Increases in taxation to reduce population smoking rates

Matrix Insight, in collaboration with Imperial College London, Kings College London and Bazian Ltd, were commissioned by Health England to undertake a research study to develop and apply a method for prioritising investments in preventative interventions for England. Seventeen preventative health interventions were included in the study. Each intervention was evaluated in terms of the following criteria: reach; inequality score; cost-effectiveness; and affordability. This report presents the results of the analysis for one of the interventions: increases in taxation to reduce population smoking rates. The full report of the study is available from the ***H.E.L.P.*** website.

Summary

Description of the intervention
A 5% increase in cigarette tax.

Criteria	Measure	Value	Certainty
1. Reach			
Percentage of population affected by the condition and that could potentially benefit from the intervention.	Adult smokers as a percentage of the population aged 15 and above in England (Office for National Statistics, 2009)	22.30%	★★★
2. Inequality score			
Ratio of the percentage of disadvantaged population to the percentage of the general population that could potentially benefit from the intervention.	Ratio of percentage of adult smokers in routine and manual occupations to percentage of smokers in the general population (Office for National Statistics, 2009)	1.55	★★
3. Cost-effectiveness			
Cost of the intervention per QALY gained (in £2007/08)	See cost-effectiveness	£0	★
Net cost of the intervention per QALY gained (in £2007/08)	See cost-effectiveness	-£3,320	★★
Timing of benefits	QALY gain and cost savings are estimated to occur in the long-run (5 years or more after the intervention).		
4. Affordability			
Total cost of implementing the intervention at the national level	Multiple of eligible individuals and unit cost of the intervention	Less than £100 million	★★★

Key to certainty grading scales

★ Low quality evidence

★★ Medium quality evidence

★★★ High quality evidence

Box 1. Cost per QALY gained

A quality adjusted life year (QALY) is a simple way of combining quality of life with length of life. One QALY is equivalent to one year in full health. The cost per QALY gained is therefore the cost of achieving one extra year of full health. Its calculation is based on the following formula:

$$cost\ per\ QALY\ gained = \frac{incremental\ cost\ of\ intervention}{QALYs\ gained}$$

The net cost per QALY gained is the cost per QALY considering the incremental cost of the intervention as well as the cost saved through health treatment avoided. Its calculation is based on the following formula:

$$net\ cost\ per\ QALY\ gained = \frac{incremental\ cost\ of\ intervention - cost\ savings}{QALYs\ gained}$$

Cost effectiveness

Cost. A 5% increase in cigarette tax is assumed to have no cost from a societal point of view. This assumption is based on the fact that the average administrative cost of taxes is very low less than 1% of revenue (Shaw et al, 2008) and that the marginal administrative cost associated with a cigarette tax increase is likely to be negligible.

Effect. Compared to current tax level (326% according to the Tobacco Manufacturers' Association), a 5% cigarette tax increment increases the quit rate by 0.11 per cent. This effect was obtained from a review undertaken to identify evidence on the effectiveness and cost-effectiveness of smoking cessation interventions.

Benefits. The benefits of the intervention derive from stopping individuals smoking. Two types of benefits are considered: QALYs and health care cost savings.[1] Based on the QALYs gained and the health care cost savings of quitting smoking, a 0.12 per cent increase in the quit rate is associated with the following benefits:

- An additional 0.001 QALYs per person
- Cost savings of £5.8 per person (£2007/08)

Please refer to decision model for details on how the QALY gain and cost savings were calculated.

