

The burden of smoking-related ill health in the United Kingdom

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ABSTRACT

Background: Smoking is one of the biggest avoidable causes of morbidity and mortality in the United Kingdom. This paper quantifies the current health and economic burden of smoking in the UK. It provides comparisons with previous studies of the burden of smoking in the UK and with the costs for other chronic disease risk factors. **Methods:** A systematic literature review to identify previous estimates of National Health Service costs attributable to smoking was undertaken. Information from the World Health Organization's Global Burden of Disease Project and routinely collected mortality data were used to calculate mortality due to smoking in the UK. Population-attributable fractions for smoking-related diseases from the Global Burden of Disease Project were applied to NHS cost data to estimate direct financial costs.

Results: Previous studies estimated that smoking costs the NHS about £1.4 billion to £1.7 billion in 1991 and has been responsible for about 100 000 deaths per annum over the past 10 years. We estimate that the number of deaths attributable to smoking in 2005 was 109 164 (19% of all deaths, 27% deaths in men and 11% of deaths in women). Smoking was directly responsible for 12% of disability adjusted life years lost in 2002 (15.4% in men; 8.5% in women) and the direct cost to the NHS was £5.2 billion in 2005–6.

Conclusion: Smoking is still a considerable public health burden in the UK. Accurately establishing the burden in terms of death, disability and financial costs is important for informing national public health policy.

Smoking is a major preventable cause of morbidity and mortality in the United Kingdom.¹ It is an important cause of cardiovascular disease, chronic obstructive pulmonary disease (COPD), lung cancer and a range of other cancers, peptic ulcer and various other medical conditions.¹ In 2005, self-reported cigarette smoking among British adults was 25% among men and 23% among women.² Despite recent reductions in the prevalence of smoking, it is still a serious public health problem in the UK.³

Because smoking imposes a huge burden on population health and NHS resources, quantifying the burden is important. Understanding the contribution of smoking to the overall burden of ill health and to National Health Service costs, compared with that of other risk factors for chronic disease, helps inform the prioritisation of limited NHS resources. In this way policymakers can understand the relative costs of different risk factors and assess whether efforts to alter population levels of risk could reduce overall costs to the NHS.

There have been various attempts to quantify the health and economic burden of smoking-related ill health in the UK. The direct healthcare costs of smoking were estimated to be between £1.4 billion and £1.7 billion in 1991.^{4–5} More recent estimates of the numbers of deaths attributable to smoking include 114 000 in 2000⁶ and 106 000 per annum between 1998 and 2002.⁷ The complexities of cost of illness studies mean they are not conducted regularly.

Providing estimates of the health and economic burden of smoking that are up to date is necessary as the prevalence of smoking is decreasing (though less so in recent years), total healthcare costs are increasing and new interventions aimed at reducing the prevalence of smoking have recently been implemented—notably the ban on smoking in public places—all of which are likely to have had an effect on the burden of smoking-related ill health. These changes are subject to time lags in the changing disease outcomes and in the prevalence figures as shown by health surveys. A method is needed, which is relatively fast and easy, to estimate the costs of smoking to the NHS.

We have proposed a relatively simple and efficient method to generate estimates of the burden of ill health related to disease risk factors of public health concern and have applied this method to generate estimates for diet, physical inactivity and obesity.^{8–10} The potential for such a standard method that is simple and reliable is worthy of attention. The estimates this method generates give similar results to more complex methods.¹⁰

This paper uses this simple method to estimate the costs of ill health attributable to smoking in the UK. The results are compared with previous estimates—in particular estimates generated by a systematic review of studies of the economic costs of smoking-related ill health in the UK.

METHODS

First, a systematic review of previous studies of the economic costs of smoking-related ill health in the UK was carried out. This review aimed to include all studies, published between 1997 and 2007, which calculated the cost of smoking in the UK or any country of the UK.

