

The economic burden of ill health due to diet, physical inactivity, smoking, alcohol and obesity in the UK: an update to 2006–07 NHS costs

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ABSTRACT

Background Estimates of the economic cost of risk factors for chronic disease to the NHS provide evidence for prioritization of resources for prevention and public health. Previous comparable estimates of the economic costs of poor diet, physical inactivity, smoking, alcohol and overweight/obesity were based on economic data from 1992–93.

Methods Diseases associated with poor diet, physical inactivity, smoking, alcohol and overweight/obesity were identified. Risk factor-specific population attributable fractions for these diseases were applied to disease-specific estimates of the economic cost to the NHS in the UK in 2006–07.

Results In 2006–07, poor diet-related ill health cost the NHS in the UK £5.8 billion. The cost of physical inactivity was £0.9 billion. Smoking cost was £3.3 billion, alcohol cost £3.3 billion, overweight and obesity cost £5.1 billion.

Conclusion The estimates of the economic cost of risk factors for chronic disease presented here are based on recent financial data and are directly comparable. They suggest that poor diet is a behavioural risk factor that has the highest impact on the budget of the NHS, followed by alcohol consumption, smoking and physical inactivity.

Keywords economic burden, non-communicable disease (NCD), risk factors, UK

Introduction

Chronic diseases are the leading cause of death globally.¹ In the UK, each year >35% of total deaths (c. 200 000) are due to cardiovascular disease (CVD), with cancer causing a further 157 000 deaths.² The total cost of CVD to the UK economy is estimated as £30 billion, 60% due to health-care costs.³ The National Institute for Health and Clinical Excellence has emphasized the importance of taking population level measures to prevent CVD in the UK.⁴

Many chronic diseases share common behavioural risk factors such as tobacco smoking, unhealthy diet, lack of physical activity and alcohol use.⁵ It is estimated that up to 80% of heart diseases, stroke and type 2 diabetes and over a third of cancers could be prevented by eliminating those shared risk factors.⁶

One-fifth of UK adults regularly smoke cigarettes² and more than a fifth of men and around 15% of women regularly exceed government benchmarks for heavy drinking.⁷ Self-reported physical activity levels in England and Scotland have slowly increased over the last 10 years; however, accelerometry data suggest that actual physical activity uptake may be far lower.⁸ Progress towards the

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target consumption level of five portions of fruit and vegetables a day has been slow and the intake of sugar and saturated fat remains higher than recommended levels.⁹

Clear estimates of the economic burden of these risk factors are important to help prioritize public health strategies. Recent work has established a method of producing comparable results for the economic burden to the NHS in the UK of disease associated with poor diet, smoking, alcohol intake, physical inactivity and overweight/obesity.^{10–14} The methods used to develop these results rely on an estimate of the percentage of the total budget of the NHS that is spent on different diseases. Until recently, the most up-to-date breakdown of the NHS budget by disease category was produced in 1996, and referred to the budget of the NHS in 1992–93.¹⁵ Therefore, the estimates of the economic cost of poor diet, physical inactivity, smoking, alcohol and overweight/obesity were based on the assumption that the contribution of different disease categories to the overall NHS budget has not substantially changed since 1992–93. Recently, a new assessment of NHS costs by disease category has been produced, based on the 2006–07 NHS budget for England. This paper reports on an update of the estimates of the economic burden to the NHS of poor diet, physical inactivity, smoking, alcohol and overweight/obesity to 2006–07 prices, using the updated data on cost by disease category.

Methods

Estimates were developed and tested using these steps:^{10–14}

- (i) Identification of diseases where poor diet, physical inactivity, smoking, alcohol or overweight/obesity are risk factors.
- (ii) Identification of the total economic cost to the NHS in the UK for these diseases.
- (iii) Identification of the population attributable fractions (PAFs) relating to the risk factors for each disease.
- (iv) Application of these PAFs to economic cost data, to calculate the direct burden of those risk factors.
- (v) Sensitivity analysis for each estimate.

