:** 388–95.

16 Bronnum-Hansen H, Juel K. Abstention from smoking extends life and compresses morbidity: a population based study of health expectancy among smokers and never smokers in Denmark. *Tob Control* 2001; **10:** 273–78.

17 Thun M, Day-Lally C, Myers D, et al. Trends in tobacco smoking and mortality from cigarette use in Cancer Prevention Studies I (1959 through 1965) and II (1982 through 1988). In: Shopland D, Burns D, Garfinkel L, Samet J, eds. Changes in cigarette-related disease risks and their implication for prevention and control: smoking and tobacco control. Bethesda: National Institutes of Health, 1997. 305–82.

18 Thun MJ, Apicella LF, Henley SJ. Smoking vs other risk factors as the cause of smoking-attributable deaths: confounding in the courtroom. *JAMA* 2000; **284:** 706–12.

19 Hart CL, Hole DJ, Gillis CR, Smith GD, Watt GC, Hawthorne VM. Social class differences in lung cancer mortality: risk factor explanations using two Scottish cohort studies. *Int J Epidemiol* 2001; **30:** 268–74.

20 Malarcher AM, Schulman J, Epstein LA, et al. Methodological issues in estimating smoking-attributable mortality in the United States. *Am J Epidemiol* 2000; **152:** 573–84.

21 Bronnum-Hansen H, Juel K. Impact of smoking on the social gradient in health expectancy in Denmark. *J Epidemiol Community Health* 2004; **58:** 604–10.

22 Banks J, Marmot M, Oldfield Z, Smith JP. Disease and disadvantage in the United States and in England. *JAMA* 2006; **295:** 2037–45.

23 Jarvis MJ, Wardle J, Waller J, Owen L. Prevalence of hardcore smoking in England, and associated attitudes and beliefs: cross sectional study. *BMJ* 2003; **326:** 1061–66.

24 Jarvis MJ, Wardle J. Social patterning of health behaviours: the case of cigarette smoking. In: Marmot M, Wilkinson RG, eds. Social determinants of health. 2nd edn. Oxford: Oxford University Press, 2006: 224–37.

25 Jha P, Chaloupka FJ, Moore J, et al. Tobacco addiction. In: Jamison DT, Measham AR, Breman JB, et al, eds. Disease control priorities in developing countries. 2nd edn. New York: Oxford University Press, 1996: 869–86. http://files.dcp2.org/pdf/DCP/DCP46.pdf (accessed June 1, 2006).

26 Jha P, Chaloupka FJ. Tobacco control in developing countries. Oxford: Oxford University Press, 2000.