Secondly the burden of ill health due to smoking in all four countries of the UK was calculated using routinely collected mortality data and data on NHS costs, together with population attributable fractions (PAFs) and other information from the World Health Organization's Global Burden of Disease Project. The PAFs generated by this project estimate the proportion of disease that can be

Table 1 Summary of studies included in review with direct healthcare cost of ill health attributable to smoking in the United Kingdom

Reference	Setting	Direct cost (method)	Disease included in estimate
Parrott <i>et al</i> , 1998 ⁴	England, 1991	Method 1: £1.5 billion (attributable fractions) Method 2: £1.4 billion (cost comparison: smokers versus non-smokers)	Cancer Lung, upper respiratory sites, oesophagus, bladder kidney, stomach, pancreas, myeloid leukaemia Respiratory Chronic obstructive pulmonary disease, pneumonia Circulatory Ischaemic heart disease, cerebrovascular disease, aortic aneurysm, amyocardial degeneration, atherosclerosis Digestive Ulcer of stomach and duodenum
Buck <i>et al</i> , 1997 ⁵	UK, 1991	Method 1: £1.7 billion (attributable fractions) Method 2: £1.4 billion (using 1994 General Household Survey data and cost to the NHS of treating illnesses caused by smoking)	Not specified

attributed to a particular risk factor by sex and region. This study used the same methods that have been used to estimate the cost of ill health attributable to other risk factors for chronic disease in the UK.⁸⁻¹⁰

Systematic review

The systematic search of the literature was conducted using the search terms “cost” and “smoking” in Medline, CINAHL, Embase, Cochrane Library, National Health Service Economic Evaluation Database, EconLit, Science Citation Index, Social Science Citation Index, Index to Scientific and Technical Proceedings and the Health Management and Policy Database from the Healthcare Management Information Consortium. An initial search strategy was developed and tested on Medline and the search terms were then used for the other databases.

Studies were included if they related to the cost of smoking to the NHS in the UK and were published in English between August 1997 and September 2007. The time limits were applied to ensure that only recent cost estimates were considered. The reference lists of all papers were reviewed to identify other potentially relevant studies. Only studies reporting a new analysis of the cost to the NHS in the UK were included. Studies reporting previous analyses or estimates based on no analysis were excluded.

Burden of disease study

The method for calculating the health burden due to smoking and the direct cost of smoking to the NHS involved five steps. They were:

- ▶ Step 1: Diseases where smoking is a risk factor (as defined by WHO) were identified from the World Health Report for 2002.¹¹
- ▶ Step 2: Data on years of life lost (YLL), years of healthy life lost to disability (YLD) and disability adjusted life years (DALYs) for the year 2002 were taken from WHO’s Global Burden of Disease Project for WHO Euro-A Region (United Kingdom and other European countries with very low child and very low adult mortality).^{11 12} Data on mortality for the

year 2005 was obtained directly from Office for National Statistics for England and Wales, and the General Register Offices for Scotland and Northern Ireland.¹³⁻¹⁵

- ▶ Step 3: In 1996, the National Health Executive published a study which ascribed 1992–3 NHS costs to different diseases as defined by the International Classification of Disease (ICD 9).¹⁶ NHS total costs were defined in this document as the sum of NHS inpatient and outpatient costs, NHS primary care expenditure, NHS pharmaceutical expenditure and NHS net community care services expenditure. The proportion of total NHS expenditure (on NHS inpatient and outpatient costs, NHS primary care expenditure, etc) by disease code in 1992–3 was applied to the total cost of the NHS in 2005–6 for all four countries in the UK to provide an estimate of the total NHS costs for diseases that were identified as being related to smoking.¹⁷⁻²⁰ The diseases related to smoking were considered to be those ascribed within the Global Burden of Disease Project including mouth and oral cancer, trachea/bronchus and lung cancer, chronic obstructive pulmonary disease and cardiovascular disease.^{11 12}
- ▶ Step 4: Estimates of the burden of disease in the PAFs were calculated by the Global Burden of Disease Project.²¹ The PAFs for smoking, by sex and condition and relevant to the UK, were extracted from the World Health Report 2002.¹¹ The smoking PAFs were calculated using a base theoretical population in which all individuals had no tobacco use.^{11 12}
- ▶ Step 5: The burden (in terms of economic cost, mortality and morbidity) of smoking was calculated by applying the PAFs for diseases related to smoking to 2005–6 disease-specific data. Cost data for each of the four countries in the UK were derived using the method described in step 3. Mortality data for each of the four countries in the UK were taken from routinely collected sources.¹³⁻¹⁵