Cost data (Step 2) were updated using 2006–07 NHS costs by disease category from the NHS Programme Budgeting estimates for England from 2006 to 07.¹⁶ Previously these estimates were taken from 1992 to 93 cause-specific cost estimates¹⁵ and inflated to 2002 costs for each risk factor listed in Step 1. The disease-specific cost estimates were collected from all PCTs in England, who were asked to categorize all spending in primary and secondary care services into 23 broad and 57 more detailed disease categories, based on the tenth revision of the International

Classification of Disease. The more detailed categorization was used for the analyses reported here. The programme budgeting database only provides estimates for costs for the NHS in England. For each disease, we applied the percentage of all costs in England to the total budget of the NHS in the UK (under the assumption that the distribution of NHS costs between diseases in England will be broadly representative of the situation in the UK). The total budget of the NHS in the UK for 2006–07 was provided by combining budgets for the NHS in England,¹⁶ Scotland,¹⁷ Wales¹⁸ and Northern Ireland.¹⁹

In some cases, the disease categorizations provided in the 1996 burden of disease report¹⁵ and the 2006–07 programme budgeting database had changed. Table 1 provides a comparison of the disease categories in the 1996 and 2008 reports.

For the calculation of the burden of alcohol-related ill health, special attention was made to the 2006–07 disease categorization of ‘trauma and injuries’. This broad category needed to be further broken down to drowning, falls, motor vehicle accidents, self-inflicted injuries, and other unintentional injuries in order to apply the necessary PAFs. This further stratification was performed by applying the proportion of deaths from each sub category (compared with all deaths from trauma and injury) to the cost of all trauma and injury (see Table 2). The mortality data were taken from the World Health Organization’s (WHO) estimates of mortality for WHO member states in 2004.²⁰ These estimates were derived by the WHO using disease-specific death certification data from the UK for an earlier year, and then projecting estimates to 2004.

For physical inactivity, smoking, alcohol consumption and overweight/obesity, the counterfactuals associated with the estimates of economic burden are drawn from the WHO global burden of disease project, and relate to the theoretical minimum within a population. The counterfactuals were therefore zero smoking, zero alcohol consumption and everyone within the population achieving at least some activity at work, home, for transport or during discretionary time. Because of the J-shaped relationship between alcohol intake and many health outcomes, this counterfactual allows for the increase in risk for some individuals and decrease in risk for others.²¹ For overweight/obesity, the theoretical minimum was taken to be the part of the distribution associated with the lowest risk, i.e. everyone in the population with a body mass index of 21 kg/m².²¹

The counterfactual for poor diet is more complicated as diets are multi-factorial. The global burden of disease project calculated PAFs for individual risk factors and warns that the PAF for combined risk factors for any specific

Table 1 Comparison of disease categorizations used in World Health Report⁵, published estimates of economic costs related to risk factors and updated disease categorizations provided in the NHS 2006–07 Programme Budgeting Manual¹⁶

