An Economic Framework for User Financial Incentives for Health Behaviour Change

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The candidate confirms that the work submitted is his own, except where work which has formed part of jointly authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

The work in Chapters *5, 6 and 9* of the thesis has appeared the following publications.

Chapter 5 and 6: Valuation survey analysis and interpretation

Meads DM, McCabe C, Camidge DC, Hill KM, House AO, Hulme CT. A contingent valuation survey of user financial incentives for health behaviour change. Value in Health, 2013;16 (3):Pages: A11-A11

Contributions: I was responsible for designing and piloting the survey, analysing the data and writing the abstract. McCabe and Hulme advised on the survey design and analysis; Camidge helped collect the data and Hill and House ran the trial which included the survey. Data entry was managed by the Clinical Trials Unit, University of Leeds.

Chapter 9: Developing a decision-analytic model

Meads DM, Hulme C, Hall P, Hill AJ. The cost-effectiveness of Primary Care referral to a UK commercial weight loss programme (in press)

Contributions: I was responsible for designing and building the model, literature reviews, conducting the analysis and writing the paper. Hulme and Hill contributed to the design of the analysis and helped edit the paper and Hall provided advice on the analysis.

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Abstract

Background: Diseases such as stroke and heart disease are chiefly caused by unhealthy behaviours and are a major societal burden. User financial incentives are being explored as a way to encourage healthier lifestyles. This research developed a framework to provide information on pricing and cost-effectiveness of incentives and guide design of future incentive schemes.

Methods: The workstreams were: a) structured, configurative literature review to identify neo-classical/behavioural economic explanations for behaviour change and incentives; b) contingent valuation survey to identify willingness to accept (WTA) and incentive pricing; c) systematic review and meta-analysis of incentives for weight loss; d) development of decision-analytic model to estimate cost-effectiveness of incentives for weight loss.

Results: The reviews identified a number of factors important for understanding the effect of incentives including internal motivation, self-control and time preference. A theoretical framework of incentive impact was developed to facilitate WTA survey design. The WTA survey was completed by 112 people (n=56 at 3 months). 57% strongly disagreed with incentive use. The mean incentive required per month depended on behaviour, ranging £103.69 for smoking cessation to £45.43 for reducing alcohol intake. The most important predictors of WTA were self-control, perceived difficulty of change and attitudes to incentives. There was some evidence that WTA incentives increased over time. Review and meta-regression provided efficacy parameters for the decision-analytic model which comprised the following health states: healthy, type II diabetes, stroke, myocardial infarction and dead. Analyses from NHS and employer perspectives indicated incentives for weight loss are cost-effective over a lifetime as they dominated usual care.

Discussion: Incentives may be most powerful if they are personalised to account for individual factors and attitudes and are dynamic in response to these. Incentives may be cost-effective in a number of scenarios. Further research is required on the long term outcomes of incentives and financing models.

Contents

Tables

Figures

List of abbreviations

APMS	Adult Psychiatric Morbidity Survey
BMI	Body Mass Index
CCT	Conditional Cash Transfers
CEAC	Cost-Effectiveness Acceptability Curve
CM	Contingency Management
CV	Contingent Valuation
CVD	Cardiovascular Disease
DALY	Disability-Adjusted Life Year
DCE	Discrete Choice Experiment
NIHR HTA	National Institute for Health Research - Health Technology Assessment Programme
ICER	Incremental Cost-Effectiveness Ratio
IMPROVE	Improving Prevention Of Cardiovascular Events
NICE	National Institute of Health and Care Excellence
NMB	Net Monetary Benefit
OECD	Organisation for Economic Co-operation and Development
ONS	Office of National Statistics
QALY	Quality-Adjusted Life Year
SES	Socio-Economic Status
VHCQ	Valuing Health Change Questionnaire
WTA	Willingness To Accept
WTP	Willingness To Pay

1. Introduction

1.1. Background

1.1.1. *Lifestyles and health*

Preventable diseases have a huge impact on individual and societal well-being and they are on the increase. Cardiovascular diseases (CVDs), including stroke and ischaemic heart diseases are the number one cause of death globally, accounting for 1 in 4 deaths.(1) In 2010, ischaemic heart disease was the leading cause of disability-adjusted life years (DALYs) globally while stroke was the third leading cause.(2) These represent 29% and 19% increases in DALYs, respectively, for heart disease and stroke on figures from 1990.(2) In England, CVDs affect 4.1 million people, killing 170,000 annually and account for around 20% of all hospital admissions.(3) The combined annual cost to the NHS of CVDs is around £20.8 billion while the annual cost to society, including loss of productivity, is in the region of £48 billion.(4)

The link between certain health behaviours or lifestyles and CVDs is well established. Around 80% of the stroke and heart disease risk is accounted for by unhealthy behaviours such as poor diet, alcohol abuse, physical inactivity and tobacco use.(5) Using data from the Global Burden of Diseases, Injuries, and Risk Factors Study 2010, analysis estimated that the leading risk factors for years lived with disease in the UK in 2010 were tobacco (accounting for 11·8% [10·5–13·3] of DALYs), followed by increased blood pressure (9·0% [7·5–10·5]), and high body-mass index [BMI] (8·6% [7·4–9·8]).(2) The study estimated that the combined risks of poor diet and physical inactivity accounted for 14·3% (12·8–15·9) of DALYs.

1.1.1.1. *Tobacco use*

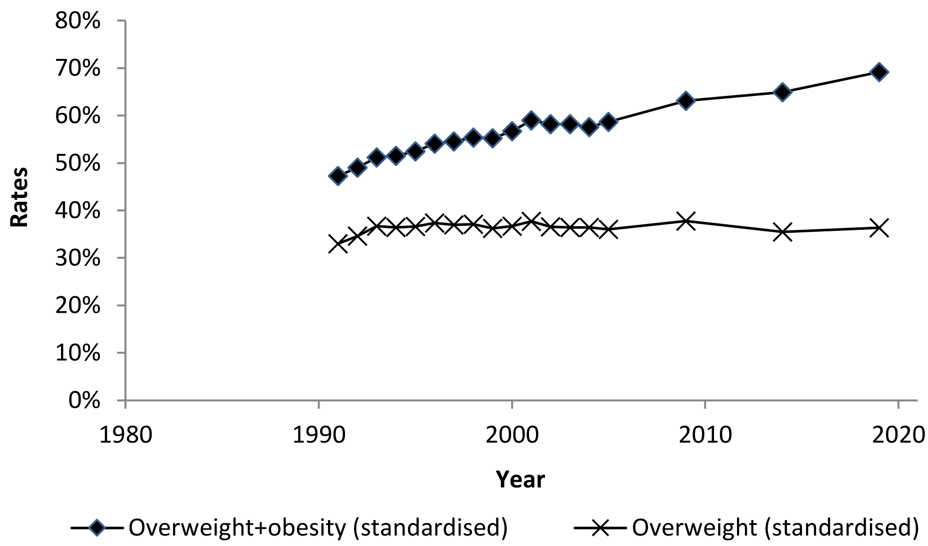
According to statistics for the year 2010, 20% of adults (20% of men and 19% of women) in England reported smoking. An average number of 12.7 cigarettes were smoked every day. In 2012 in the UK, £18.2 billion (1.9% of household expenditure) was estimated to be spent on tobacco products. There is a downward trend in smoking prevalence with rates in 2008/2009 being 22% compared to 39% in 1980.(6) However, data indicates that this trend is largely a consequence of an overall increase in people who have never or only occasionally smoked. The proportion of this group rose from 43% in 1982 to 55% in 2010.(6) The inference we might make is that the decline in smoking rates is less associated with successful quitting and that when people start to smoke, they continue to smoke. In addition, possibly because they are cheaper per cigarette, there has been an increase in the use of hand-rolled cigarettes. As these are often smoked without a filter they may represent a higher health risk than filter cigarettes as more nicotine and tar is inhaled.