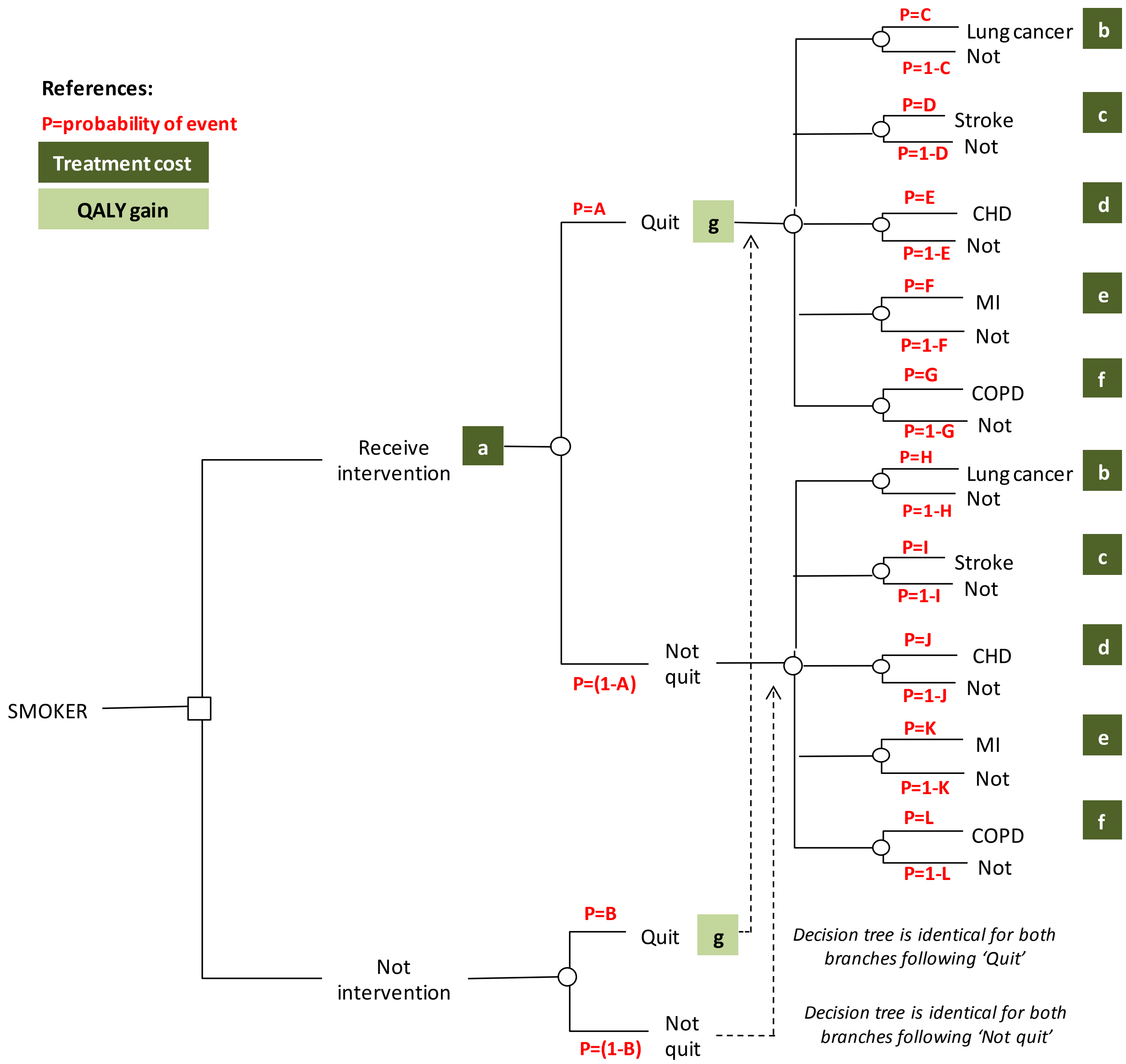
[1] Cost associated with increased life expectancy resulting from the intervention –such as pensions and health care costs– are not included in the analysis.