| <i>Risk factor</i> | <i>Associated condition (World Health Report)</i> | <i>Disease categorization (1992–93 cost categories)^a</i> | <i>Disease categorization (2006–07 cost categories)</i> |
|----------------------|---|--|---|
| Overweight/obesity | Diabetes mellitus | Diabetes mellitus (250) | Diabetes |
| | Ischaemic heart disease | Ischaemic heart disease (410–414) | Coronary heart disease |
| | Ischaemic stroke | Stroke (430–438) | Cerebrovascular disease |
| | Hypertensive disease | Hypertension (401–405) | Problems of circulation (other) ^b |
| | Breast cancer | Female breast cancer (174) | Cancer, breast |
| | Colon/rectum cancer | Colorectal cancer (153–154) | Cancer, lower gastrointestinal system |
| | Corpus uteri cancer | Genito-urinary cancers, female (179, 181–184) | Cancer, gynaecological |
| | Osteoarthritis | Osteoarthritis (715) | Problems of musculoskeletal system |
| Poor diet | N/A | Cardiovascular disease (390–459) | Problems of circulation |
| | N/A | Cancer (140–239) | Cancers and tumours |
| | N/A | Diabetes and other disease of the hormone and immune system (240–279) | Endocrine, nutritional and metabolic disorders |
| | N/A | Dental caries and other diseases of the digestive system (520–571) | Dental problems |
| Smoking | Chronic obstructive pulmonary disease | Chronic obstructive pulmonary disease (490–492, 494–496) | Obstructive airways disease |
| | Mouth and oropharynx cancers | Mouth cancers (140–149) | Cancer, head and neck |
| | Trachea/bronchus/lung cancers | Larynx, lung and other respiratory cancers (161–165) | Cancer, lung |
| | Other cancers | Other cancers (150–159, 170–239) | Other cancers ^c |
| | Other medical conditions | Ulcers and respiratory conditions excluding chronic obstructive pulmonary disease (460–487, 493, 500–519, 531–533) | Problems of the respiratory system (other) ^d , problems of the gastrointestinal system |
| Alcohol ^e | CVD | CVD (390–459) | Problems of circulation |
| | Cirrhosis of the liver | Chronic liver disease and cirrhosis (571) | Hepatobiliary |
| | Epilepsy | Epilepsy (345) | Neurological (other) ^f |
| | Stroke ^g | Stroke (430–438) | Cerebrovascular disease |
| | Ischaemic heart disease | Ischaemic heart disease (410–414) | Coronary heart disease |
| | Unipolar depressive disorders | Other non-organic psychoses (296–299) | Mental health disorders, other ^h |
| | Liver cancer | Kidney and other urinary cancers (189) | Cancer, urological |
| | Mouth and oropharynx cancers | Mouth cancers (140–149) | Cancer, head and neck |
| | Oesophagus cancers | Oesophagus cancer (150) | Cancer, upper gastrointestinal system |
| | Other cancers | Other cancers (151–188, 190–239) | Other cancers ⁱ |

Continued

Table 1 Continued

| Risk factor | Associated condition (World Health Report) | Disease categorization (1992–93 cost categories) ^a | Disease categorization (2006–07 cost categories) |
|---------------------|--|---|--|
| Physical inactivity | Ischaemic heart disease Ischaemic stroke Breast cancer Colom/rectum cancer Diabetes mellitus | Ischaemic heart disease (410–414) Stroke (430–438) Female breast cancer (174) Colorectal cancer (153–154) Diabetes mellitus (250) | Coronary heart disease Cerebrovascular disease Cancer, breast Cancer, lower gastrointestinal system Diabetes |

^aFurther conditions that fall under 'trauma and injuries' are covered in Table 2.

^bIncludes all diseases of the circulatory system except 'coronary heart disease', 'cerebrovascular disease' and 'problems with rhythm'.

^cAll cancers other than 'cancer, head and neck' and 'cancer, lung'.

^dAll problems of the respiratory system excluding 'obstructive airways disease'.

^eICD-9 codes in brackets

^fAll neurological conditions excluding 'chronic pain'.

^gThe World Health Report provides separate PAFs for haemorrhagic stroke and ischaemic stroke. Since cost data are not available by stroke subtype, we have averaged the PAFs using the weighting of 2:1 in favour of ischaemic stroke, in accordance with the estimated ratio of mortalities by stroke subtype in the UK.⁴¹

^hAll mental health disorders excluding 'substance misuse', 'organic mental disorders', 'psychotic disorders' and 'child and adolescent mental health disorders'.

ⁱAll cancers other than 'cancer, urological', 'cancer, head and neck' and 'cancer, upper gastrointestinal system'.

disease may be less than the sum of PAFs for individual risk factors. In order to calculate a combined PAF for diet, we triangulated estimates of the percentage of disability adjusted life years (DALYs) that were due to diet-related risk factors in the WHO European region,²² the EU²³ and Australia,²⁴ and conservatively estimated that 10% of DALYs were due to diet.¹⁴ Since 30% of DALYs in the WHO European region were due to CVD and cancer, we assumed a PAF of 0.33 for diet. Using this method, it should be assumed that the counterfactual for poor diet is a combination of all counterfactuals for diet-related risk factors in the global burden of disease project: everyone consuming 600 g per day of fruit and vegetables, having total cholesterol levels of 3.8 mmol/l and a body mass index of 21 kg/m².