Although smoking is on the decline it still represents a major health risk. Smoking is the primary cause of preventable illness and premature death in England, accounting for 81,400 deaths in 2009.(7) In 2011/12 there were around 1.6 million hospital admissions (an average of 4,300 per day) of adults aged 35 and over where the primary diagnosis was a smoking-related disease.(6) The most common smoking-related diseases leading to hospital admission were circulatory, followed by cancers and respiratory diseases. Furthermore, in 2012/2013 almost 13% of mothers were smokers at the time of delivery in England. This was estimated to cause up to 5,000 miscarriages, 300 peri-natal deaths and approximately 2,200 premature births.(8)

1.1.1.2. Diet and weight

In 2011 65% of men and 58% of women in England were classed as overweight (BMI = 25-30) or obese (BMI ≥ 30). Obesity is on the rise with rates in England increasing from 13.2% to 26.2% for men and from 16.4% to 26.1% for women in the period 1993-2011.(9, 10) A distinct but possibly related trend also appears in diet with household purchases of fruit moving in the opposite direction being 4.1% lower in 2011 than in 2008. Figure 1 shows the increase in rates of obesity and proportion of people overweight in England from 1980 to 2005 and future predictions from 2005 to 2020. A clear upward trend is evident; this is the case in most other OECD countries.(11)

Figure 1: Past and projected future rates of obesity and overweight in England, age 15-74



Source: Recreated using OECD analysis of national health survey data

In 2004 it was estimated that 34,100 deaths were attributable to obesity in England.(12) Along with the significant morbidity and mortality associated with obesity comes the substantial financial burden on the NHS and wider-society costs which appear set to increase in coming years. A recent analysis predicted that the annual costs of treating obesity-related diseases would increase by £648 (95% CI 352–944) million per year by 2020 and £2 (95% CI 1·2–3·0) billion by 2030. These increases would represent 0·5%–2% of the total health-care spending in 2009 in the UK (£109·7 billion).(13)

A corollary of increasing obesity levels are higher rates of obesity-related diseases such as type II diabetes. The number of people diagnosed with diabetes - over 90% with type II diabetes, a major cause of which is obesity - rose from 2.2 million in 2006 to 2.9 million in 2011.(14) The global mortality rate associated with diabetes has doubled since 1990 to 1.3 million (1) and it is estimated that 24,000 people die early annually in England and Wales because of the condition.(15) The annual direct NHS diabetes treatment costs are around £9.8 billion (2010/11) which is close to 10% of the total NHS budget; this is predicted to increase to £16.9 billion by 2035/36. The indirect costs, for example of treating the complications of diabetes including kidney failure, stroke, amputations and blindness, are expected to increase from £7.7 billion to £13.5 billion over the same period.(14)

1.1.1.3. Physical activity

Around 65% of men and 76% of women aged over 16 are not physically active enough to meet the current national recommendations - that is, they spend less than 30 minutes on 5 or more days a week involved in at least moderately intense activities.(16) It was estimated that in 2011/12 only 36% (41% of men and 31% of women) of adults in England participated in sport for 30 minutes at least once a week.(12) The societal cost of physical inactivity in England, including the direct costs of treatment for major lifestyle-related diseases and the indirect costs caused through sickness absence, has been estimated to be £8.2 billion a year (2002 prices).(17)

1.1.1.4. Alcohol abuse

The 2007 Adult Psychiatric Morbidity Survey (APMS) (18) provides estimates of the levels of hazardous drinking, harmful drinking and alcohol dependency in England. In 2007, 24% of adults were classified as hazardous drinkers while 6% of men and 2% of women were classified as harmful drinkers. The prevalence of alcohol dependence was 9.3% in men compared to 3.6% in women. These levels represent a slight decrease from 2000 figures for men while the levels for women remained about the same. However, levels of health service resource use due to alcohol consumption are on the rise. In 2011, there were 167,764 prescriptions of alcohol dependency medication in the NHS – an increase of 4.7% on the 2010 prescriptions (160,181) and of 63% on the 2003 figure (102,741).(19) Hospital admissions related to alcohol consumption have also increased significantly in recent years. Admissions almost doubled over the last decade; rising from just over half a million in 2002/2003 to over a million in 2009/2010. There was an 11% increase in admissions from 2010 to 2011 alone.(19) According to the Office of National Statistics (ONS) definition, there were 6,669 deaths in 2010 in England that were directly attributable to alcohol. This figure was a 22% increase on 2001 figures (5,476).(19) The Global Burden of Disease study reported that, along with obesity, alcohol was the only other leading DALY risk factor that did not decrease between 1990 and 2010.(20) The annual estimated (directly and partly attributable) cost of alcohol misuse to the NHS in England including hospital stays and visits, and A&E and GP visits is £2.7 billion (2006/2007 prices) – a figure likely to increase with the trend for increased resource use.(21)

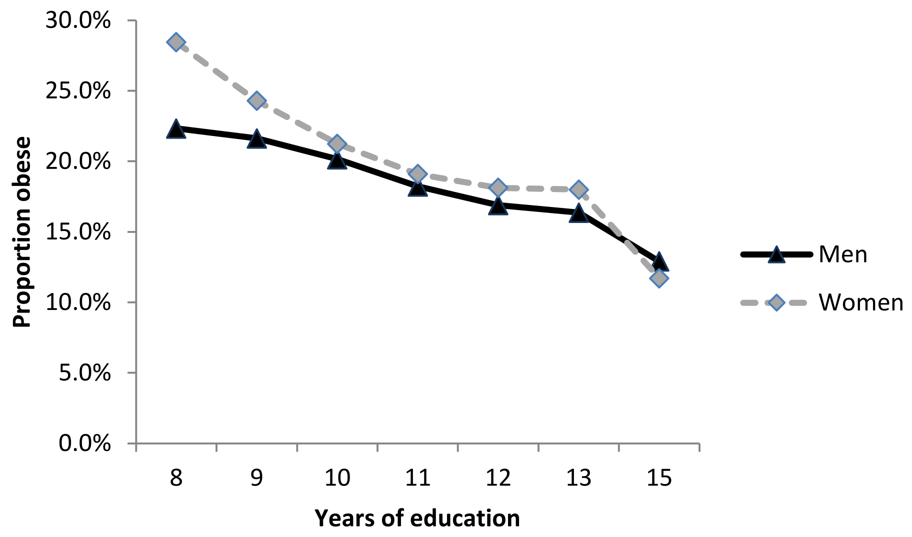
1.1.1.5. Lifestyles and health inequalities

In 2010 the life expectancy in England and Wales was 85 for men and 89 for women; these figures represent an increase from 1960 of around 10 years for men and 8 years for women.(22) Thus life expectancy is improving, albeit at a slower rate in recent years. However there are variations in the degree of improvement and recent statistics suggest that that although life expectancy continues to improve in most areas of the UK, there is a widening gap between areas with the highest and lowest life expectancies. ONS data indicate that between the 2004–06 to 2008–10 period, the gaps between the areas with highest (Kensington and Chelsea) and lowest (Glasgow City) life expectancies increased from 12.5 to 13.5 years for males and from 10.1 to 11.8 years for females.(23)

The social class or socio-economic status (SES) of an individual has been shown to have a robust association with life expectancy. In a recent study using census data for England and Wales, the largest increase in life expectancy in males between 1982–86 and 2002–06 (5.3 years) was experienced by those in the lower managerial and professional classes (such as school teachers and social workers).(24) The smallest increases were experienced by those in the lowest SES groups – 3.8 and 3.9 years for semi-routine and routine occupations, respectively. Consequently the gap in life expectancy between highest and lowest SES groups increased from 4.9 in 1982-1986 to 5.8 years in 2002-2006. A similar trend was apparent in females over the same period with the gap in life expectancy between the highest and lowest SES groups growing from 3.8 to 4.2 years.

A number of studies have found a relationship between obesity levels and SES, with rates of obesity generally being higher in lower SES groups in high income countries.(11) This gradient is most apparent for women and either less pronounced or absent in men.(11) However, when years of education are used to categorise groups rather than SES, as Figure 2 shows, there is a clear gradient in both sexes.

Figure 2: Obesity by years of education in England



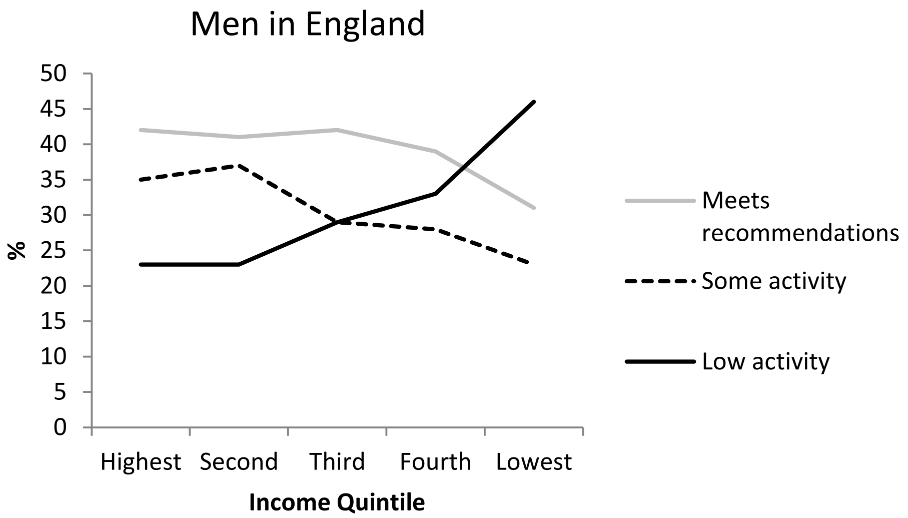
Source: Recreated using OECD analysis of national health survey data