Decision model

An economic model was built to estimate the cost-effectiveness of the intervention. The model estimates the QALY gain and cost savings associated with the intervention. Figure 1 illustrates the structure of the model, which is based on the following assumptions:

- The effect of the intervention is given by a change in the chances of an individual's quitting smoking.
- Individuals receiving the intervention are assumed to be 45 years old on average.
- Smoking is assumed to be associated with five diseases: lung cancer, stroke, coronary heart diseases (CHD), myocardial infarction (MI) and chronic obstructive pulmonary disease (COPD). These diseases have impacts in terms of quality of life and health care costs.
- The probabilities of experiencing these diseases vary for smokers and former smokers. Former smokers have reduced probabilities of experiencing the diseases. Thus, quitting smoking reduces the probability of experiencing these diseases and produces corresponding improvements in quality of life and health care cost savings.

Figure 1. Smoking cessation model



Unless stated otherwise, the analysis was undertaken in accordance with H.M. Treasury's Green Book (HM Treasury, 2003). Specifically:

- Any costs and effects incurred more than one year after the intervention were discounted at 3.5%.
- Where necessary monetary values were converted in 2007/8 prices using Gross Domestic Product (GDP) deflators (HM Treasury, 2008).
- Where necessary monetary values were converted into pounds sterling using: www.x-rates.com

The model draws the following estimates from the literature:

- The unit cost of the intervention (Table 1).
- The effect of the intervention on people's smoking behaviour (Table 1).
- The probabilities that those who smoke experience diseases (Table 2).
- The probabilities that those who don't smoke experience diseases (Table 2).
- The impact of experiencing diseases on quality of life, measured in QALYs (Table 3).
- The impact of experiencing diseases on health care treatment costs (Table 3).

Table 1. Intervention costs and effects (monetary values in £2007/08)

Ref	Description	Value	Calculation and source
a	Cost of intervention	£0	This assumption is based on the fact that the average administrative cost of taxes is very low (always less than 1% of revenue, Shaw et al 2008 p.27) and that the marginal administrative cost associated with a cigarette tax increase is likely to be negligible.
A	P(if intervention, 12-month quit)	0.0011	Based on the price of a 20 cigarette pack (£5.39; average for 2007/08, Tobacco Manufacturers' Association), a 5% tax increase is equivalent to a 0.97% price increase. The corresponding reduction in prevalence is therefore 0.11%. This is the result of multiplying 0.97 times the 1% price prevalence elasticity (0.12%). The price prevalence elasticity was calculated as the simple average prevalence elasticity for men (-0.0008 -not significantly different from zero, thus assumed zero) and women (-0.0023 -significantly different from zero, $p<0.05$) based on Townsend et al (1994). Prevalence elasticity estimates are based on a multiple regression analysis of how the smoking patterns of different socioeconomic and age groups were influenced by price, income, and a factor representing the net effects of health publicity and other social trends including social acceptability and restrictions in workplace and public places. See evidence review for further details.
B	P(if no intervention, 12-month quit)	0.0000	This is set to zero given that prevalence elasticity provides an estimate of the reduction in prevalence associated with a price increase, while controlling for other factors influencing prevalence of smoking.