A sensitivity analysis was conducted to assess how sensitive the results were to the assumption that PAFs generated for the WHO EUR-A region were suitable for use in the UK. Prevalence rates used to generate the PAFs for each risk factor were compared with equivalent rates drawn from the Health Survey for England 2006²⁵ and the General Household Survey 2006.²⁶ The ratio between the UK prevalence rate and the EUR-A prevalence rate was applied to the modelled cost estimates, and the range for the sensitivity analysis was between the estimates adjusted for UK prevalence rates and the original estimates using the EUR-A prevalence rates. The cost estimates for poor diet were not included in the sensitivity analysis because of the difficulties in defining PAFs for poor diet, as described already.

Results

In 2006–07, 46% of total NHS costs (over £43 billion) were due to diseases related to poor diet, physical inactivity, smoking, alcohol and overweight/obesity (although not all of these costs were due to the risk factors, since not all of the incident cases of these conditions were due to the risk factors) (Table 3). Of the behavioural risk factors, £5.8 billion was spent on poor diet-related ill health, £3.3 billion on alcohol-related ill health, £3.3 billion on smoking-related ill health and £0.9 billion on physical inactivity-related ill health. Over £5 billion was spent on overweight/obesity-related ill health, although this includes costs from poor diet and physical inactivity.

Proportional NHS costs due within disease categories were similar in 1992–93 and 2006–07 for most of the diseases with some notable exceptions. For example, the percentage of NHS costs due to cerebrovascular disease fell from 4.1% in 1992–93 to 1.2% in 2006–07, and costs due to osteoarthritis increased from 1.6% in 1992–93 to 5.0% in

Table 2 Further stratification of 'trauma and injuries' disease category for calculation of the economic costs to the NHS of alcohol-related conditions

| World Health Report Category | Number of deaths, 2004 | Percentage of all trauma and injury deaths | Estimated percentage of NHS costs |
|------------------------------|------------------------|--|-----------------------------------|
| Drowning | 2000 | 10 | 0.4 |
| Falls | 4000 | 19 | 0.8 |
| Motor vehicle accidents | 3700 | 18 | 0.8 |
| Self-inflicted injuries | 4700 | 23 | 1.0 |
| Other unintentional injuries | 5200 | 25 | 1.1 |
| All trauma and injuries | 20 770 | 100 | 4.3 |

2006–07. A combination of the changes in costs by disease, the differences in disease categorization displayed in Table 1 and the change from 2002 or 2006 prices to 2006–07 prices explains the difference between the original estimates and the updated estimates presented here. The original estimates of the cost of poor diet, physical inactivity and overweight/obesity were based on 2002 prices; so it would be expected that updating to 2006–07 prices would increase the estimates. That has been the case for the costs of overweight/obesity, which increased from £3.2 to £5.1 billion. However, the costs for both physical inactivity and poor diet have slightly reduced in the updated estimates, because of a downwards revision in the total percentage of NHS costs of related conditions between 1992–93 and 2006–07. The original estimates for the cost of smoking and alcohol were based on 2006 prices, where the estimate used for the total budget for the NHS (£94.2 billion) was higher than that used in 2006–07 (£81.3 billion). This difference explains some of the reduction in the estimate of smoking-related ill health, from £4.4 to £3.3 billion. The estimate for the cost of alcohol-related ill health increased, due to an increase in the percentage of NHS costs due to alcohol-related conditions.

Table 4 shows the results of the sensitivity analysis. For physical inactivity, alcohol consumption, and overweight and obesity, the prevalence estimates for the WHO EUR-A region were very similar to equivalent estimates for the UK in 2006, and as such the sensitivity range for the costs associated with these risk factors is narrow (ranging from £5.1 to £5.2 billion for overweight and obesity). This was not the case for smoking, where the UK prevalence of smoking is considerably lower than the prevalence in the EUR-A region. The sensitivity range for smoking was £2.3 to £3.3 billion.