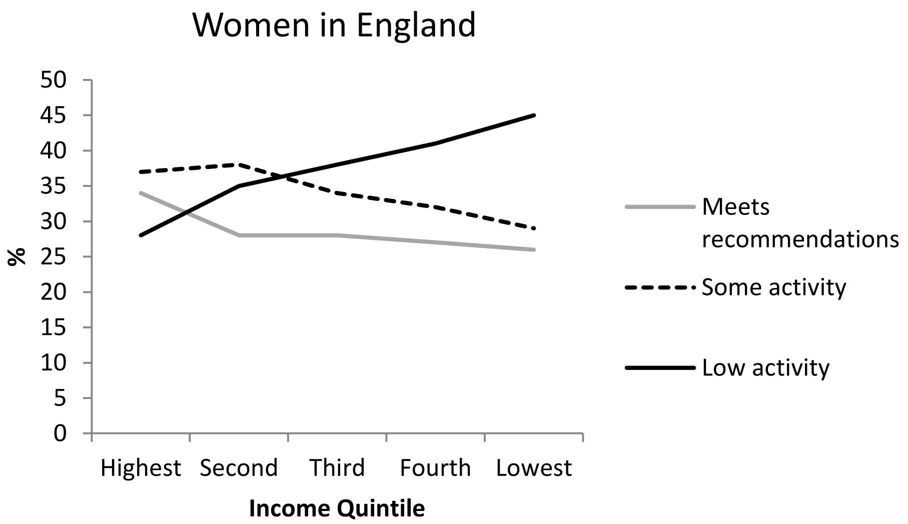
While only 15% of people in managerial and professional roles smoke, 30% of those in routine and manual occupations smoke.(25) Recent analysis of smoking trends in England suggests that although smoking declined between 2001-2008, it increased in the lowest SES groups and the number of people quitting declined in the same period.(26) Crucially, those in lower SES groups have higher uptake and lower success in quitting.

A more complex link exists between SES status and alcohol consumption in England. In general, those in higher SES and income groups drink more often than those in lower SES groups according to national surveys, counting the proportion drinking on five or more days in the last week or number of people who consumed more than 8/6 units on at least one day in the last week.(19) However, a recent analysis indicated that men in the lowest SES group were 3.5 times more likely to die from alcohol-related diseases than men in higher managerial and professional jobs. A similar pattern was found for women where 'routine' workers had 5.7 times the alcohol-related mortality risk than women in higher professional roles.(27)

The picture for physical activity is less clear-cut in terms of the SES gradient. However, data from a recent British Heart Foundation report (28) based on the Health Survey for England for 2008 (Figure 3) suggests that higher income households are more successful in achieving recommended levels of physical activity – defined as 30 minutes or more of moderate or vigorous activity on at least 5 days a week.

Figure 3: Self-reported physical activity in English adults, 2008 by income quintile





Data source: Recreated from British Heart Foundation: Physical activity statistics, 2012

Vascular diseases explain over 50% of the mortality gap between rich and poor in England.(3) According to the Marmot Review: *Fair Society, Healthy Lives,* those dying early due to health inequalities annually in England lose in total between 1.3 and 2.5 million years of life. The review posits that health inequalities are unfair if they are preventable by reasonable means and are consequently a matter of social justice. Marmot calls for a strategy of '*proportionate universalism*' to tackle health inequalities

– universal policies that are of a scale and intensity proportionate to the level of inequality that address social inequalities, widely seen as a root cause of health inequalities. Two years after the publication of the review, figures indicate that life expectancy has increased in most of the 150 health authorities areas in England that took over responsibility for public health in 2013.(29) However, the gap in life expectancy between the most and least affluent areas also increased, indicating that health inequalities are still widening.

There is considerable evidence that lifestyle and health behaviours are a significant driver of preventable illness and mortality in England. These illnesses represent a substantial financial burden to the NHS at a time when they are compelled to meet the ‘Nicholson Challenge’ and find £billions in efficiency savings. Unhealthy behaviours are typically higher in low SES groups and hence are a key factor in the still widening health inequalities in England (see (30) for a review).(3) Furthermore, evidence is emerging that unhealthy behaviours are ‘clustered’ such that (for example) individuals who smoke are more likely to be inactive and overweight.(31)

There are compelling arguments on the grounds of social justice, health service efficiency and economics for targeting unhealthy behaviours with a view to reducing preventable diseases. Two of the five aims of the newly formed Public Health England relate to behaviour change: helping people to live longer by reducing preventable deaths from conditions such as heart disease, stroke, cancer and liver disease; and helping employers to facilitate and encourage their staff to make healthy choices. Both the recent White Paper on the NHS, and Marmot Review outlined the need to encourage the adoption of healthier lifestyles in the UK (especially among lower SES groups) in an effort to address health inequalities. The ethical and economic need and justification for tackling unhealthy lifestyles is unequivocal; the question is: how can this be achieved?

1.1.2. Policy options for health behaviour change

There are a number of strategies available to governments and public health policy makers to try and bring about behaviour change in individuals exhibiting risky behaviour. These vary in a number of different ways including the unit at which they are targeted (e.g. population vs. specific group vs. family vs. individual), the aspect of consumption or behaviour they are targeting (e.g. cost, availability, motivations) and the level of government intervention required (intrusive vs. laissez-faire). There are many theories to explain behaviour change including the Theory of Planned

Behaviour and Health Belief Model.(32) Recently, Michie and colleagues conducted a systematic review, meta-analysis and Delphi process with experts to reach a consensus framework for describing behaviour change that incorporated aspects of such theories.(33, 34) Given the rigorous development process, Michie et al's Behaviour Change Wheel is used here as a framework to categorise policy options for behaviour change. The Behaviour Change Wheel, lists seven 'policy categories' (legislation, regulation, fiscal, service provision, environmental/social planning, communication/marketing, guidelines); nine 'intervention functions' (training, enablement, modelling, environmental restructuring, restrictions, education, persuasion, incentivisation and coercion); and six 'sources of behaviour' within three groups (Motivation – automatic and reflective; Capability – physical and psychological; Opportunity – social and physical). Governments will typically employ a combination of interventions across the seven policy categories contemporaneously in an effort to change public health behaviour. A brief description of the seven policy categories with examples are given below.

1.1.2.1. Legislation and regulation

Governments might choose to use legislative powers to ban or restrict the consumption of certain products. Examples of this include the banning of smoking in public spaces in England that came into effect on 1st July 2007; this legislation is now common-place with similar laws in place across Europe and North America. Also in 2007, the UK brought in legislation preventing the sale of tobacco to people under the age of 18 (previously 16). England are currently considering the banning of smoking in cars when children are passengers, a law which is already in place in parts of Canada, the US and Australia. Other examples include the attempt by Michael Bloomberg, Mayor of New York City, to ban 'super-sized' sugary soft drinks in New York cinemas, cafes and restaurants (this legislation is currently challenged in the courts by the drinks producers) and by legislation to ban (e.g. in Denmark and Switzerland) or clearly label (e.g. US and Canada) trans-fats in food. Governments and public health bodies also use regulatory powers to protect consumers - examples of this include regulations of tar, nicotine and carbon monoxide in cigarettes. These types of intervention appear to be highly effective in most cases. For example, analysis has suggested that the smoking ban in England has been responsible for an additional 300,000 people attempting to quit smoking (35), a 2.4% reduction in heart attacks (36) and 1900 fewer A&E visits annually due to asthma attacks,(37) along with other benefits such as reduced premature births and lower second-hand smoke exposure to children.(36)

1.1.2.2. Fiscal

Governments may also use price manipulation to try and reduce demand for unhealthy products. General taxation on cigarettes and alcohol has been found to significantly reduce consumption.(38, 39) However, policies affecting a one-off price rise are increasingly being introduced or discussed as options. Taxes on alcohol and fatty or sugary foods (called ‘sin taxes’) are currently receiving media attention as countries battle to curb rising obesity levels. If we consider that the (over) consumption of unhealthy goods leads to ‘negative externalities’ in the form of reduced long term health and increased burden on health services (or insurers) then a scenario arises where social costs exceed the private costs of consumption. The imposition of a tax to reduce production and consumption in this circumstance such that either demand or supply is decreased to a point where private costs more closely approximate social costs, the tax imposed can be considered a form of Pigovian tax.(40) In 2011 the Danish government introduced such a Pigovian (‘fat’) tax which levied a tax of DKK 16 (around £1.83) per Kilogram of saturated fat (if the product was >2.3% fat) on goods such as cakes, butter, meat and processed foods. Recently calls have been made to target sugar consumption and introduce a sugar tax to combat childhood obesity.(41) This approach was adopted in Finland in 2011 and France in 2012 where taxes have been levied on sugary drinks and both fat and soda taxes have recently been demanded in England.(42, 43) There is little evidence available on the efficacy of such measures (44) although data from the Danish fat tax indicated that sales of margarine, butter and cooking oil fell by 10-20% over the previous year and the government gained $200 million tax revenue.(45)

Another fiscal policy that has received a great deal of media attention recently in the UK is minimum unit pricing of alcohol. The Scottish parliament passed an act in May 2012 setting a 50p minimum price per unit of alcohol to try and reduce consumption. However, this has not yet been implemented as it is being challenged in the courts by the Scotch Whisky Association and other drinks manufacturers on the basis that it breaches EU trade laws. England and Wales did introduce a law to ban selling alcohol for less than the combined tax and duty paid on it which was effectively a very low minimum pricing strategy.(46) Although the English government was considering a higher minimum price of 40p per unit, this policy option was dropped in March 2013.