Table 2. Transition probabilities

Ref	Description	Value	Calculation and source
The probability of contracting the disease for (former) smokers was assumed to be equivalent to the average prevalence of the disease among (former) smokers. These were calculated for three different age groups: 55 to 64, 65 to 74, and 75 and older. The following formula was used in the calculation: $D = \frac{x}{t} \cdot D_x \cdot RR_x + \frac{y}{t} \cdot D_x \cdot RR_y + \frac{z}{t} \cdot D_x \cdot RR_z$ where: D = prevalence of disease; RR = relative risk of contracting the disease; x = non-smokers; y = former smokers; z = smokers.; and t = total population.			
C	P(if smoker, lung cancer) by age group	0.0045 0.0297 0.0329	These were obtained by applying the following parameters to the above formula: ▪ Prevalence of the disease in the total population by age group (D=0.0015; D=0.008; D=0.008). ▪ Relative risk of lung cancer among men (RR smokers=1; RR former smokers=0.44; RR non-smokers=0.03) and women (RR smokers=1; RR former smokers=0.21; RR non-smokers=0.05). ▪ Proportion of smokers in the general population by age group (z/t=0.195; z/t= 0.116; z/t=0.08). ▪ Proportion of former smokers in the general population by age group (y/t=0.367; y/t=0.419; y/t=0.469). All data refers to the UK (Flack et al, 2007).
H	P(if former smoker, lung) cancer) by age group	0.0014 0.0087 0.0095	
D	P(if smoker, stroke) by age group	0.0272 0.0961 0.1684	These were obtained by applying the following parameters to the above formula: ▪ Prevalence of the disease in the total population aged 65 to 74 years old (D=0.022; D=0.076; D=0.133). ▪ Relative risk of stroke (RR smokers=1.37; RR former smokers=1.11; RR non-smokers=1). ▪ Proportion of smokers in the general population by age group (z/t=0.195; z/t= 0.116; z/t=0.08). ▪ Proportion of former smokers in the general population by age group (y/t=0.367; y/t=0.419; y/t=0.469). All data refers to the UK (Flack et al, 2007).
I	P(if former smoker, stroke) by age group	0.0220 0.0778 0.1365	
E	P(if smoker, CHD) by age group	0.2149 0.4564 0.5771	These were obtained by applying the following parameters to the above formula: ▪ Prevalence of the disease in the total population aged 65 to 74 years old (D=0.111; D=0.215; D=0.264). ▪ Relative risk of CHD (RR smokers=3.12; RR former smokers=1.55; RR non-smokers=1).

Ref	Description	Value	Calculation and source
J	P(if former smoker, CHD) by age group	0.1068 0.2267 0.2867	▪ Proportion of smokers in the general population by age group (z/t=0.195; z/t= 0.116; z/t=0.08). ▪ Proportion of former smokers in the general population by age group (y/t=0.367; y/t=0.419; y/t=0.469). All data refers to the UK (Flack et al, 2007).
F	P(if smoker, myocardial infarction) by age group	0.0854 0.1644 0.1694	These were obtained by applying the following parameters to the above formula: ▪ Prevalence of the disease in the total population aged 65 to 74 years old (D=0.067; D=0.121; D=0.121). ▪ Relative risk of MI among men (RR smokers=1.6; RR former smokers=1.11; RR non-smokers=1) and women (RR smokers=2.76; RR former smokers=1.05; RR non-smokers=1). ▪ Proportion of smokers in the general population by age group (z/t=0.195; z/t= 0.116; z/t=0.08). ▪ Proportion of former smokers in the general population by age group (y/t=0.367; y/t=0.419; y/t=0.469). All data refers to the UK (Flack et al, 2007).
K	P(if former smoker, myocardial infarction) by age group	0.0592 0.1141 0.1175	
G	P(if smoker, COPD) by age group	0.0114 0.0578 0.1152	These were obtained by applying the following parameters to the above formula: ▪ Prevalence of the disease in the total population aged 65 to 74 years old (D=0.01; D=0.05; D=0.10). ▪ Relative risk of COPD among men (RR smokers=1; RR former smokers=0.84; RR non-smokers=0.68) and women (RR smokers=1; RR former smokers=0.96; RR non-smokers=0.92). ▪ Proportion of smokers in the general population by age group (z/t=0.195; z/t= 0.116; z/t=0.08). ▪ Proportion of former smokers in the general population by age group (y/t=0.367; y/t=0.419; y/t=0.469). All data refers to the UK (Flack et al, 2007).
L	P(if former smoker, COPD) by age group	0.0103 0.0519 0.1034	

Table 3. Associated outcomes (monetary values in £2007/08)

Ref	Outcome	Value	Calculation and source
All lifetime treatment cost calculations were based on the present value of the annual treatment cost through the expected duration of the disease. The duration of the disease was assumed to be given by the difference between the average onset and mortality ages for the disease. Three possible onset ages were considered: 60, 70 and 80 years old. Total treatment costs were discounted to the age of individuals receiving the intervention, which was assumed 45 years old, at a 3.5% annual rate.			