RESULTS

Systematic review

The search strategy generated 4338 papers of possible relevance. After applying the inclusion criteria 4207 were rejected on the

Table 2 Proportion of deaths (mortality), years of life lost in early deaths (YLLs), years of life lost in disability (YLDs) and disability adjusted life years (DALYs) due to smoking-related diseases in WHO-EUR-A region, 2002

	% of mortality (n = 3 920 000)	% of YLLs (n = 23 972 000)	% of YLDs (n = 27 762 000)	% of DALYs (n = 51 734 000)
Conditions related to smoking				
Mouth and oral cancer	0.6	1.0	0.1	0.5
Trachea/bronchus/lung cancer	5.3	6.8	0.2	3.2
Other cancers	21.4	25.1	2.9	13.2
Chronic obstructive pulmonary disease	3.6	2.6	4.1	3.4
Cardiovascular diseases	41.1	29.5	6.4	17.1
Other medical conditions*	2.5	2.0	4.7	3.5
Total related to smoking	74.4	66.9	18.3	40.8
Communicable diseases, maternal/perinatal conditions and nutritional deficiencies	6.2	6.0	4.0	4.9
Digestive diseases†	4.2	5.2	3.8	4.4
Diabetes mellitus	2.4	1.9	2.4	2.1
Diseases of the genitourinary system	1.6	1.1	1.0	1.1
Neuropsychiatric disorders	4.7	4.8	45.3	26.5
Musculoskeletal diseases	0.5	0.4	7.6	4.3
Injuries	4.8	11.5	4.7	7.9
Other	1.2	2.3	12.9	7.9
Total	100.0	100.0	100.0	100.0

*Includes peptic ulcer and all respiratory conditions except chronic obstructive pulmonary disease.

†Excluding peptic ulcer.

basis of title or abstract and a further 135 were rejected after reviewing the full paper. The majority of papers were excluded because they reported on the cost of smoking in countries other than the UK—mostly the United States. Some studies were excluded because they only reported the costs of a particular intervention, such as smoking cessation or nicotine replacement patches.

There were two studies that met the inclusion criteria and reported on the economic cost of smoking to the NHS in the UK.^{4,5} Both studies provide estimates for 1991 ranging from £1.4 billion to £1.7 billion and are summarised in table 1. Parrott *et al*⁴ produced similar cost estimates using two different approaches; the application of attributable fractions to 1991 cost data for diseases including a number of cancers, respiratory and circulatory diseases and by comparing the costs of smokers and non-smokers. Buck *et al*⁵ produced a slightly higher estimate also using a PAF although comparisons between these studies are difficult because the diseases included in the second study were not specified.

Burden of disease study

Morbidity and mortality

Table 2 shows the proportion of deaths, YLLs, YLDs and DALYs in WHO EUR-A region by disease for 2002. It shows that those diseases associated with smoking were responsible for 74% of all mortality, 67% of YLLs, 18% of YLDs and 41% of DALYs.

Table 3 shows the total DALYs lost and the PAFs for smoking-related ill health in WHO EUR-A region for 2002. It shows that 12.1% (male: 15.4%; female: 8.5%) of all DALYs lost were directly attributable to smoking. Cardiovascular disease was the largest contributor to the burden of disease attributable to smoking, accounting for 3.8% of all DALYs lost followed by trachea/bronchus/lung cancer (2.7%) and chronic obstructive pulmonary disease (2.3%).

Using PAFs derived from the WHO's Global Burden of Disease Project, we estimated that of the 588 478 deaths in the

UK in 2005, 109 164 deaths (18.6%) were directly attributable to smoking (27.2% of all male deaths (77 154) and 10.5% of all female deaths (32 010)). The proportion of deaths attributable to smoking ranged from 19.7% in Scotland to 12.2% in Northern Ireland (table 4).