A recent model analysing the impact of alcohol consumption and pricing estimated that a minimum unit alcohol price of 50p in England would reduce overall alcohol consumption by 6.7%, leading to 3,060 fewer deaths and 97,700 fewer hospital admissions over ten years. It would also result in 424,400 fewer days absent from work, 25,900 fewer people unemployed in the first year and save society £9.7bn over 10 years.(47)

Alcohol minimum pricing strategies have not yet been implemented on a country-wide basis although 8 out of 10 Canadian provinces have some form of minimum price. Given this there is little data on the effectiveness of the strategy although there are some positive results coming out of Canada. Analyses indicate minimum pricing led to significantly reduced alcohol consumption, with consumption of higher strength drinks falling most.(48) To illustrate, the study found that a 10% increase in the minimum price of beer led to a 22% decrease in consumption of higher strength (> 6.5% alcohol/volume) beer compared with an 8% reduction in lower strength beers.

The extent to which fiscal policies are successful in reducing inequalities will depend to a large degree on the price elasticity of demand of different income groups. Evidence suggests however that the elasticity of demand for addictive goods may be low as they are viewed as necessity goods. Wagenaar et al’s meta-analysis of alcohol fiscal interventions found the mean elasticity for alcohol to be -0.51 across 91 studies with the elasticities for heavy drinkers in 10 studies reported as -0.28. A report of 86 studies on tobacco pricing found a mean price elasticity of –0.48 with another review estimating a general range between -0.2 and -0.6 in high income countries.(49) Regardless, reviews generally report that lower income and SES groups are more responsive to price increases than higher income groups.(50)

There is evidence that fiscal policies do reduce consumption with higher effect sizes achieved than with behavioural interventions.(39) However, as the price elasticity of demand for addictive goods is often low, the impact of imposing such taxes will not be commensurate. In fact it may mean that they encourage those who are most likely to change behaviour (least addicted) to change first, leaving those with the most unhealthy consumption habits. Thus the ‘pain’ of the policies (on moderate consumers and unhealthy consumers) may not be matched by the successes in behaviour change.

Due to governments’ reluctance to pursue such policies in the past there is limited evidence currently available on the impact of sin taxes on different income groups (and therefore health inequalities). However one model, as well as showing that such policies are regressive, also predicts that they may not necessarily bring about the proportionate reductions in consumption in lower income groups required to redress the health-income imbalance.(51) While fiscal policies may be more effective than lighter touch interventions and be an additional way of generating government income (which may be redirected to subsidise healthy behaviours), such interventionist policies are politically unpopular (see (52) for a parliamentary debate on minimum alcohol pricing) and come with a number of drawbacks. Fiscal policies may be regressive as taxes and minimum prices will be proportionately higher for low income groups; this jeopardises the aim to achieve distributive justice. Taxes may be proportionately lower on high quality goods only consumed by the wealthy – for example, minimum alcohol pricing will probably not change the price of champagne or high quality spirits and wines. Fiscal policies are also non-discriminatory and thus do not target specific groups or individuals; this being the case they may punish 'moderate' consumers. Interventionist policies also interfere with the freedoms and choices of individuals, drawing accusations of a 'nanny state'.

In addition to these drawbacks, fiscal policies, as with any other type of policy, have a risk of significant (often unexpected) negative consequences. For example, raising the price of cigarettes has led to an increase in the consumption of roll-your-own cigarettes (as they are cheaper) which tend to have a higher negative health impact than manufactured cigarettes. The Danish fat tax was rescinded after just one year because people were able to circumvent the tax by purchasing unhealthy goods across the border in Sweden and Germany. There was also a deleterious economic impact as there were some job losses in related local industries (e.g. pastry producers). Other negative consequences include increased smuggling, increased black market activity, home production and risky consumption.

1.1.2.3. Service provision

Through the NHS the government provides a number of individual-level interventions available for deployment by healthcare professionals to try and change health behaviour. These range from advice and counselling, health coaching, free quit smoking kits and nicotine replacement therapies and referral to gyms or weight loss programmes. The myriad services that are available have had limited success in changing lifestyles and this is especially the case in people with low-income, although few interventions have been targeted specifically at this group.(53) There has been low participation in the NHS health checks for those most at risk of CVDs.(54) There are reports of high non-adherence rates with statins(55), - and in general with CVD medications, especially among lower-income groups(56) - smoking cessation(57), and physical activity programmes.(58) A recent review of weight loss interventions concluded that - surgical procedures aside – most had limited efficacy.(59, 60) A recent trial found offering smoking cessation counselling or free nicotine replacement products gave no additional benefit to phone helpline support alone.(61) Furthermore, the effects of interventions are often not sustained; for example, smoking cessation in a recent trial of nicotine replacement therapy and pharmacy counselling fell from 22.5% at 4 weeks to 3.6% at 52 weeks.(62) In addition, a review of NHS smoking cessation services indicated an average quit rate decline from 53% at 4 weeks to 15% at one year.(63) There are, however, examples of NHS services having a significant positive impact; a recent analysis of the NHS health trainer scheme suggested that it was effective at increasing physical activity and improving diet, especially among lower income groups.(64)

1.1.2.4. Environmental/social planning

Michie et al described environmental and social planning interventions as designing and/or controlling the physical or social environment. This may involve creating cycle lanes, for example or the ban on tobacco displays in shops recently introduced in England. In a social context it may include attempting to change the social norm which pervades in society or regions relating to health behaviour. There is some support for this strategy (65) although little longitudinal population-level data exists to enable an evaluation of this approach in England.

1.1.2.5. Guidelines

Guidelines are provided by public health bodies to enable consumers to make informed choices about consumption. Typically this involves making the public aware of the risks of unhealthy behaviours, the benefits of healthy behaviour and the levels of consumption that are risky. The government provides guidance, for example, on safe alcohol consumption, healthy levels of salt, fat and sugar intake and recommendations on healthy levels of physical activity. These guidelines are usually packaged as interventions along with communication and marketing campaigns such as the NHS's Change4Life.

1.1.2.6. Communication/marketing

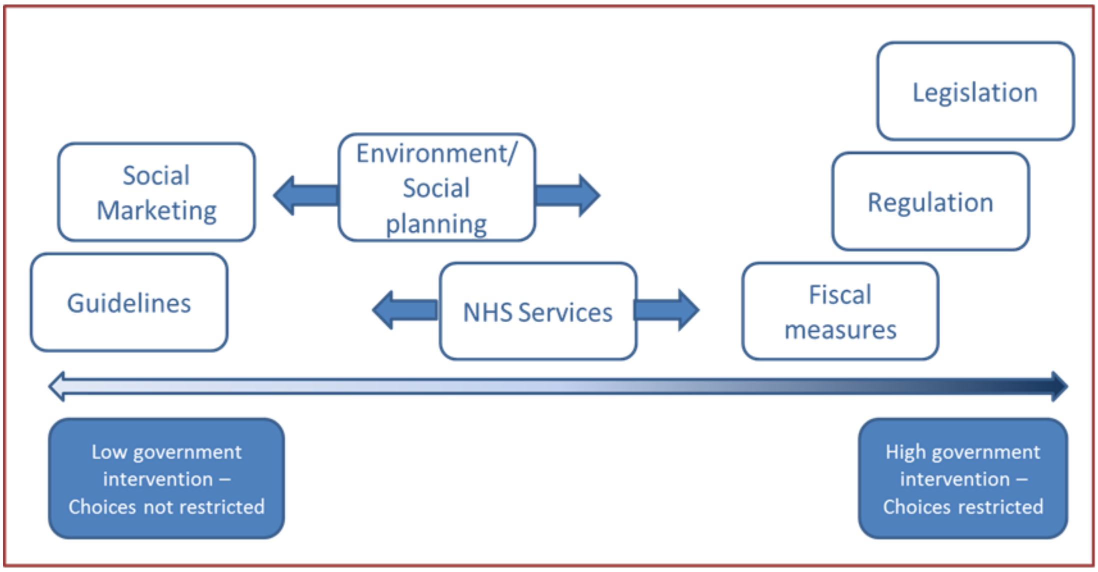
Communication strategies aim to provide information and to educate the population in order that they make healthier choices. Change4Life is possibly the largest communication campaign in the UK with an annual budget of around £1.6 million (although this has dropped from £9.2 million) followed by anti-smoking campaigns (£1.1 million in 2010/11). However it is unclear how effective these messages are. A recent review of the Change4Life mass marketing campaign concluded that it has had limited beneficial impact.(66)

