Public Health Research Consortium

An economic model of adult smoking related costs and consequences for England

- Smoking is a major avoidable cause of morbidity and mortality in the UK, with smoking related deaths estimated at over 100,000 per year.

- In 2005, the direct annual cost to the NHS in England due to smoking related conditions was estimated to be £4.4 billion, which was equal to 6.5% of the total health care budget for England.

- Few attempts have been made to model the long-term costs and health consequences of smoking. There is a clear need for a model for England based on population-specific data.

- The model developed for this project uses a cohort of non-smokers, smokers and ex-smokers to estimate lifetime health care costs and health consequences for the population of England.

- The model shows that smoking is associated with increased lifetime health care costs and reduced life-years lived. Smoking cessation reduces the costs of health resource use as the number of years since quitting increase. Moreover, smoking cessation results in significant gain in life years due to reduced morbidity and mortality.

- These benefits in health consequences will result in significant cost savings for the NHS.

- The model can be used to evaluate cost-effectiveness of health care interventions aimed at improving smoking cessation and reducing smoking uptake.

Background

Smoking is a major avoidable cause of morbidity and mortality in the UK, with smoking related deaths estimated at over 100,000 per year. In 2005, the direct annual cost to the NHS in the UK due to smoking related conditions was estimated to be £5.2 billion. The costs were highest in England (£4398.9m, equal to 6.5% of the total health care budget for England), followed by Scotland (£409.4m), Wales (£234.2m) and Northern Ireland (£127.9m).

The burden of illness of smoking can primarily be attributed to increased risk of illnesses including myocardial infarction (MI), stroke, chronic obstructive pulmonary diseases (COPD), and lung cancer.

The aims of the study were to conduct a literature review of the economic models of adult smoking, and develop a *de novo* economic model of adult smoking for England.

This short report presents the findings of a literature review of cost models, and the methodology and results of the economic model of smoking cessation. Full details of the review methods and model design can be found on the PHRC website (www.york.ac.uk/phrc/).

Review of economic models

A review was undertaken to identify studies using economic models to estimate the cost of adult smoking in the population. Studies using only health outcomes without applying costs were omitted from the review.

Few attempts have been made to model population level lifetime costs and outcomes of smoking using longer term cohort models. Despite the numerous static models which apply smoking attributable risk fractions to annual costs to derive point estimates, longer term health care costs and health consequences have often been neglected. Moreover, modelling frameworks based on crude and static application of non-disease-specific smoking-attributable risk tend to produce short-term static estimations of costs and outcomes that are prone to confounding.

The dearth of long term cost and outcomes models may be due to a range of factors, such as disease and cost data limitations, uncertainty over the timeframe over which to project these costs, disagreements over which diseases to include in the modelling exercises, and most importantly, the complexity of modelling disease pathways for multiple conditions associated with smoking. These models are particularly data intensive, requiring demographic, smoking prevalence, disease and cost information. Much of this information is not routinely available and needs to be modelled to generate data in the form that can be used to estimate these long term costs of smoking.

The projection of health care costs over the lifetime of individuals also has the potential to magnify any errors in the attribution of diseases to smoking, faced with uncertainties in the parameter estimates used to drive the model. Further complexities arise with other causal factors linked with smoking, making it difficult to attribute the causal factor entirely and exclusively to smoking. There is also disagreement over the discount rate to apply to longer term costs, with rates of between zero and 10% evident in the literature. Whilst NICE guidance recommends a 3.5% rate, this is not universally accepted, hence making the presentation of results difficult to generalise and interpret without extensive sensitivity analysis.

The review highlights the need for a long-term economic model to estimate lifetime costs and health consequences associated with smoking and the benefits of smoking cessation. The model should take account of dynamic attributes, including age, gender and years of smoking cessation, that are directly related to clinical events. Moreover, there is a need for a model that is specific for the context of England and is based on population-specific epidemiological data.

Developing the economic model

A population-based cohort model was developed that uses a Markov framework to evaluate lifetime impact of continued smoking and smoking cessation. The model explicitly evaluates four smoking-related conditions, i.e. myocardial infarction, stroke, chronic obstructive pulmonary disease and lung cancer. These conditions

are known to have the highest economic and health related consequences associated with smoking. The model also incorporates higher smoking-related risk of mortality due to conditions other than the four diseases modelled explicitly.

Lifetime costs and health consequences were modelled for three population groups: never smokers, current smokers and ex-smokers. The probability of events in the latter two groups was modelled using relative risk estimates from the published literature. Risk reduction in ex-smokers was modelled as a function of time since quitting smoking, age and gender.

The results are presented as direct health care costs and cost savings and life years lost/gained during the lifetime of a cohort of 1,000 individuals in the population. The cohort entered the model at the age of 35 years; individuals were assumed to be healthy (free from the four smoking-related diseases) and were followed until death or until they reached the age of 100 years, whichever occurred first.

The model runs separately for men and women and estimates costs for each smoking-related group and the cost savings and life years gained associated with smoking cessation at varying cessation rates. Costs and life years gained were discounted at the rate of 3.5% to account for the preference for present over future.