Ref	Outcome	Value	Calculation and source
b	Lung cancer treatment cost by onset age of disease	£4,923 £3,490 £2,474	The annual treatment of lung cancer cost was estimated by Flack et al (2007) at £5,742 (in £2007/08). The mortality age was assumed to be equal to that for colon cancer and to increase with the onset age of the disease. As reported by Matrix (2006), the mortality ages assumed are: 64, 74 and 86 years old.
c	Stroke treatment cost by onset age of disease	£4,905 £2,101 £2,187	The annual treatment cost was estimated by Matrix (2006) at £2,194 (in £2007/08) based on data from the Department of Health. The average mortality was assumed to increase with the onset age of the disease. As reported by Matrix (2006), the mortality ages assumed are: 64, 72 and 84 years old.
d	CHD treatment cost by onset age of disease	£7,182 £4,547 £2,809	The annual treatment cost was estimated by Matrix (2006) at £1,511 (in £2007/08) based on data from the British Heart Foundation. The average mortality was assumed to increase with the onset age of the disease. As reported by Matrix (2006), the mortality ages assumed are: 72, 78 and 87 years old.
e	Myocardial infarction treatment cost by onset age of disease	£10,790 £6,831 £4,221	The annual treatment cost was estimated by Flack et al (2007) at £2,270 (in £2007/08) based on data from the Department of Health and the Health and Social Care Information Centre. The mortality age was assumed to be equal to that for CHD and to increase with the onset age of the disease. As reported by Matrix (2006), the mortality ages assumed are: 72, 78 and 87 years old.
f	COPD treatment cost by onset age of disease	£4,594 £2,908 £1,797	The annual treatment cost was estimated by Flack et al (2007) at £967 (in £2007/08) based on data from the National Clinical Guideline on Management of COPD. The mortality age was assumed to be equal to that for CHD and to increase with the onset age of the disease. As reported by Matrix (2006), the mortality ages assumed are: 72, 78 and 87 years old.
g	QALYs: 12 month quit	1.29	This is the number of QALYs gained associated with lifetime quitting based on the number of quitters at 12 months. It was estimated by Fiscella and Franks (1996) using the results from the Healthy People 2000 Years of Healthy Life research project (US). It implicitly assumes a 35% relapse rate.

Effectiveness evidence

A literature review was undertaken by Bazian to identify evidence on the effectiveness and cost-effectiveness of increases in taxation to reduce population smoking rates. Further details are available on the evidence methods page of the ***H.E.L.P.*** website.

The review of the evidence on the effectiveness of increases in taxation to reduce population smoking rates identified three econometric studies. Table 4 provides the following details of the studies identified:

- Population
- Intervention
- Results

Table 5 provides a quality assessment of the effectiveness and cost-effectiveness studies. Further details are available on the quality appraisal methods page.

The following criteria were applied to select effectiveness evidence for undertaking the economic analysis:

- Location. Studies from the UK were preferred over studies from other locations.
- Population. Studies applied to the general population were preferred over studies applied to restricted population groups (e.g. pregnant women; individuals from specific communities/nationalities).
- Counterfactual. Studies for which the counterfactual intervention was ‘usual care’ or ‘do nothing’ in a UK setting were preferred over studies for which the counterfactual was different from ‘usual care’ or ‘do nothing’.
- Method. Studies using more rigorous design methods (e.g. randomised control trials or quasi experimental designs with regression models controlling for confounders) were preferred over studies using less rigorous design methods (e.g. before-after studies or simple correlation analysis).