A report on a 2010 Scottish survey, The Knowledge, Attitudes and Motivations to Health(67), found that 87% of people were aware of advice to eat five portions of fruit or vegetables a day, but only 22% achieved that level of consumption. Similarly, 52% of adults felt they were they physically active enough to be healthy, but only 39% met the recommended levels of 30 minutes of moderate activity on most days of the week. The figures suggest that knowledge of what constitutes healthy behaviour is insufficient in itself.

1.1.2.7. The politics of public health policy

Political orientation often holds sway over public health policy and governments are keen to avoid a stance that draws accusations of the nanny state. This being the case, political expediency may determine policy selection as much as policy effectiveness. For illustrative purposes, the seven policy strategies outlined by Michie et al have been plotted in Figure 4 on a continuum indicating the possible level of government intervention and associated impact on consumer choice (or degree of intrusiveness). At the light touch (laissez-faire) end of the continuum there is little direct intervention in an attempt to change behaviour with only guidance and marketing campaigns used to educate and persuade people to change. At the other extreme are legislative interventions where choices are restricted or completely removed.

Figure 4: Continuum of Government Intervention in Health[1]



Currently in England, public health policy that include bans, taxes and minimum pricing have so far been eschewed in favour of strategies such as the 'Responsibility Deal'(68) even though the former are likely to provide superior outcomes. The Responsibility Deal is a voluntary agreement which food and drinks manufacturers and voluntary organisations can enter into with the government to bring about change without the use of legislation. The impact of the deal has been limited and highly contentious.(69) To date the deal requires manufacturers and sellers of products to commit to pledges such as calorie reduction, salt reduction, alcohol awareness and labelling such as providing calorie information. As of February 2013 more than 480 companies had signed up to pledges. Examples of action include ASDA restricting alcohol displays in store foyers and PepsiCo and Britvic pledging to actively encourage more people to choose low-calorie drinks in cinemas. However, evidence of the health impact of the deal is limited and assessing its success will prove difficult.(70, 71)

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[1] Figure created by the author but using concepts from the Nuffield Intervention Ladder (http://nuffieldbioethics.org/report/public-health-2/policy-process-practice/)

1.1.2.8. The challenges in changing health behaviour

The widening health inequalities, largely attributable to unhealthy lifestyles, suggest that - thus far - behaviour change policies have been unsuccessful in persuading individuals in lower SES groups to adopt healthier lifestyles. Health seeking behaviour and adherence to preventative measures being lower in this group.(3) Even when individuals have significant incentives to change they find it difficult. For example, according to a recent analysis of a national clinical audit of diabetes in England by Diabetes UK, only 20% of patients are currently achieving NICE standards for controlling their condition (which includes a healthy diet and physical activity).(72) This is despite the fact that uncontrolled disease can lead to blindness and amputation.

The explanations for the apparent stubbornness of unhealthy lifestyles are manifold and are offered from biological, psychological, social and economic perspectives. Economic research has shown that the demand for health investments is price inelastic (73) and a recent study reporting a discrete choice experiment found that respondents were not willing to pay for help in achieving weight loss.(74) In the latter study, while respondents valued weight loss and reduced risk of CVDs, they valued their current lifestyles more and so were disinclined to change behaviours. In fact the analysis yielded a negative willingness to pay value for change in lifestyle indicating that participants would need to be paid in order to attempt behaviour change. This is consistent with theories of ‘rational addiction’ which illustrate that some see the costs (disutility) of behaviour change as outweighing the (discounted) potential future benefits (utility).(75) In this case it may well be rational for individuals to continue with their current lifestyle course. Meanwhile neo-classical economic research based on human capital theories (76, 77) suggest that, given the likely future returns on health capital and health investments, some may quite rationally decide to continue to ‘disinvest’ in their health. This effect would intuitively be stronger for individuals who have low expected future earnings.

Despite the commitment of government and health services to bring about behaviour change, the prioritisation of health inequality reduction, the multifarious services offered by the NHS and extensive marketing and education campaigns, sustained behaviour change remains elusive. Decades of applying conventional methods of identifying barriers and enablers to change and the application of psychological models of behaviour have, on the whole, not yielded the desired results. When behaviour change strategies achieve some success they may not have the desired effect of inequality reduction. Hence, as articulated in a recent commentary, new strategies may be required to tackle inequalities: “*giving bigger doses to the poor of what benefited the rich is no guarantee of equal benefits, never mind proportionately higher benefits for the poor*”(78).

1.1.2.9. Growing interest in financial incentives for health

In recent years both the UK and US governments have become interested in the behavioural concepts presented in the book ‘Nudge – Improving Decisions about Health, Wealth and Happiness’.(79) In the book ‘paternalistic libertarianism’ is presented as an effective way of influencing individuals’ behaviour by the manipulation of choices, defaults, biases and use of targeted incentives, negating the need for more interventionist policies. It has been the catalyst for the creation of the Behavioural Insights Team in the UK who advise the government on how to change behaviour on a number of issues including *inter alia* tax, health, health and safety, and pensions.(80) The group recently created a framework to help describe behaviour and facilitate behaviour change entitled MINDSPACE (Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect, Commitments, Ego). Elsewhere, a Department Of Health report, *Health Lives, Healthy People*, the government set out their strategy for public health in England and state: ‘*We will trial new ways of changing behaviours, using emerging ideas from behavioural science, such as the use of social norms, changing defaults and providing incentives*’ (page 44).(7) Use of financial incentives in health and their suitability as an NHS intervention was discussed by the National Institute of Health and Care Excellence’s Citizen’s Council - a group of the general public called upon to discuss key issues and to provide a barometer of general population opinion.(81) In addition, the UK has seen the creation of two academic centres set up to study incentive use; the Contingency Management Programme focussing on addiction research and the Centre for the Study of Incentives in Health, both at King’s College London. Further to this, two comprehensive systematic reviews of incentives have recently been completed.(82, 83) There are also signs that incentives initiatives are being employed by local authority and third sector agencies as a public health improvement tool.

It is apparent then that, in the UK and elsewhere, there has been a heightened interest in user incentives for health, especially as a tool to change behaviour in low SES groups. The reasons for this interest are a matter of conjecture but may include: the perceived failure of traditional behavioural interventions; nascent evidence of the effectiveness of incentives; the unwillingness of governments to use fiscal and legislative policies; and, at the same time, the growth of behavioural economics which advocates modification of behaviour without restricting choices.

1.1.3. Financial incentives in health

1.1.3.1. History of incentive use

Financial incentives can be defined as monetary or non-monetary rewards (e.g. vouchers and prizes) offered to individuals to encourage them to behave in a desired manner. They may also include fee remission or reduction in insurance premiums, for example. The term 'incentive' is also used generally in this thesis (except where specified) to cover financial 'disincentives' (where an individual pays money as a punishment when failing to reach a target or stick to a desired behaviour) and lotteries (where rewards are uncertain). In substance abuse studies, financial incentives are commonly termed contingency management (CM); and in development economics they tend to be termed conditional cash transfers (CCTs). CM is a general approach of behaviour reinforcement that may include financial incentives as a reward for desired behaviour.