Key findings

The results estimate that the difference between current smokers and non-smokers in lifetime direct health care costs for a cohort of 1,000 men is £8.6 million (not discounted) or £4.1 million (discounted at 3.5%). For a similar cohort of women, the cost difference was £7.8 million (not discounted) or £3.1 million (discounted).

The model further estimates that the lifetime health care cost savings from smoking cessation for a cohort of 1,000 men (35 year old) are £4.9 million (not discounted) or £2.6 million (discounted). The cost savings for a comparable cohort of women are £4.8 million (not discounted) or £2.1 million (discounted). The model also estimates shorter-term cost savings after 10 and 20 years of cessation which are substantially smaller than lifetime cost savings.

The impact of varying smoking cessation rates on lifetime health care cost savings for a cohort of 1,000 individuals was also investigated.

5% cessation rate (i.e. 50 individuals quit)(men: £246,320; women: £241,365)

10% cessation rate
(men: £492,640; women: £482,730)

20% cessation rate
(men: £985,280; women: £965,459)

30% cessation rate
(men: £1,477,919; women: £1,448,189),

40% cessation rate
(men: £1,970,559; women: £1,930,919)

50% cessation rate
(men: £2,463,199; women: £2,413,649).

The distribution of the costs associated with each of the four smoking-related conditions was explicitly modelled. The results suggest that the greatest cost savings for both men and women after smoking cessation occurs due to reduction in MI events

The model also explores the impact of continued smoking and smoking cessation on life years lived. The results predict that in a cohort of 1,000 smokers (35 year old), smoking would lead to lifetime loss of 6,610 years (undiscounted) and 1,604 years (discounted at 3.5%). Corresponding figures for a comparable cohort of females was 6,521 years (undiscounted) and 1,475 (discounted at 3.5%). The model also predicts that smoking cessation would result in life year gain of 4,262 years (undiscounted) or 1,070 years (after discounting at 3.5%) in men and 4,534 (undiscounted) or 1,046 (after discounting at 3.5%) in women for a cohort of 1,000 smokers.

The model further explores gain in life years for a range of smoking cessation rates. For instance, our model predicts that a 5% cessation rate in a cohort of 1,000 male smokers would result in a gain of 213.5 years (undiscounted) or 53.5 (discounted) years over the lifetime of the cohort. Since the fatal events averted by smoking

cessation were likely to occur in later years of life, the discounted estimates of life years gained are much smaller than the undiscounted estimates.

Based on the analysis above, the model further investigated the lifetime impact of continued smoking and smoking cessation for the current prevalent population of England (35 years old and over). The model estimates that the lifetime healthcare cost of smoking for the prevalent smoker male population of England is £23,346,713,488 (undiscounted) or £15,759,393,151 (after discounting at 3.5%). The corresponding figures for females are: £21,418,726,434 and £13,233,295,694. The model further estimates that the total potential lifetime cost savings that can be achieved if all current smokers in England quit smoking are equal to £11,488,311,471 (men, undiscounted), £8,483,900,719 (men, discounted), £11,804,906,335 (women, undiscounted) and £7,681,536,736 (women, discounted). Therefore, if 1% of the total prevalent smoker population of England were to quit smoking, the total lifetime cost savings would be equal to £232,932,178 (undiscounted) and £161,654,375 (discounted at 3.5%).

Conclusions

There is a dearth of economic models that estimate long-term impact of continued smoking and smoking cessation on population cohorts. The economic model developed for this study estimates the lifetime health care costs and consequences of adult smoking and the benefits of cessation for the population of England.

The model has some limitations. Decision analytic models inevitably make certain assumptions and have to be selective with respect to the pathways modelled and the costs and consequences captured. However, we note that the results of the model may underestimate cost savings and life year gains because the model does not allow concurrent pathway progression for the four conditions explicitly modelled. Also, because the model primarily focuses on four most common smoking-related conditions, it is likely to produce conservative estimates of the overall benefits of quitting. One should also note that the model evaluates only the direct impact of smoking and ignores the environmental effect of passive smoking. However, the current model can be extended to include evidence on additional benefits of smoking cessation.

The economic model presented here can be used as a decision tool by policy-makers who will be able to predict the impact of smoking cessation and prevention interventions in terms of cost savings and life years saved. Moreover, the modelling framework has the potential to be adapted to accommodate evidence from smoking cessation trials to predict long-term costs and consequences of cessation strategies. Finally, the model has the flexibility to accommodate, at a later stage, any epidemiological changes in the underlying incidence and prevalence rates and the risk of morbidity and mortality in the population of interest.

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About PHRC: The Public Health Research Consortium (PHRC) is funded by the Department of Health Policy Research Programme. The PHRC brings together researchers from 11 UK institutions and aims to strengthen the evidence base for public health, with a strong emphasis on tackling socioeconomic inequalities in health. For more information, visit: www.york.ac.uk/phrc/index.htm