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NATIONAL INSTITUTE FOR HEALTH AND CLINICAL EXCELLENCE

Economic Analysis of Interventions for Smoking Cessation Aimed at Pregnant Women

Supplementary Report

Update information

November 2021: NICE guideline PH26 (June 2010) has been updated and replaced by NG209.

This guideline contains the evidence and committee discussion for recommendations from PH26 dated [2010] and [2010, amended 2021].

See www.nice.org.uk/guidance/NG209 for all the current recommendations and the evidence behind them.

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C O N S O R T I U M

Contents

Section 1: Methods

1.1 BACKGROUND

This supplementary report aims to investigate the impact of seven potential interventions to promote smoking cessation for pregnant women. The outputs are reported in terms of the cost and QALY consequences of each approach.

Seven alternative approaches were considered in the analysis:

- No intervention;
- Cognitive behaviour strategies;
- Stages of change;
- Feedback;
- Rewards;
- Pharmacotherapies;
- 'Other' interventions.

In each case, the total costs and health outcomes were calculated in order to allow a cost-effectiveness analysis to be undertaken.

To calculate the cost implications of smoking whilst pregnant, the following steps were taken:

- The lifetime healthcare costs associated with a woman who is a smoker were calculated (allowing for the effectiveness of the intervention);
- Additional costs associated with the infant were calculated;
- The above costs were summed to give a total cost.

The health benefits (i.e. quality-adjusted life years (QALYs)) were also estimated. These were calculated by summing the health benefits of both the mother and the child. Smoking whilst pregnant has implications for the infant in terms of:

- Higher rates of sudden unexpected death in infancy (SUDI);
- Higher rates of mortality;
- Breathing difficulties;
- Prematurity;
- Smaller birth weight;
- Smaller stature when older;
- Slower growth and head circumference;
- Learning difficulties, hyperactivity and behavioural problems;
- Lower IQ.

Smoking whilst pregnant also increases the probability of neonatal death. An intervention that reduces the number of smokers will, therefore, lead to reduction in infant deaths. The number of deaths averted as a result of each intervention were calculated and used to derivethe associated gain in quality-adjusted life years (QALYs).

1.2 COSTS AND BENEFITS ASSOCIATED WITH THE PREGNANT WOMAN

1.2.1 Additional Cost of Smoking for a Woman who is Pregnant

A previously published model was used to calculate the cost implications associated with each intervention, based on its rate of effectiveness. The model was run using female- specific data. The reader is referred to the previous report for a full description of the model[1].

The model used in this further analysis compares different smoking cessation interventions to determine their incremental cost-effectiveness. The interventions modelled in this analysis are different from those used in the main report and focus on interventions aimed specifically at pregnant women.

A hypothetical cohort of 1,000 pregnant smokers has been modelled in six-monthly cycles over their entire lifetime.

As in the original model, during each cycle smokers could either quit (become former smokers), remain smokers or die; and former smokers could either relapse (become smokers), remain as quitters or die.

Each cycle, smokers and former smokers face a probability of five co-morbidities included:

- Lung cancer;
- Coronary heart disease (CHD);
- COPD;
- Myocardial infarction (MI);
- Stroke.

There are a number of further co-morbidities associated with being pregnant, namely:

- Ectopic pregnancies;
- Placenta praevia;
- Premature separation of the placenta;
- Pre-eclampsia.

The probability of developing these additional co-morbidities is increased if the woman smokes during pregnancy, see Table 1.1 [3]. However, a search of the literature failed to

[1] Flack S, Taylor M & Trueman P. *Cost-Effectiveness of Interventions for Smoking Cessation*. Report to NICE, 2007.

identify the extent to which these co-morbidities would impact upon the mother's utilityand/or associated costs. The pregnancy-specific co-morbidities have, therefore, been excluded from the model. As such, this exclusion will lead to an underestimation of the true cost and QALYs lost associated with smoking whilst pregnant.

1.3 COSTS AND BENEFITS ASSOCIATED WITH THE INFANT

1.3.1 Additional Costs Associated with Children of Smoking Mothers

Petrou *et al.* 2005 [2] carried out a comprehensive assessment of the long term economic consequences of maternal smoking during pregnancy. The study used data from the Oxford Record Linkage Study (ORLS), which is a collection of linked birth and death certificates and statistical abstracts (NHS inpatient and day cases). The study period was the 1st January 1980 to the 31st December 1989. 120,106 infants were born during the study period, of which 119,028 were born alive. Information on maternal smoking and resource utilisation were available for 101,332 (85.1%) of the infants and are shown in Table 1.2. To calculate the additional costs associated with children whose mothers smoked during pregnancy the authors summed together the total hospital stay for each infant (for each admission, regardless of diagnosis) and multiplied this by the *per diem* cost of the relevant speciality, during:

- The first year of life;
- The first five years of life.