The use of CCTs has been common in low and middle income countries for some time as a means of reducing poverty.(84) Initiatives include: *Oportunidades (*originally called *Progresa) (85)*, a national scheme in Mexico which by 2002 had targeted five million poor families with an annual budget of $2.1 billion aiming to increase human capital via improvements in health, nutrition and education of their children; and *Bolsa Familia* in Brazil, which offered payments to encourage the enrolment of children in school.(86) Since these schemes were introduced in the 1990's, similar programmes have been introduced across South and Central America (Argentina, Chile, Colombia, Costa Rica, El Salvador, Ecuador, Honduras, Nicaragua, Peru and Uruguay) and Asia (Bangladesh and Pakistan). Evaluations have generally concluded that these have been successful (87) and had positive results in terms of preventive health and health status.(88, 89)

The concept of incentives is based on B.F. Skinner's classic psychological theory of operant conditioning.(90) One of the key principles of this is positive reinforcement whereby a behaviour or response is followed by a reward or stimulus which in turn increases the frequency of the behaviour. Edward Thorndike also conducted studies that illustrated what he called the Law of Effect where responses that were followed by pleasant stimuli or consequences were repeated, and those with unpleasant consequences were less likely to be repeated.(91) A key principle of economics is that people respond to incentives. Incentives in the form of remuneration and bonus payments have been an important tool in management and business for centuries, ensuring that firms have sufficient motivation to produce and employees have sufficient motivation to work, delivering specified levels of quality and quantities within a given period.

Recently some employers – particularly in the US – have also used incentives to influence the health behaviour of its employees.(92, 93) For example, following the success of a clinical trial evaluating the effectiveness of incentives for smoking cessation with its employees, General Electric has now rolled out the incentive scheme to all 152,000 staff members.(94) General Electric believes the scheme will pay for itself in three to five years with higher employee productivity, lower absenteeism through sickness and lower healthcare costs. Other examples include IBM offering $150 twice annually to staff completing online health surveys and reaching targets such as weight loss, diet change and set physical activity levels. Discovery, South Africa’s largest private health insurance firm, offered rewards (such as cinema tickets and flights) for participation in health and fitness programmes; a strategy that was found to yield positive outcomes in terms of increased participation levels and reduced sickness.(95) Disincentives are also being used widely. For example Alabama City charges employees a $50 a month insurance premium if they smoke while a South Florida city council no longer hires people who smoke. Scotts Miracle-Gro offers cheap gym membership and levy a health insurance premium increase of $40 per month if individuals do not take a voluntary health risk assessment and a higher levy if they do take the assessment, found to be at risk and choose not to change their behaviour.(96) According to a recent US survey of workplace wellness programs in nearly 800 US companies, 83% offered incentives or disincentives to encourage participation and encourage certain behaviours.(97) These types of incentives have had limited exposure in the UK although PruHealth (a partnership between Prudential and Discovery insurance companies) are offering the Vitality health incentive programme - a scheme that offers incentives such as reduced gym membership, cinema tickets, reduction of bicycle cost, train tickets and holidays for healthy behaviour.

1.1.3.2. Current use of financial incentives

There has been a rapid growth in the number of incentive studies which is indicative of their increased general usage. According to a clinical trials database (https://clinicaltrials.gov) there are a large number of incentive studies currently or soon to be recruiting (mainly in the US). A search of the meta-trial register with the term 'contingency management' yielded 126 results. The studies included incentives for HIV testing (98), healthy eating (99), weight loss (100), management of tuberculosis (101), reducing adolescent alcohol abuse (102), and cocaine-dependence.(103) UK studies are few but on the increase. Two UK trials are evaluating the use of incentives for smoking cessation in pregnant women (104, 105). Another is evaluating their use to encourage human papillomavirus vaccination in 16-18 year old females (106) and a further study is evaluating their use to promote breastfeeding.(107) The National Institute for Health Research Health Technology Assessment (HTA) Programme has also recently funded two large trials of incentive interventions: for the reduction of cannabis use and relapse in early psychosis at a cost of £2million (HTA Ref: 09/144/50); and adherence to anti-psychotic maintenance medication at a cost of £1million (HTA Ref: 07/60/43).

In addition to these studies there are a number of local authorities running behaviour change schemes. These follow local initiatives such as the Help 2 Quit programme run by Shropshire NHS and Give It Up For Baby run by NHS Tayside which offer incentives to pregnant women who quit smoking.(108) The Significant Other Scheme (SOS) scheme funded by the Department of Health and run in the Yorkshire and Humber region also offered incentives to pregnant women for smoking cessation. SOS offered £20 high street vouchers on entry to the scheme and every four weeks on achieving cessation (confirmed with a CO test) up to two months post birth. Another £40 was available for a "significant other supporter" if the mother did not smoke for the scheme duration. The smoking cessation reward scheme run by Tobacco Free Futures also targeted pregnant women in the NorthWest. Both schemes concluded that, when combined with support, incentives were an effective intervention. Evidently, most of the incentive research in the UK to date has focussed on contingency management in addiction and on maternal and post-natal health behaviour.

The private sector has also recently seen growth in this area with a number of companies offering incentive schemes to motivate individuals to achieve their health (and other) targets. For example the website Stickk (http://www.stickk.com/) asks participants to commit an amount of money (a disincentive termed 'deposit contract') to achieving a certain goal such as stopping smoking or weight loss. The deposit is lost and donated to a charity (or 'anti-charity') if they fail but paid back to them if they achieve their goal. Other examples using the same (dis)incentive principles are Beeminder (https://www.beeminder.com/), 21Habit (http://21habit.com/) and GymPact (http://www.gym-pact.com/) although the latter shares lost deposits among successful individuals. Weightwins (http://www.weightwins.com/) is a UK site which rewards individuals for weight loss (and maintenance) (http://www.healthywage.com/ is a similar site in the US) which charges a fee for registration and financially rewards individuals who achieve weight loss targets. It is not clear how popular these sites are but as of October 2014 Stickk – a US site – claims that over 250,000 commitments had been made with almost $20 million contingent on success.

1.1.3.3. Effectiveness of incentives

One of the key expectations of incentives is that they may help to reduce inequalities since low SES groups should be more responsive to smaller absolute incentives.(109, 110) The neo-classical economic rationale is that people with low income will have higher marginal utility of money; this being the case incentives may help to achieve distributive efficiency.(111)

To date there is promising but, mixed, evidence for the efficacy of financial incentives in achieving behaviour change. They appear most promising in the area of substance abuse where, according to NICE, there is a '*considerable and compelling evidence base*'.(112) There is also stronger evidence for incentives when the target behaviour is a discrete event such as visiting a clinic or vaccination as opposed to sustained behaviour change.(113) Incentives have produced some positive results in encouraging weight loss (114) and physical activity (115) but further research is needed to justify widespread use.(113) A Cochrane review of 19 competition and incentive studies for smoking cessation found that despite encouraging more people to attempt quitting, only one study found a significant effect on quit rates at 12 months or later follow-ups.(116) The exception was a study by Volpp et al (2009) where large incentives (possible $750) were contingent on completion of a cessation programme ($100) and cessation at 6 ($250) and 12 months ($400).(117) Overall, 15.4% of the incentive group enrolled in a cessation programme (10.8% completed), compared with 5.4% of the controls (2.5% completed). At 15 or 18 months, quit rates for the incentivized and control groups were 9.4% vs. 3.6%, respectively (P=0.001). Volpp et al (2008) found promising short-term effects in a weight loss study with 50% of obese people in a 16 week commitment contract programme achieving a weekly weight loss goal of 0.45 kg (1lb) compared to only 10% of usual care group.(114) As with many other behaviour change interventions though, incentives suffer a fading effect such that benefits are not typically sustained past 12 months (or past the end of the incentive programme).(116, 118-121) More recent reviews in smoking cessation (122, 123), weight loss (124) and reducing unhealthy behaviours in people with serious mental illness (125) have been less pessimistic. A review conducted by Higgins et al. (2012) considered 6 controlled trials of incentives for cessation of smoking among socioeconomically disadvantaged pregnant women.(122) The largest (n=220) study (by Donatelle et al, 2000 (126)) - where women were offered vouchers to the value of $50 then $25 monthly - found abstinence rates at end-of-pregnancy and 2-months postpartum in the voucher and control conditions to be 32% vs. 9% and 21% vs. 6%, respectively.

1.1.3.4. Cost-effectiveness of incentives

To date, few studies have conducted economic evaluations of incentive schemes for behaviour change. A recent paper reported the cost-effectiveness of a 12 week incentive reward scheme versus self-monitoring designed to increase employee physical activity.(127) Participants in the incentive scheme earned points on a ‘loyalty card’ redeemable against rewards for every minute of physical activity they undertook. The incremental cost-effectiveness ratio (ICER) for the incentive versus self-monitoring was £2,900 (2013 prices) per quality-adjusted life year (QALY) with (bootstrapped) sensitivity analysis indicating an 85% probability (assuming a willingness to pay threshold of £30,000/QALY) that the incentive scheme was cost-effective. While the study presents promising results it is limited as the costs and benefits of the interventions were not modelled for the lifetime of the participant.