Discussion

One of the aims of deriving comparable estimates of the cost of risk factors to the NHS is to provide evidence to allow policy-makers to prioritize interventions aimed at

preventing chronic disease. The update of cost estimates using more recent data on cost by disease category is therefore important to ensure that the evidence is up-to-date and reliable. The updated estimates reinforce that the largest economic burden to the NHS is due to poor diet and that much of this food-related burden is due to overweight and obesity. Physical inactivity asserts a considerable burden on the NHS, but not as high as other behavioural risk factors.

The main difference between the results presented here and the original estimates is that the economic burden of alcohol is now similar to the burden due to smoking. It is important to remark that this change in priority is *not directly* due to changes in the prevalence of smoking or binge drinking in the UK (since the PAFs used to calculate both sets of estimates were the same). Rather, it is due to changes in the disease-specific costs associated with alcohol and smoking. In turn, these differences in costs may be due to changes in the incidence of these diseases (which in turn could be influenced by the prevalence of smoking or binge drinking) or changes in the cost of treatment of these diseases. For example, the impact of unipolar depressive disorders (which are associated with alcohol intake) on the NHS budget has changed considerably between the 1991–92¹⁵ and 2006–07 estimates²⁷—due in part to differences in coding these conditions in the two reports (see Table 1). Although changes in coding between the reports hinder comparisons between the two sets of estimates, use of the updated 2006–07 costs ensure a more realistic estimate of the burden of risk factors to the NHS.

The analysis for this paper required a comparison of two sets of cause-specific NHS costs (for the years 1992–93¹⁵ and 2006–7,¹⁶ which revealed some interesting changes in relative cost of conditions to the NHS. Such comparisons can be problematic: percentages may change due to a change in spending on a specific condition, or a change in spending on other conditions; changes in spending on a specific condition could reflect changes in incidence, prevalence or treatment methods for that condition.

Table 3 Original and updated economic costs of poor diet, physical inactivity, smoking, alcohol and overweight/obesity to the NHS