The reasons for admission were not provided in the study. However, the authors do report that children of mothers who smoke are more likely to be admitted as a result of a broad range of conditions and disease in addition to "admissions directly attributable to intrauterine growth restriction, low birth weight, preterm delivery and respiratory illness". As such, it was assumed that these costs were reflective of all the additional costs associated with smoking during pregnancy.

The Health Survey for England 2004[2] reports that 27% of women aged 16 to 54 aresmokers. 7% of **all** women are light smokers (fewer than 10 per day), 10% are medium smokers (10 to 19 per day) and 6% are heavy smokers (20 or more per day). Due to lack of data it has been assumed that these figures are the same for all pregnant women aged 16 to 44[3]. The above information was used to calculate the weighted cost associated with children whose mothers smoked during pregnancy and only affects the weighted average in Table 1.2.

77% of all conceptions result in a live birth (http://www.statistics.gov.uk/downloads/theme_population/PopulationTrends128.pdf [4]). The 77% was calculated by dividing the number of births by the number of conceptions, in 2005 (the most recent available date with data):

[2] http://www.dh.gov.uk/en/Publicationsandstatistics/PublishedSurvey/HealthSurveyForEngland/index.htm

645,800 (page 56)
837,400 (page 59)

It has been assumed that the woman receives the smoking cessation intervention at or soon after conception and before the loss of any fetus.

Table 1.2: Additional hospitalisation costs associated with children whose mothers smoked during pregnancy

	Mean additional cost due to smoking
First year of life:	
1-9 cigarettes per day compared to no smokers	£103.52
10-19 cigarettes per day compared to no smokers	£214.52
Heaviest smoker compared to no smokers	£374.17
Weighted average	£223.54
First five years of life:	
1-9 cigarettes per day compared to no smokers	£172.12
10-19 cigarettes per day compared to no smokers	£382.90
Heaviest smoker compared to no smokers	£576.22
Weighted average	£370.90

1.3.2 QALY gains for the infant

The gains in QALYs associated with each smoking cessation intervention were calculated using the following formula:

$$QALY\ gains = Deaths\ averted \times expected\ lifetime\ QALYs$$

Deaths averted

During the first four weeks following birth the neonatal death rate is 3.5 per 1,000 live births, for the population as a whole [4]. The probability of death for the child of a non-smoker was calculated using the following equation:

$$Death(non\text{-}smoker) = \frac{Death(population)}{(1.4xS)+N}$$

Where:

Death(non-smoker) = probability death for a non-smoker
Death(population) = probability of death for the population as a whole
S= Percentage who are smokers
N= Percentage who are non-smokers

The probability of death for a non-smoker is increased by 40% if the mother smokes during pregnancy [3]. A smoking intervention that reduces the number of women who smoke during pregnancy will, therefore, lead to a reduction in the number of infants who die. The number of deaths averted was calculated as follows:

Deaths averted = Reduction in the number of smokers x difference in the probability of death

Where:

Reduction in the number of smokers = [(No. smokers following 'no intervention') – (No. smokers following the intervention)] x 77%[3]

Difference in the probability of death = Probability of neonatal death for a smoker – probability of neonatal death for the population as a whole

Expected lifetime QALYs

At birth an infant can expect to live for 79 years (average of the male and female life expectancy at birth) [5]. Each year of life has an associated QALY weight, which can be any value from zero (equivalent to death) to one (full health) and varies by age (see Table 1.2) [6]. These values were used to calculate the total number of QALYs an infant can expect to receive in their lifetime. The figure was calculated by multiplying the time spent in each age group by its equivalent quality of life weight.

Table 1.2: QALY weights

Age group	EQ 5D UK		
	Average	Men	Women
0-19	Assumed to be the same as the 20-29 age group		
20-29	0.901	0.91	0.892
30-39	0.881	0.897	0.864
40-49	0.837	0.854	0.82
50-59	0.801	0.816	0.785
60-69	0.767	0.786	0.747
70-79	0.713	0.736	0.689
80-89	0.667	0.711	0.622
Total number of expected QALYs	**67 (=24 after discounting at 3.5% per year)**		

Accounting for early mortality, the child of a quitting mother is likely to experience 23.56 QALYs, compared to 23.54 for the child of a non-quitting mother. This difference is purely accounted for by the total number of life years lost due to premature death. As described above, the child of a smoking mother is estimated to cost around £371 more than the child of a quitting mother.