Elsewhere, a study concluded that incentives for smoking cessation were cost-effective, finding the average cost per quitter to be relatively low (£191; price year not stated) compared to other interventions. However, interpretation of the relative cost-effectiveness of the intervention is limited by the fact that authors do not present outcomes in terms of QALYs or consider the lifetime impact of smoking cessation.(128) This was also the case for an analysis of team commitment contracts for smoking cessation in Thailand.(129) Another study presents the cost-effectiveness of a workplace incentive for weight loss.(130) The authors report the cost-effectiveness ratios per pound (0.45 kg) of weight loss to be $25.50 (£15.24) and

$58.10 (£34.72) (2011 prices) for incentivised and none-incentivised groups, respectively. The study did not include healthcare costs but did include costs avoided through absenteeism and productivity gains. A further study of incentives for weight loss by Relton and colleagues (131) reported that the total cost of their incentive study was £75,000. This equated to an average cost of £186.57 per participant and - assuming weight loss of 4 kg - a mean cost per kg lost of £46.64 (all 2010 prices).

The remaining economic evaluations of incentives are found in contingency management of substance abuse and mental health. One such evaluation assessed the cost-effectiveness of incentives for achieving antipsychotic medication adherence.(132) The cluster-randomised controlled trial offered participants in the incentive group £15 (2012 prices) for every antipsychotic medication injection they received. Over 12 months, adherence rates in the control arm were 71% while the incentive arm achieved 85% (p=0.003 for adjusted difference). The results were extremely encouraging for the incentive arm but, again, QALY outcomes were not incorporated. Other contingency management studies using prize- and voucher-based incentives in opioid-dependent patients also neglect to present cost-per-QALY outcomes.(133, 134)

Generally speaking, the few published economic evaluations do not meet NICE requirements for technology appraisals and efforts within them to explore methodological issues are minimal. Given the dearth of research in the area this is commonly identified as a key target for future research.(121, 135, 136) The costs of programmes relate to the cost of incentive scheme set-up, monitoring and provision which is itself dependent on the incentive amount, payment frequency and duration. Cost savings may come from a reduction in future behaviour-related diseases and associated resource savings. Quality of life and survival benefits may arise from an increase in healthy behaviour directly and avoidance of future disease. While this appears a relatively straight-forward decision-analytic modelling task, there are a number of additional considerations when evaluating the cost-effectiveness of financial incentives. One relates to the level of incentive offered. While it is presumed that larger incentives lead to better outcomes, it is unclear what the precise relationship is and, since increasing the incentive increases costs, it is important to consider what the optimal incentive pricing might be. Related to this is the idea that the same incentive amount may have a different motivating effect on different individuals - for example, if they have differing income levels and marginal utility of money. A further issue worthy of consideration is the impact of incentives in the long term (or at least after they are removed) and whether crowding-out or crowding-in occurs. Such phenomena might influence cost-effectiveness and, in the absence of data to prove or disapprove their existence, assumptions might need to be applied to estimate their potential impact.

One aspect of the current research is to conduct an economic evaluation of financial incentives and explore some of the methodological considerations outlined above. This is reported in Chapters 8 and 9.

1.1.4. Controversies surrounding incentives

There are a number of issues surrounding financial incentive use in health that require consideration; these and the potential barriers to incentive use are discussed below.

1.1.4.1. Ethical issues

A major criticism of incentives is that they (and paternalistic libertarianism in general) are based on the assumption that policy makers make better choices for individuals than the individuals themselves. Further - that incentives represent a form of bribery and coercion, used to compel individuals to behave in ways they would not do if they had unfettered choice.(137-139) It could be countered that incentives do not represent government will over individual will as choices are not restricted, merely that some (healthier) choices are made more likely. However if incentives are offered to low income groups it is debateable to what extent they have free will over the decision to accept it or not.(138) These criticisms are concordant with the thoughts of John Stuart Mill who in 1859 argued that:

"*The only purpose for which power can be rightfully exercised over any member of a civilized community, against his will, is to prevent harm to others. His own good, either physical or moral, is not sufficient warrant*."(140)

More recently the liberal philosopher Ronald Dworkin argued that the state should be neutral as for an activity or behaviour to truly improve an individual's life then the individual must endorse its value themselves rather than be nudged or incentivised toward it; this he termed the '*endorsement constraint*'.(141) It could be argued that, as unhealthy lifestyles lead to greater burden on health services, the opportunity cost in terms of alternative uses of those resources foregone represent a potential 'harm to others', which is consistent with Mill's statement. Others have criticised Dworkin's idea of government neutrality (142) and in a piece defending the nanny state, Alain De Botton wrote:

"*We don't currently live in a "free" society in the true sense of the term. Every day, our minds are assaulted by commercial messages that reach us from all sides. The whole billion-pound-a-year advertising industry runs counter to any assertion that we're currently free and un-nudged as it stands..... We face temptations and compulsions which we revile, but which we lack the strength and encouragement to resist, much to our eventual self-disgust and disappointment.*"(143)

There are robust and defensible arguments for governments intervening in individual's health and choices (144), especially - as alluded to by De Botton - when individuals make choices that are inconsistent with their preferences and inconsistent with maximising their (future) quality of life.(113) These choices, unless guided by a paternalistic agent, might be more susceptible to inconsistency if the individual is highly present-biased, is disadvantaged or has low levels of health education.(145) Much of the incentives research in the UK has targeted pregnant women; as this includes the well-being of an individual (the unborn child) who has no control over their choices. Certainly in this case it is possible that there is a stronger moral imperative for incentive use.

Another claim against incentives is that they will change the Dr-Patient relationship from one based on trust to a financial affair.(113, 138) There is little narrative evidence of this occurring although the picture may change if incentives are applied on a wider scale and are provided by the health service. GPs in England have however been independent financial agents for a long time and have explicit incentives (in the form of the Quality Outcome Framework) of their own in which case it could be argued that the principal-agent relationship is already partly a financial transaction. Another criticism aimed at incentives is that they are essentially unfair since they reward individuals for being over-indulgent, for doing something they should do themselves and for which they already have incentives (improved health).(138) By extension, they could be seen as punishing those who do consume responsibly. It is not clear however that free will, opportunity and informed choice in health behaviour can be assumed. Health behaviour does not occur in a vacuum but, when it is a conscious choice (which may be seldom), is a function of upbringing, social norms, education, circumstances and a conflation of many other factors only some of which an individual has autonomy over. It has been argued that for this reason individuals are not fully responsible for their health behaviour.(146)

There is certainly scope for incentives to be abused, especially with individuals who have limited control over their situation. For example, a recent think tank called for the benefits of unemployed people to be docked if they failed to adhere to prescribed exercise regimes (147) and incentives were offered in the US if drug-abusing women acceded to sterilisation.(148) However, all arguments considered, the use of incentives (if only in research) is warranted given the potential benefits of reduced inequalities.

1.1.4.2. Acceptability

Even if evidence weighed in favour of the use of incentives on a wider scale, it is likely that there would be opposition to this move. Governments may be wary of funding schemes that could be considered unfair or unacceptable by the public. They have hesitated in encouraging their use and it is possible that research in the area has been stymied for that reason. Despite NICE guidance recommending the use of contingency management in alcohol abuse, years after publication this has not been attempted in the UK. With the growing notion that incentives may have some part to play in health behaviour change, a number of studies have specifically looked at the acceptability of them to the general public.

One of the first explorations of acceptability in the UK was with the NICE Citizen's Council who discussed their use in 2010.(81) In the event, 20 out of the 32 (62.5%) Council members thought there were circumstances when incentives were a legitimate use of public funds. There were however a number of caveats:

- incentives should never be exchangeable for tobacco or alcohol;
- should only be offered to people who are committed to changing their health behaviours;
- cash incentives should be only offered as a last resort;
- progress of participants should be monitored throughout;
- results of the schemes should be analysed so that more can be learnt about their effectiveness

Ipsos MORI conducted a poll in 2012 to evaluate the acceptability of offering incentives to low income groups to encourage behaviour change.(149) Key findings were that incentives were more acceptable to the public than taxation or legislation and were more acceptable when children were involved. The way the questions were framed also made a significant difference with ‘rewards’ considered much more acceptable than ‘payments’.