Table 4. Effectiveness of increases in taxation to reduce population smoking rates

Study reference	Population	Intervention	Results
Comprehensive systematic review undertaken as part of CRD report 39. 3 of 42 studies assessing effect of price or taxation on smoking outcomes were set in the UK. These are extracted here.			
Borren et al, 1992; UK ▪ econometric study	Participants in Tobacco Advisory council surveys between 1961 and 1987	Average weekly cigarette consumption from Tobacco Advisory Council surveys (1961 - 1987). Consumption by social class for men was estimated from published data and results from Townsend. For women, only years with available consumption by class data were used and estimated as if it were cross-sectional data. Cigarette price data were obtained by dividing expenditure at current prices by that at 1980 prices, then deflating by an all items price index. Personal disposable income data was from the Monthly Digest of Statistics. A single equation time-series model assuming demand is log linear; separate equations by socioeconomic group and gender. Wald tests used to compare price elasticities between social classes.	Price elasticity (stratified by socioeconomic class and gender) ▪ Men – 1: -0.69 ($p<0.05$) – 2: -0.48 ($p<0.05$) – 3: -0.84 ($p<0.01$) – 4: -0.89 ($p<0.01$) – 5: -0.31 ▪ Women – 1: -1.04 ($p<0.01$) – 2: -0.93 ($p<0.01$) – 3: -0.65 ($p<0.01$) – 4: -0.85 ($p<0.01$) – 5: -0.45 ($p<0.05$)

Study reference	Population	Intervention	Results
Townsend et al, 1987; UK ▪ econometric study	Participants in Tobacco Advisory council surveys between 1961 and 1977; 10,000 adults.	Tobacco Research Council (1961 to 1977) annual data on cigarette consumption by social class (data inflated to agree with sales data and eradicate bias). Average incomes of professional, management, clerical and manual workers from Family Expenditure Survey (1960 to 1977). Economic data from UK National Income and Expenditure Yearbook (1982). Single equation time-series model assuming demand is log linear; separate equations for each socioeconomic group.	Price elasticity, men only (stratified by socioeconomic group) ▪ 1: 0.15 ▪ 2: -0.34 ▪ 3: -0.54 ▪ 4: -0.87 ▪ 5: -1.26 (none were significant at the 5% level)

Study reference	Population	Intervention	Results
Townsend et al, 1994; UK ▪ econometric study	Participants in British General Household survey (1972-1990)	British General Household Survey (1972-1990), giving biennial data on proportion of adults smoking >1 cigarette per day and numbers smoked per smoker. Annual national disposable income and cigarette prices were from the national income and expenditure accounts. National income was divided by the population and deflated by the RPI to give real per capita income. Multiple regression model assuming that demand is log linear. Separate equations fitted by sex for each socioeconomic and age group.	Price elasticity (SE), by gender and by socioeconomic group ▪ Men – All: -0.47 (0.19); p<0.05 – I: 0.03 (0.42) – II: -0.12 (0.32) – III non-manual: -0.67 (0.24); p<0.05 – III manual: -0.49 (0.19); p<0.05 – IV: -0.47 (0.17); p<0.05 – V: -1.02 (0.31); p<0.05 ▪ Women – All: -0.014 (0.006); p<0.05 – I: -0.06 (0.02); p<0.05 – II: -0.05 (0.01); p<0.01 – III non-manual: -0.02 (0.01) – III manual: -0.01 (0.01) – IV: 0.01 (0.01) – V: 0.02 (0.02)

Table 5. Quality assessment for econometric studies

Study reference	QA for econometric studies				Score	Grading (++ 4-5; + 3; -0-2)
	Reports statistical assumptions?	Adequate sample size?	Strategies to minimise bias and conf?	Unambiguous direction of causality?		
Borren, 1992; UK	Yes	Yes	Yes	Yes (time series study)	4	++
Townsend, 1987; UK	Yes	No (critique by Borren)	Yes	Yes(time series study)	3	++
Townsend, 1994; UK	Yes	Don't know	Yes	Yes (time series study)	3	++

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