[3] 77% of all conceptions result in a live birth [4] (i.e. not all pregnant women who participate in a smoking cessation intervention will have a baby). Therefore the results were adjusted to take account of the fact that only 77% of pregnancies result in a live birth.

1.4 EFFECTIVENESS OF INTERVENTIONS

A Cochrane review was identified that focussed on interventions for promoting smoking cessation during pregnancy[4]. This review did not investigate the costs of the interventions, but did provide evidence on the rate of smoking at the late stages of pregnancy.

Table 1.3, below, shows the effectiveness (relative risk versus control group), based on the evidence of the Cochrane review.

Table 1.3: Effectiveness of interventions

Intervention	Relative risk
No intervention	-
Cognitive behaviour strategies	95%
Stages of change	99%
Feedback	92%
Rewards	76%
Pharmacoetherapy	95%
'Other'	96%

In the Cochrane review, 9,352 of the 10,351 patients in the control groups were smoking at the late stage of pregnancy. Therefore, we used a quit rate of 9.7% for the 'no intervention' strategy. Though this rate is higher than that of the general population, it can be explained by the fact that women who are pregnant have a greater incentive to quit (i.e. neonatal health awareness, social unacceptability, *etc*.) compared to those who are no pregnant. Relative risk ratios were applied to each of the other interventions to produce the following rates of smoking at the late stage of pregnancy.

Table 1.4: Rate of smoking in late pregnancy

Intervention	Rate of smoking (late pregnancy)	Rate of smoking (after one year)
No intervention	90.3%	97.1%
Cognitive behaviour strategies	85.8%	95.7%
Stages of change	89.4%	96.8%
Feedback	83.1%	94.9%
Rewards	68.7%	90.6%
Pharmacoetherapy	85.8%	95.7%
'Other'	86.7%	96.0%

Personal communication with Peter Hajek suggests that 70% of pregnant women who stop smoking will relapse within a year. The cessation rates were adjusted to take account of this at one year (see third column).

[4] Lumley L *et al*. Intervention for promoting smoking cessation during pregnancy. Review. The Cochrane Collaboration 2009. John Wiley & Sons.

1.5 COST OF INTERVENTIONS

Costs of each intervention were calculated in order to add a 'one-off' cost to the outcomes for each person in the model. The cost of each intervention are shown in Table 1.5, below.

Table 1.5: Cost of intervention

Intervention	Cost
No intervention	£0.00
Cognitive behaviour strategies	£155.68[a]
Stages of change	£26.00 [b]
Feedback	£142.31[c]
Rewards	£52.83[d]
Pharmacoetherapy	£100.43[e]
'Other'	TBC

a Based on eight groups sessions, at £19.46 per session.
b Based on three nurse calls of 15 minutes, at a cost of £29.96 per hour. Plus cost of self help material (£3.53).
c Assumed 7 calls in the first month, with monthly calls for the next twelve months. Each call lasted 15 minutes. Assumed nurses made all calls, at £29.96 per hour.
d Based on the 'Quit to Win' campaign, costed at $78.57 (Shiplet *et al*. 1995).
e Based on the cost of nicotine replacement therapy.

Section 2: Results

2.1 RESULTS FOR THE MOTHER

The cost and health outcomes associated with each intervention (as calculated by the main cost-effectiveness model) are shown in Table 2.1, below. The incremental costs andQALYs, compared to 'no intervention' are shown in Table 2.2.

Table 2.1: Total health care costs and QALYs for the mother

Intervention	Health care costs for mother	QALYs for mother
Control	£3,186.25	16.316
Cognitive behaviour strategies	£3,159.66	16.347
Stages of change	£3,180.69	16.323
Feedback	£3,145.28	16.364
Rewards	£3,094.65	16.423
Pharmacotherapies	£3,159.66	16.347
Other	£3,164.73	16.341

Table 2.2: Incremental health care costs and QALYs for the mother

Intervention	Incremental cost	Incremental QALYs
Control	-	-
Cognitive behaviour strategies	-£26.59	0.031
Stages of change	-£5.56	0.006
Feedback	-£40.98	0.047
Rewards	-£91.60	0.106
Pharmacotherapies	-£26.59	0.031
Other	-£21.52	0.025

2.2 RESULTS FOR THE CHILD

As described in Section 1.3, children of mothers who smoked during pregnancy are likely to incur greater costs and experience fewer QALYs than those of non-smoking mothers. The results, based on the relative weighting of smokers and non-smokers during pregnancy for each intervention are shown in Table 2.3, below. Incremental results are shown in Table 2.4.