| | % of total NHS costs | | PAF | Total NHS costs (£millions) | |
|---------------------------------------|----------------------|---------|-----|-----------------------------|-------------------------|
| | 1992–93 | 2006–07 | | Original costs (2002) | Updated costs (2006–07) |
| Physical inactivity | | | | | |
| Ischaemic heart disease | 2.6 | 2.9 | 23 | 526 | 542 |
| Ischaemic stroke | 4.1 | 1.2 | 12 | 347 | 117 |
| Breast cancer | 0.3 | 0.6 | 11 | 26 | 54 |
| Colon/rectum cancer | 0.5 | 0.5 | 16 | 61 | 65 |
| Diabetes mellitus | 1.0 | 1.3 | 15 | 101 | 158 |
| Total | 8.5 | 6.5 | | 1062 | 936 |
| Overweight and obesity | | | | Original costs (2002) | Updated costs (2006–07) |
| Ischaemic heart disease | 2.6 | 2.9 | 34 | 778 | 801 |
| Ischaemic stroke | 4.1 | 1.2 | 34 | 983 | 332 |
| Breast cancer | 0.3 | 0.6 | 12 | 29 | 59 |
| Colon/rectum cancer | 0.5 | 0.5 | 16 | 61 | 65 |
| Hypertensive disease | 1.4 | 4.5 | 58 | 576 | 2121 |
| Corpus uteri cancer | 0.1 | 0.2 | 49 | 41 | 80 |
| Osteoarthritis | 1.6 | 5.0 | 21 | 229 | 853 |
| Diabetes mellitus | 1.0 | 1.3 | 79 | 533 | 835 |
| Total | 11.6 | 16.2 | | 3231 | 5146 |
| Poor diet | | | | Original costs (2002) | Updated costs (2006–07) |
| CVD | 12.0 | 9.2 | 33 | 2780 | 2468 |
| Diabetes mellitus | 2.0 | 2.8 | 33 | 463 | 751 |
| Cancer | 4.0 | 6.2 | 33 | 927 | 1663 |
| Dental caries | 8.0 | 3.4 | 33 | 1853 | 912 |
| Total | 26.0 | 21.6 | | 6023 | 5793 |
| Smoking | | | | Original costs (2006) | Updated costs (2006–07) |
| Trachea/bronchus/lung cancers | 0.4 | 0.3 | 85 | 235 | 207 |
| Other cancers | 3.7 | 5.7 | 10 | 306 | 463 |
| Chronic obstructive pulmonary disease | 2.2 | 0.8 | 68 | 1188 | 442 |
| CVD | 12.1 | 9.2 | 22 | 2134 | 1645 |
| Other medical conditions | 5.8 | 5.7 | 11 | 536 | 510 |
| Total | 24.3 | 18.9 | | 4399 | 3267 |
| Alcohol | | | | Original costs (2006) | Updated costs (2006–07) |
| Cirrhosis of the liver | 0.7 | 0.9 | 56 | 319 | 410 |
| Epilepsy | 0.7 | 2.7 | 41 | 243 | 900 |
| Unipolar depressive disorders | 0.0 | 7.7 | 5 | 0 | 313 |
| Ischaemic heart disease | 2.6 | 2.9 | –1 | –21 | –24 |
| Stroke | 3.2 | 1.2 | 0.7 | 0.7 | 7 |
| Mouth and oropharynx cancers | 0.0 | 0.2 | 35 | 0 | 57 |
| Oesophagus cancer | 0.1 | 0.3 | 41 | 31 | 100 |
| Liver cancer | 0.0 | 0.6 | 32 | 10 | 156 |
| Other cancer | 3.9 | 5.1 | 10 | 291 | 415 |
| Drowning | 0.0 | 0.4 | 34 | 0 | 115 |
| Falls | 0.9 | 0.8 | 15 | 120 | 101 |
| Poisoning | 0.1 | 0.2 | 39 | 35 | 63 |
| Motor vehicle accidents | 0.9 | 0.8 | 38 | 284 | 238 |
| Self-inflicted injuries | 1.0 | 1.0 | 20 | 181 | 159 |
| Other intentional injuries | 0.0 | 0.0 | 26 | 0 | 8 |
| Other unintentional injuries | 0.7 | 1.1 | 24 | 147 | 211 |
| Total | 14.9 | 25.9 | | 1742 | 3228 |

Total NHS budget 2002: £70.2 billion; 2006: £94.2 billion; 2006–07: £81.3 billion.

Table 4 Sensitivity analysis of the impact of using EUR-A PAFs to generate cost estimates for the UK

| Risk factor | EUR-A prevalence rate | UK prevalence rate | Adjustment factor ^a | Sensitivity range of total costs to NHS |
|-------------------------------------|-----------------------|--------------------|--------------------------------|---|
| Physical inactivity ^b | 17 | 18 ^c | 1.05 | £0.9–£1.0 billion |
| Overweight and obesity ^d | 26.7 | 27.2 ^c | 1.01 | £5.1–£5.2 billion |
| Smoking ^e | 32 | 22 ^f | 0.69 | £2.3–£3.3 billion |
| Alcohol intake ^g | 87 | 86 ^c | 0.99 | £3.2–£3.2 billion |

^aAdjustment factor = ratio of UK prevalence rate to EUR-A prevalence rate.

^b'Prevalence rate' refers to percentage of adults who do no or very little physical activity.

^cEstimate taken from 2006 Health Survey for England.

^d'Prevalence rate' refers to mean BMI.

^e'Prevalence rate' refers to percentage of adult current smokers.

^fEstimate taken from 2006 General Household Survey.

^g'Prevalence rate' refers to percentage of adults who consume no alcohol at all.