Direct cost to the NHS

Table 5 shows that the direct cost to the NHS for smoking attributable conditions was estimated to be £5.17 billion (5.5% of total healthcare costs) in 2005–6. Of the £5.17 billion directly attributable to smoking, the largest proportion was due to cardiovascular diseases (£250.8 million). Table 5 also shows the direct cost to the NHS for smoking attributable conditions by countries in the UK.

DISCUSSION

We estimate that 109 164 deaths (18.6% of all deaths) in the UK in 2005 can be attributed to smoking (27.2% of male deaths and 10.5% of female deaths). Our estimate is similar to that produced by Twigg *et al*—that on average, each year 106 100 deaths (17.2% of all deaths) were from smoking-attributable causes across the UK over the period 1998–2002 (23% of male deaths and 12% of female deaths).⁷ Other previous estimates of smoking attributable deaths include 120 000 in 1995 by Callum *et al*,²² 117 400 in 1997 by the Royal College of Physicians²³ and 114 000 in 2000 by Peto *et al*.⁶ This suggests that overall numbers of deaths attributable to smoking in the UK have not changed much in the past 10 years.

It is difficult to compare estimates of the number of smoking attributable deaths because of methodological differences, the changing prevalence of smoking, changes in the resident population (57 million in 1991 to 61 million in 2006 in the UK), etc. For example Callum and White²⁴ used age-specific attributable fractions for London to derive estimates across all boroughs and parliamentary constituencies—an approach that underestimates the attributable burden of smoking in areas

Table 3 Total disability adjusted life years (DALYs) lost and population attributable fractions for smoking-related ill, by gender, in WHO EUR-A region, 2002

Smoking-related conditions	Male				Female				Total			
	DALYs lost (n)	PAF DALYs lost (%)	DALYs lost to smoking	% of all male DALYs	DALYs lost (n)	PAF DALYs lost (%)	DALYs lost to smoking	% of all female DALYs	DALYs lost (n)	PAF DALYs lost (%)	DALYs lost to smoking	% of all DALYs
Mouth and oral cancer	213 052	0.0	0	0.0	50 554	0.0	0	0.0	263 605	0.0	0	0.0
Trachea/bronchus/lung cancer	1 237 789	90.0	1 114 010	4.1	429 890	69.0	296 624	1.2	1 667 678	85.0	1 410 633	2.7
Other cancers	3 344 506	19.0	635 456	2.3	3 457 554	2.0	69 151	0.3	6 802 060	10.0	704 607	1.4
Chronic obstructive pulmonary disease	908 350	79.0	717 597	2.6	836 077	57.0	476 564	2.0	1 744 427	68.0	1 194 161	2.3
Cardiovascular diseases	5 004 686	32.0	1 601 499	5.9	3 833 645	10.0	383 365	1.6	8 838 331	22.0	1 984 864	3.8
Other medical conditions*	978 824	16.0	156 612	0.6	812 751	6.0	48 765	0.2	1 791 575	11.0	205 377	0.4
Total related to smoking	10 708 383	39.3	4 211 964	15.4	8 607 719	24.0	2 065 853	8.5	19 316 102	33.0	6277 817	12.1

*Includes peptic ulcer disease and all respiratory conditions except COPD.

†Excluding peptic ulcer disease.

COPD, chronic obstructive pulmonary disease; PAF, population attributable fractions.

where smoking prevalence is higher than in London and overestimates the effect where smoking rates are lower than in London. Twigg *et al*⁷ used the same published relative risk factors as Callum and White to calculate smoking attributable mortality for primary care trusts and strategic health authorities in England. These authors extended the previous approach by applying multi-level synthetic estimation techniques to produce estimates at small area level and combining primary care trusts estimates to create figures for the four countries within the UK.