Table 2.3: Five-year health care costs and lifetime QALYs for the child

Intervention	Health care costs for child	QALYs for child
Control	£675.66	23.542
Cognitive behaviour strategies	£672.89	23.543
Stages of change	£675.10	23.542
Feedback	£671.22	23.543
Rewards	£662.35	23.546
Pharmacotherapies	£672.89	23.543
Other	£673.44	23.543

Table 2.4: Incremental health care costs and QALYs for the child

Intervention	Incremental cost	Incremental QALYs
Control	-	-
Cognitive behaviour strategies	-£2.77	0.0009
Stages of change	-£0.55	0.0002
Feedback	-£4.44	0.0014
Rewards	-£13.31	0.0043
Pharmacotherapies	-£2.77	0.0009
Other	-£2.22	0.0007

2.3 INCREMENTAL COST-EFFECTIVENESS ANALYSIS

The incremental costs and QALYs for the mother and child can be summed together to give the total benefits associated with each treatment (compared against 'no intervention'). These are shown in Table 2.5, below.

Table 2.5: Incremental health care costs and QALYs for the mother and child

Intervention	Incremental cost	Incremental QALYs
Control	-	-
Cognitive behaviour strategies	-£29.36	0.0315
Stages of change	-£6.12	0.0066
Feedback	-£45.41	0.0486
Rewards	-£104.90	0.1105
Pharmacotherapies	-£29.36	0.0315
Other	-£23.74	0.0254

It can be seen that, in all cases, the interventions are associated with a reduction in total costs and an increase in incremental QALYs. However, it should be noted that this analysis does not include the cost of the intervention itself. This is due to the level of uncertainty around the actual resources required for each intervention.

Table 2.6, below, shows the total costs (i.e. including the cost of the intervention) as well as the incremental QALYs and the incremental cost-effectiveness ratio (ICER).

Table 2.5: Incremental cost-effectiveness analysis

Intervention	Incremental cost (including intervention)	Incremental QALYs	ICER
Control	-	-	-
Cognitive behaviour strategies	£126.32	0.0315	£4,005
Stages of change	£19.88	0.0066	£3,033
Feedback	£96.90	0.0486	£1,992
Rewards	-£52.07	0.1105	Dominant
Pharmacotherapies	£71.07	0.0315	£2,253
Other	-£23.74	0.0254	Dominant

Table 2.6, below, shows the 'net benefit' associated with each intervention, based on the costs and benefits reported above. To calculate the net benefit, the monetary value of the QALYs is calculated, assuming that one QALY is worth £20,000. The cost savings are added to this figure in order to show the full money benefit of each intervention.

Table 2.6: Net benefit of each intervention (including cost of intervention)

Intervention	Net benefit
Control	-
Cognitive behaviour strategies	£505
Stages of change	£111
Feedback	£876
Rewards	£2,261
Pharmacotherapies	£560
Other	£532

In 2008, there were 708,708 live births in England and Wales[5]. Based on the fact that 77% of conceptions result in a live birth, we can infer that there were a total of 920,400 conceptions. We also know that 27% of women of childbearing age are smokers and, as such, can infer that there were 248,508 smoking pregnant women in 2008.

Hypothetically, we can suggest that (assuming those women did not receive any other interventions), the net benefit at a societal level for each of the interventions would be as follows:

[5] http://www.statistics.gov.uk/pdfdir/bdths0509.pdf

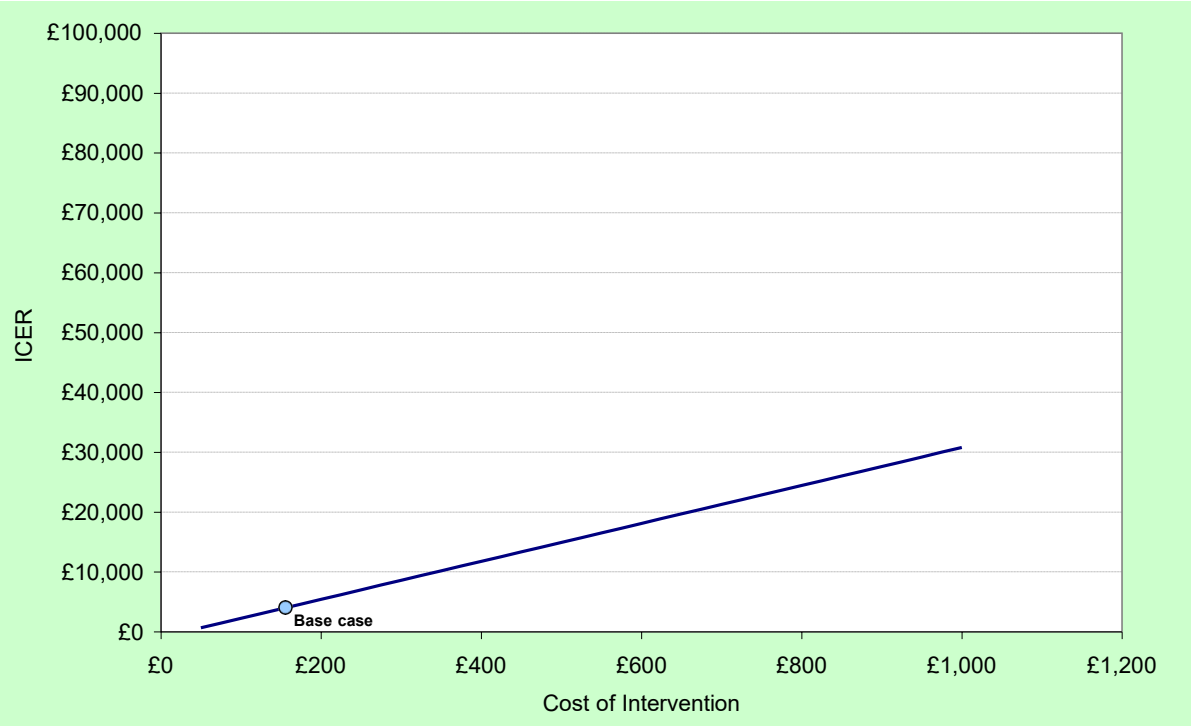
Table 2.7: Societal net benefit of each intervention

Intervention	Societal net benefit
Control	-
Cognitive behaviour strategies	£125,377,047
Stages of change	£27,645,619
Feedback	£217,659,053
Rewards	£561,950,573
Pharmacotherapies	£139,107,114
Other	£132,236,904

* Excludes cost of intervention

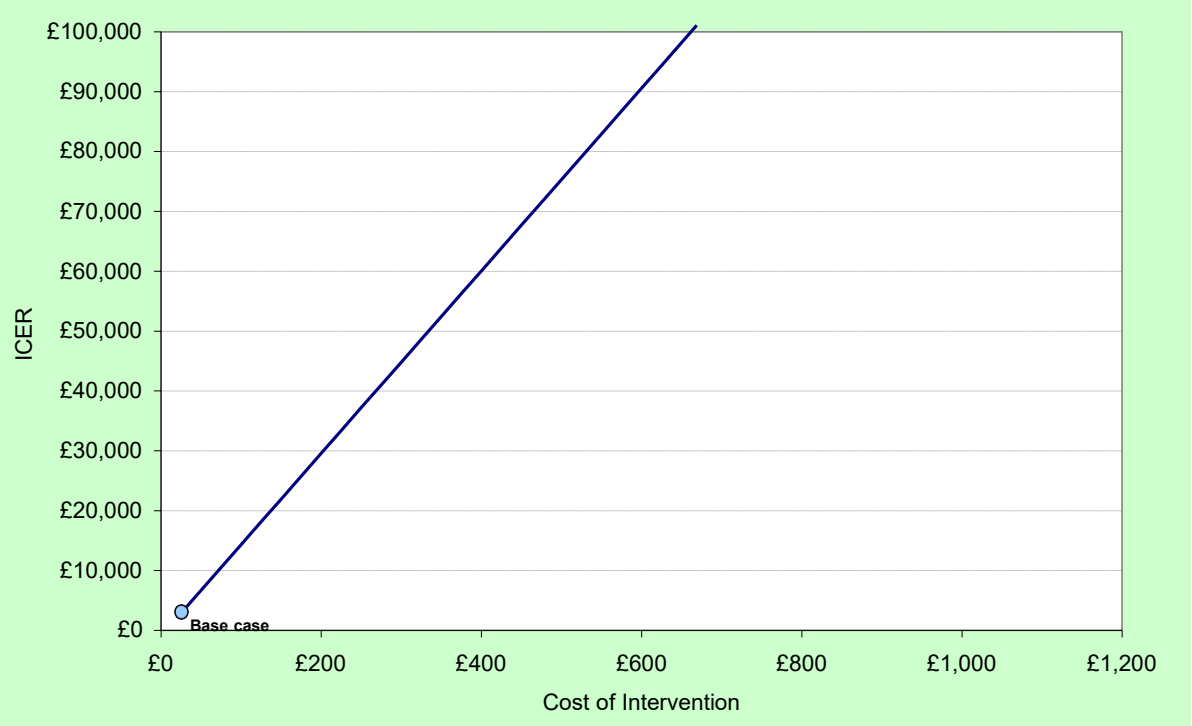
Because the specific cost of each intervention is uncertain, sensitivity analyses have been undertaken to identify the impact of changes in the intervention cost upon the incremental cost-effectiveness ratio for each intervention. The results of the sensitivity analysis are provided below.