Cerebrovascular disease was responsible for 4.1% of NHS costs in 1992–93 and only 1.2% of NHS costs in 2006–07, which seems at odds with the ageing population of the UK. While incidence rates for stroke are falling in the UK, the prevalence of stroke is increasing.²⁸ It seems likely, therefore, that this change in relative burden to the NHS is either a reflection of considerable uncertainty in the cause-specific NHS cost estimates, or is due to changes in treatment methods for stroke since the early 1990s that have reduced the financial burden to the NHS.

The National Audit Office (NAO) estimated that the direct cost of overweight and obesity to the NHS in 2002 was £1.1 billion.²⁹ This figure provided a baseline value for simulations of obesity costs in the Foresight project.³⁰ It is considerably lower than the equivalent reported in this paper, mainly due to the counterfactuals used in the two analyses (BMI = 25 for the NAO report, BMI = 21 here). The cabinet office estimated that population meeting national nutritional guidelines would provide health benefits of £19.9 billion each year in quality-adjusted life years (QALYs).³¹ Our estimate is much lower but does not put an economic value on QALYs. The *Game Plan*³² estimated that the total cost of physical inactivity is £1.9 billion per annum (£0.3 billion NHS, £0.8 billion work absence and £0.8 billion early mortality)—direct cost to the NHS was higher in our estimate of £0.9 billion, although the authors of *Game Plan* suggested that the cost to the NHS may be as high as £1.7 billion per annum. Previous estimates of the cost of alcohol consumption to the NHS^{33–35} ranged from £1.4 to £1.7 billion (2.5% of total NHS cost) for England and £95.6 million for Scotland (9% of total NHS cost). Our cost estimate is between these two estimates when judged as a proportion of NHS costs (4%). Our updated

estimates of the cost of smoking was £3.3 billion while Parrott *et al.*,³⁶ estimated the cost to be around £1.4 billion in the UK in 1991, and Buck *et al.*,³⁷ estimated it to be £1.4–1.7 billion in the UK in the same year, but comparisons with our estimate are hampered by a 15 year gap between the studies.

The methods used to develop the estimates in this paper rely on the PAFs calculated by the WHO.^{5,38,39} These PAFs are based on broad WHO regions (specifically the EUR-A region of developed European countries with very low child and adult mortality) and as such they may not accurately represent the picture in the UK. PAFs must take account of the underlying prevalence of a risk factor within a population (since, for example, in a population with zero smokers, none of the ischaemic heart disease could be attributable to smoking), and the use of WHO regional PAFs will therefore affect the accuracy of these estimates. This limitation has been addressed by a sensitivity analysis, which suggests that using EUR-A PAFs for the UK has very little impact on the estimated costs for alcohol consumption, physical inactivity and overweight/obesity, but the results for smoking are more sensitive to this assumption. This is almost entirely due to differences in male smoking rates—the WHO estimates the prevalence of male smoking in the EUR-A region to be 37% compared with only 23% in the UK.²⁵ This suggests that the cost of alcohol consumption in the UK may be higher than the cost of smoking, and this should be considered when using these results to prioritize public health issues in the UK. A separate but related issue is the uncertainty that accompanies these estimates of the cost of risk factors in the UK regarding the PAFs and the use of cause-specific NHS cost estimates. The WHO suggests that the uncertainty associated

with the PAFs for physical inactivity, smoking and alcohol consumption is $\pm 10\%$, whereas the uncertainty for the overweight/obesity PAF is about $\pm 3\%$.²¹ The uncertainty of cause-specific NHS cost estimates provides a significant limitation of the estimates presented here.

A further limitation is that the range of diseases associated with each risk factor was taken to be those for which the WHO has calculated a PAF, although there are possibly other additional conditions associated with these risk factors (e.g. physical activity and depression).⁴⁰ The possible overlap between risk factors (such as overweight and obesity) was not addressed here but should be considered when calculating the total economic burden of these risk factors.

This study developed a well-established methodology^{10–14} by updating cost data by disease category from 1992–93 to 2006–07. The resultant estimates of the cost of risk factors are directly comparable, based on recent financial estimates and can easily be repeated in future years. This updated comparison of costs should help policy-makers to prioritize resource allocation and make effective use of limited NHS resources.

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