The decline in overall prevalence of smoking together with the increase in smoking among younger age groups increases the complexity of the issue. In this study we used the WHO's (2002) population attributable fractions for smoking-related conditions and the latest (2005) mortality data for the UK. This study therefore provides the most up-to-date estimates of the burden of smoking-related illness.

Our study estimates that smoking cost the NHS over £5 billion in 2005–6. This equates to 5.5% of total NHS expenditure in 2005–6. The systematic review identified two studies that estimated the cost of smoking to the NHS. The first study estimated the cost to be between £1.4 billion and £1.5 billion in 1991⁴ and the second study estimated the cost between £1.4 billion and £1.7 billion in the same year.⁵ However, the total NHS healthcare cost has gone up from £31 billion in 1991–2 to £80 billion in 2005–6,^{16, 17} so although our estimate is higher than these previous estimates, it does not

differ greatly as a proportion of total healthcare costs (4.9% to 5.5% in 1991 compared to 5.5% in 2005–6). We can assume that much of the difference in cost was due to the increase in overall healthcare costs since 1991.

Another potential source of difference between our estimate of the cost of smoking to the NHS and previous estimates is the PAFs used. Both the previous studies used smoking attributable fractions calculated for 1991 taken from Callum (1995),²² while our study used PAFs for 2002 from WHO's World Health Report.¹¹ Our estimate that smoking was responsible for 5.5% of total healthcare costs is comparable with estimates of the economic burden in other developed countries. These estimates range from 11.8% of total healthcare costs (in the United States in 1993²⁵) to 3.3% (in Germany in 2003²⁶).

In this paper we have underestimated the burden of smoking-related ill health for three reasons. First, we have not included indirect costs in our economic analysis; second, we have not included the burden due to passive smoking; and, third, we have not considered all conditions related to smoking. Indirect costs include those caused by production losses due to smoking-related premature mortality, morbidity and informal care of people with smoking-related illnesses, but also other costs such as sickness absence payments and the costs of smoking-related fires. For Scotland, Parott *et al* estimated that the annual cost of smoking-related productivity losses, absence from work and fire associated with smoking were, in 2000, £40 million, £450

Table 4 Total deaths and deaths attributable to smoking by gender and countries in the UK, in 2005

	All ages				
	England	Wales	Northern Ireland	Scotland	UK total
All deaths					
Male	227 479	15 146	14 224	26 522	283 371
Female	251 967	16 958	6957	29 225	305 107
Total	479 446	32 104	21 181	55 747	588 478
Deaths attributable to smoking					
Male	63 462	4343	1863	7485	77 154
Female	26 001	1808	720	3481	32010
Total	89 463	6152	2583	10 966	109 164
% deaths attributable to smoking	18.7	19.2	12.2	19.7	18.6

Table 5 Percentage of total NHS costs attributable to smoking for different diseases in 1992–3 and 2005–6 and cost

	England			Wales		Scotland		Northern Ireland		Total UK cost attributable to smoking (£m)
	1992–3 (% NHS total costs) ^a	PAF (%)	Total NHS costs 2005–6 (£m)	Cost attributable to smoking (£m)	Total NHS costs 2005–6 (£m)	Cost attributable to smoking (£m)	Total NHS costs 2005–6 (£m)	Cost attributable to smoking (£m)		
Smoking-related conditions										
Mouth and oral cancer	0.1	0	40.4	0.0	2.2	0.0	3.8	0.0	1.2	0.0
Trachea/bronchus/lung cancer	0.4	85	278.3	235.4	14.8	12.5	25.9	21.9	8.1	6.8
Other cancers	3.7	10	2952.1	305.8	157.2	16.3	274.8	28.5	85.8	8.9
Cardiovascular diseases	12.1	22	9698.9	2,133.8	516.5	113.6	902.8	198.6	281.9	62.0
Chronic obstructive pulmonary disease	2.2	68	1746.9	1187.9	93.0	63.3	162.6	110.6	50.8	34.5
Other medical conditions*	5.8	11	4676.0	536.0	249.0	28.5	435.2	49.9	135.9	15.6
Total related to smoking	24.12		19 392.6	4398.9	1032.7	234.2	1805.1	409.4	563.7	127.9
Infectious diseases	1.0		835.9		44.5		77.8		24.3	
Neuropsychiatric disorders	25.9		20 791.9		1107.2		1935.3		604.4	
Musculoskeletal diseases	7.8		6260.3		333.4		582.7		182.0	
Injuries and accidents	3.8		3057.5		162.8		284.6		88.9	
Other	37.2		29 847.0		1589.4		2778.1		867.7	
Total	100.0		80 185.2		4270.0		£7464.0		2331.0	