Figure 2.1: Cognitive behavioural strategies



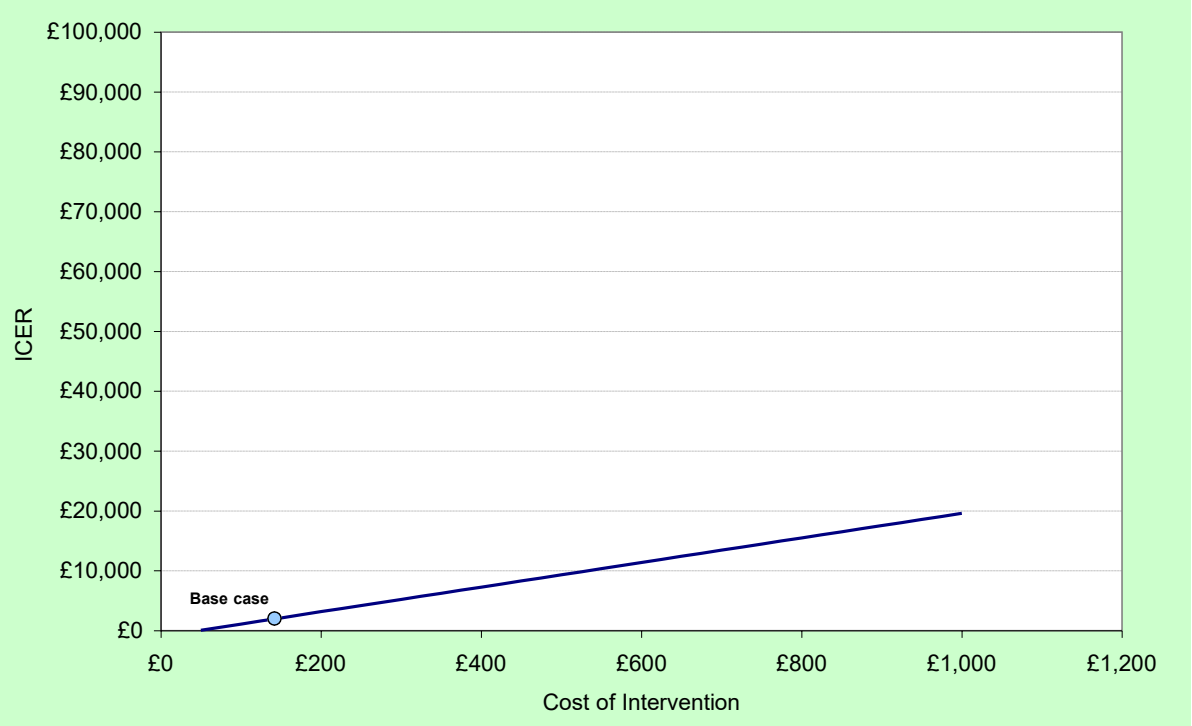
This demonstrates that cognitive behavioural strategies will be cost-effective (compared against 'no intervention' if the total cost of the intervention remains below £650.

Figure 2.2: Stages of change



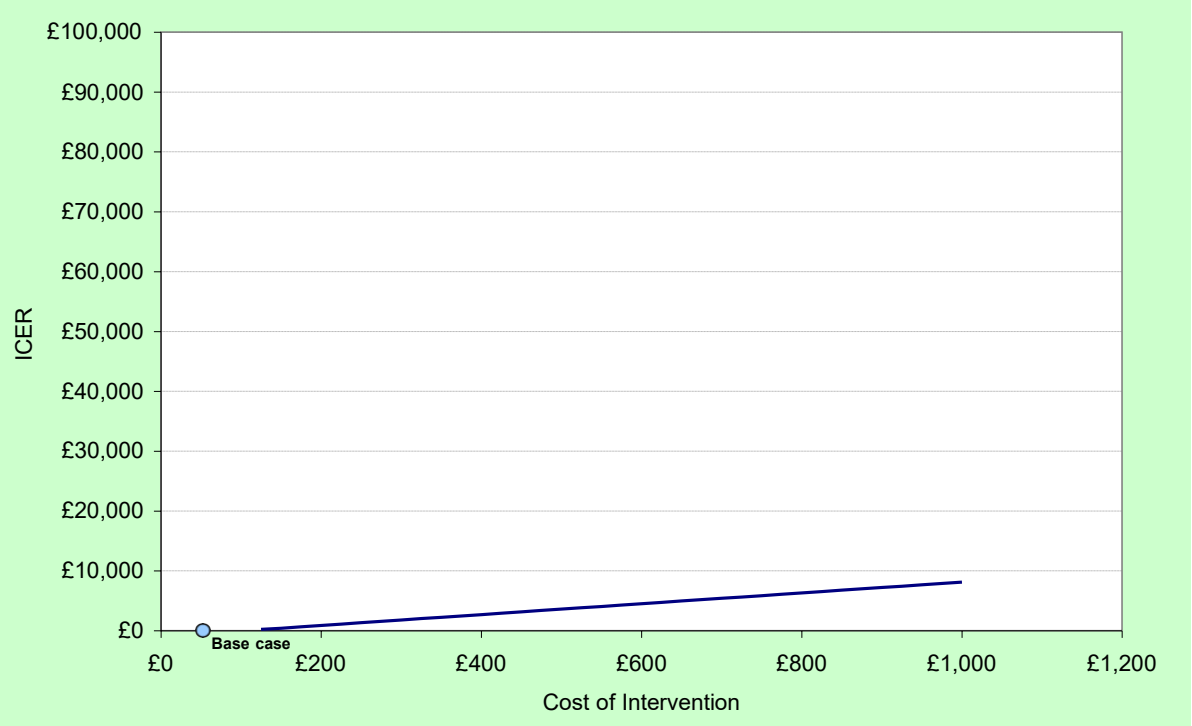
This demonstrates that the stages of change approach will be cost-effective (compared against 'no intervention' if the total cost of the intervention remains below £150.

Figure 2.3: Feedback



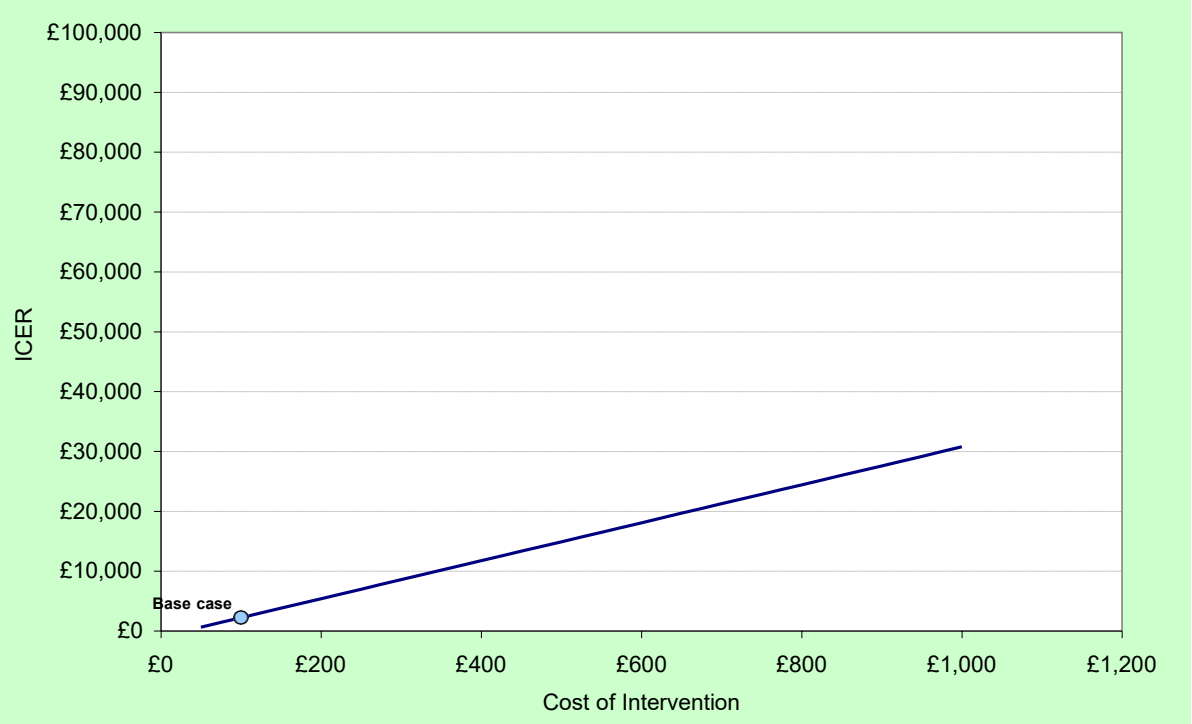
This demonstrates that the feedback approach will be cost-effective (compared against 'no intervention' if the total cost of the intervention remains below £1,000.