*Includes peptic ulcer disease and all respiratory conditions except COPD; †Excluding peptic ulcer disease.

COPD, chronic obstructive pulmonary disease; DALY, disability adjusted life years; PAF, population attributable fraction.

What this paper adds

- ▶ The cost of smoking-related ill health to the National Health Service in the UK is £5.2 billion per year, nearly 5.5% of the total NHS budget.
- ▶ The cost of smoking to the NHS, as a proportion of the total NHS budget, has not changed substantially since the early 1990s.
- ▶ The cost of smoking to the NHS is comparable to the cost of diet-related ill health, estimated to be approximately £6.0 billion per year.

million and £4 million, respectively.²⁷ Including indirect costs would increase our estimate of the financial burden considerably.

The British Medical Association estimates that each year in the UK at least 1000 people die as a result of secondhand smoke²⁸ and more than 17 000 children under the age of 5 are admitted to hospital because of the effects of passive smoking.²⁹ Parrott and Godfrey have estimated that each year in the UK £410 million is spent in treating childhood illnesses related to passive smoking.³⁰ If these estimates are correct then including the effects of passive smoking would substantially increase our estimates of the health and financial burden due to smoking.

The analysis presented here only considered conditions for which the WHO Burden of Disease Study has calculated PAFs. Our report did not include other conditions reported to be associated with smoking such as infertility, complications during pregnancy, stillbirths, neonatal deaths, post-menopausal osteoporosis, eye diseases, etc.^{31, 32} The WHO Global Burden of Disease data are also limited by the lack of age-specific information. The application of a single estimate across the total adult population assumes that disease patterns are consistent across all age groups.

A further limitation to this and similar studies is the absence of current NHS cost data by disease category. In this study the data had to be extrapolated from 1992 data (because there is no more recent study) and clearly methods of treating diseases associated with smoking (and the costs associated with those methods) have changed significantly since then. In 2002, the Department of Health initiated the National Programme Budget Project (NPBP), which provides detailed expenditure information for primary care service under 23 programmes of care based on medical conditions such as mental health, cardiovascular disease and cancer. While these data are only available for England and only for some specific disease categories they provide a chance to understand the change in relative proportion of costs for these diseases between 1992 and 2006–7. In 2005–6 the NPBP reported problems of circulation as costing £6.1 billion, obstructive airway disease £534 million and infectious diseases at £1.2 billion. For England our method returned estimates £9.7 billion for cardiovascular disease, £1.7 billion for COPD and £834 million for infectious disease.

The methods used for this study only provides a picture of the past burden of smoking because of its retrospective nature, and does not reflect the success or otherwise of recent interventions. This is because of the lag time between any intervention and the subsequent influence on disease outcomes. As one example, Peto⁶ found that people who stop smoking before middle age will avoid 90% of the risk attributable to tobacco but the effect of cessation would not show itself on

hospital costs until later life when the symptoms of lung cancer would manifest.

These limitations notwithstanding, comparative information about the costs of smoking and other risk factors for chronic disease is important in making resource allocation decisions regarding smoking cessation and other preventive actions. Previous work using the methods used here has estimated 2002 costs due to poor diets in the UK to be £6 billion, overweight and obesity to be £3 billion and physical inactivity to be £1 billion.^{9–10} This study enables a comparison to be made between the direct cost of smoking to the NHS and other disease risk factors. This comparison should help policymakers prioritise public health interventions and make effective use of limited NHS resources.

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