Figure 2.4: Rewards



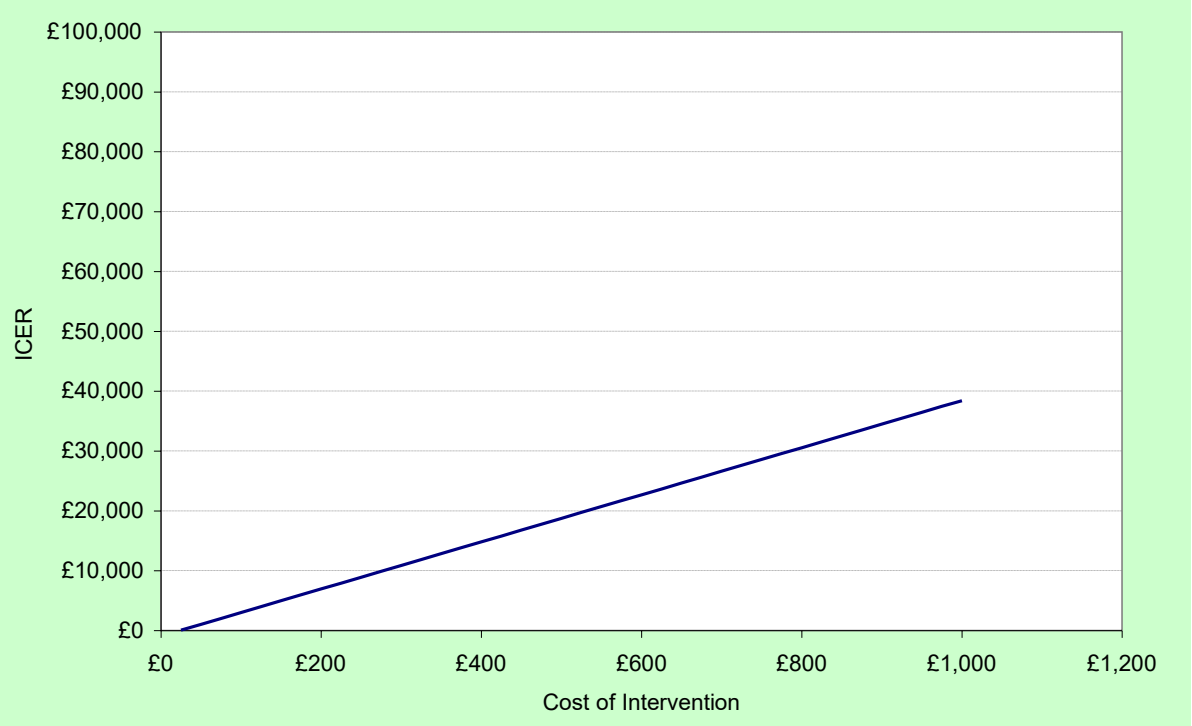
This demonstrates that the rewards approach will be cost-effective (compared against 'no intervention' at all ranges included within this analysis.

Figure 2.5: Pharmacoeconomics



This demonstrates that the pharmacotherapy intervention will be cost-effective (compared against ‘no intervention’ if the total cost of the intervention remains below £650.

Figure 2.6: Other



This demonstrates that ‘other’ approaches will be cost-effective (compared against ‘no intervention’ if the total cost of the intervention remains below £500.

Section 3: Conclusions

3.1 MAIN FINDINGS AND CONCLUSIONS

This analysis allows the user to determine the net benefit, or 'value' of a range of interventions to promote smoking cessation in pregnant women. All interventions were shown to reduce costs and increase QALYs, for both the mother and the child. Furthermore,at a societal level, the net benefit (i.e. accounting for money and health gains), could be in excess of £500 million.

Detailed costing of each intervention should be undertaken, which would allow the decision-maker to determine the relative cost-effectiveness of each intervention.

There are a number of limitations inherent within the model. Due to a lack of data on the relative risk of having each co-morbidity by smoking status it was not possible to 'spilt' former smokers into 'recent' and 'long-term' categories. It is unclear what the impact of this simplification will have on the model's results. If the probability of developing some or all of the co-morbidities returns to the level found in non-smokers after a certain period of time the model will have overestimated the number of people with each co-morbidity. This in turn may have resulted in an overestimation of the associated costs and an underestimation of the associated QALYs.

Within the model it is assumed that smokers attempt one type of intervention and only try it once. In 'real life' smokers who fail with one intervention may:

- Be more likely to repeat the intervention successfully;
- Go on to try a number of different smoking cessation interventions.

The effectiveness of the interventions was taken from published studies and, as such, may not necessarily be generalisable to the general population.