A recent study exploring the public perception of incentives in the UK and US found little support for them in weight loss, addiction and smoking but did so for mental health.(150) However, the study authors concluded that incentives could not be rejected on the basis of public opinion alone and that further research is required to inform policy. Elsewhere, a US general public sample (n=1010) was asked which of a number of smoking cessation interventions (including an incentive) they would support. The financial incentive received the lowest support (39.3%) but was not statistically different from treatment (45.8%, p=0.14) or medication (41.7%, p=0.58).(151) While most studies have approached the general public to ascertain their opinion (although a fair proportion will engage in some unhealthy behaviour) a study in Australia approached socially-disadvantaged smokers. The study found that 46% believed incentives were an excellent/good idea; 38% viewed them as a bad/very bad idea and 47% believed incentives did more good than harm. Those who smoked were more likely to agree with incentive use than those who did not. Another study sought the opinion of healthcare professionals on the acceptability of incentives for promoting breastfeeding finding that the major concern was the risk to the relationship with the patient.(152)

Research is ongoing into what forms public opinion on the issue but it is likely that the framing of incentives may be important – for example they may be more acceptable if they are shown to be more cost-effective than alternatives or it is shown that individuals in receipt are not necessarily responsible for their circumstances and behaviour. This was the finding by Promberger et al (2012) who conducted a discrete choice experiment on incentive acceptability.(153) Results indicated that the acceptability of incentives was dependent on their effectiveness with even small increases in efficacy (measured by an attribute describing the percentage of people they are proven to help) leading to relatively large changes in acceptability. To illustrate, increasing how effective the incentive is when describing it (from 10% to 11%) increased the number of people supporting their use from 46% to 55%. In concordance with the NICE Citizen Council views, healthy grocery vouchers were more acceptable than either cash or vouchers for luxury items. In addition, incentives had more support when used for weight loss than for smoking cessation (60% vs. 40%).

Incentives will remain a contentious issue, especially when concepts of responsibility and public money are introduced. The issue of public opinion is only a major concern when public money is at stake; this is not the case when individuals put their own money at stake via websites such as Stickk and WeightWins. It is clear that the way schemes and studies describe incentives is important, as is their effectiveness. Although there is currently little evidence to suggest that incentives are cost-effective compared to standard behaviour change interventions, should that be the case it is likely that their acceptability will be even higher.

1.1.4.3. Unintended negative consequences

In addition to questions over the morality and acceptability of incentives, there is concern about their potential for unintended negative consequences. A particular worry is that incentives may ‘crowd-out’ good behaviour. Humans have an intrinsic reward system that delivers a ‘warm glow’ (or utility) following certain actions or behaviours. Examples of behaviours that might initiate the intrinsic reward system are acts of altruism, pro-social behaviour, achieving goals and honouring commitments. In a classic text ‘The Gift Relationship: from Human Blood to Social Policy’ (1970)(154) Richard Titmuss describes the different national policies relating to blood donation and in particular whether people are paid for it or not. Titmuss considered a scenario where blood giving policy changes from donation to payment and describes a potential phenomena he termed ‘crowding out’; that the intrinsic motivation and reward for carrying out an altruistic act (the gift of blood) may be extinguished if the act is no longer altruistic but leads to financial remuneration (‘extrinsic reward’). In this scenario, if the expected utility of remuneration is less than that provided by the altruistic act, then overall motivation may be reduced and blood donations may decline. There is some evidence that this is the case (155) although not when non-monetary incentives are used.(156) There is substantive corroborating evidence for its existence from the fields of education and employment.(157-159) However there is little or no evidence in the field of health behaviour change of this phenomenon. As noted in the earlier sections, intrinsic motivation alone does not currently appear to be sufficient to persuade individuals (especially those in lower income groups) to change their behaviour, therefore the impact of any crowding-out may be minimal. In fact it is the lack of intrinsic motivation which is a major argument in favour of incentive use.

Conversely, there is evidence that incentives can ‘crowd-in’ behaviour and lead to positive, spill-over effects. A study of rewards for gym attendance showed that, physical activity actually increased after the incentive was removed - as a result, the authors believe, of habit formation.(115) An English pilot study offering incentives for smoking cessation during pregnancy reported that, in 42% of cases, someone close to the incentivised participant had also quit smoking. Furthermore, 94% of the households that were not smoke-free at study outset were so at study end even though the incentive was not contingent on that particular outcome. The success of incentives – certainly for complex behaviours - may depend on their ability to encourage the formation of habits. In theory, incentives provide the motivation (that for whatever reason is absent or insufficient) for individuals to initiate behaviour change and by the time the incentive is removed intrinsic motivation (or automated behaviours) will have taken over to ensure that behaviour change is maintained. However, there is currently little evidence to corroborate or refute this hypothesis.

An additional worry is that individuals may engage in deception or strategic behaviour to acquire financial incentives. For example, pregnant women may either start to smoke or consider delaying cessation in order that they can join an incentive scheme. This may be unfounded though; a review of smoking cessation incentive studies found no evidence of this type of behaviour.(116)

1.1.5. Summary

Preventable illnesses are a significant burden on health services and societies. Unhealthy behaviours explain a large proportion of preventable illness risk and are in several cases increasing, or, at any rate, increasing disproportionately in low income groups. This latter phenomenon contributes to increasing health inequalities in England. As these illnesses are preventable, reducing them – and necessarily the unhealthy behaviours that cause them – is viewed as a matter of social justice. However, current methods available to bring about behaviour change have either had limited impact or are perceived to be politically unpalatable. In this context, the use of financial incentives is starting to be explored as a tool to change behaviour. Evidence to date for their use is promising but often effects are not sustained. There are a range of arguments offered in opposition of incentives; on the grounds of ethics, acceptability and their potential for negative consequences. Robust counter arguments can be made against each of these and it is clear that, rather than being ruled out, the use of incentives should be discussed further in light of study evidence.

1.1.6. Need for further research

A number of incentive trials have recently been initiated and it is also clear that local government authorities (now responsible for public health) are creating their own incentive schemes. Research in this area is growing and we are beginning to understand what works.(123, 158, 160, 161) We know, for example that incentives work better for one-off or simple behaviours (e.g. vaccination, screening attendance) than sustained behaviour (e.g. maintained weight loss) – although this was challenged in a recent review (83); that incentive levels need to be high enough (relative to income) to motivate (or, larger incentives are better than smaller ones)(162); immediate rewards are better than delayed ones; frequent and increasing incentives are required for sustaining behaviour change; and rewards for group performance are better than those for individual performance.(121, 163) However it is acknowledged that the mechanism by which incentives work is complex and may be different depending on the context.(164)

General guidance aside, there are still many unanswered questions relating to the design, implementation, and (cost-)effectiveness of incentives with several reviews calling for more research in the area.(110, 124, 165) Methodological trials are underway in the US including one evaluating different incentive structures on smoking cessation including (individual and cooperative) financial rewards and deposit contracts.(166) Other studies are exploring the timing and duration of incentives (167) and impact of different win probabilities in an incentive lottery.(168) Key outstanding questions include: which health behaviours are incentives most effective for?; what type of incentive structure is most effective and does this vary between social groups or health behaviours?; are incentives effective in engaging and changing behaviour of low income groups?; what is the optimal timing and frequency of incentive delivery?; what is the impact of unintended consequences, particularly crowding-out? can effect be sustained after incentives are removed?; are they cost-effective?

Very little research has been done on the pricing of incentives although it is clearly of importance.(162, 169) The Paul-Ebhohimhen and Avenell review of incentive studies in weight loss found a weak trend in favour of incentives being more effective when they exceeded 1.2% of individuals' disposable incomes.(121) Bonevski and colleagues ran a survey of incentives for smoking cessation finding that the most common incentive level required for 12 months of cessation was either \$500 or \$1000.(170) You et al constructed a discrete choice experiment to identify incentive levels for weight loss.(171) The study found that the effect of both cash and grocery cards were about 10 times larger than that of a gym pass and that payment timing was important (monthly payments and one cumulative payment at 12 months being preferred to a single payment at 3 months). At this preferred payment structure, an incentive of $98 resulted in a predicted participation rate of over 90% among overweight or obese men and women. Reviews have found it difficult to identify in studies a rationale or justification for the choice of the incentive amount or payment schedule.(121, 135) Several authors call for further research to establish optimal incentive levels and potential factors influencing efficacy.(83, 116, 160, 172)

Notwithstanding the promise highlighted by some studies of incentives, any incremental behaviour change success they have brought have, in the main, been modest. However, it is possible that incentive schemes could be finessed to yield improved results.(173) Volpp and colleagues argue behavioural economics suggests that "*the same decision errors that contribute to poor health-related behaviors can be used to "supercharge incentive programs".* It may also be possible to apply a 'personalised medicine' approach, tailoring incentives to individuals. Further, by making incentives dynamic – should that be practicable - they could respond to fluctuations in levels of motivation and to changes in the feedback of behaviour change success (or failure). If low motivation (or lack of intention) is the target health 'disease' and financial incentive the 'treatment' it is possible to conceive of a dose-response model where incentives are commensurate with the deficit in motivation and change in line with this. In addition, in behaviours which are not 'all or nothing' such as physical activity or weight loss, there is also the need to account for goal setting of the desired behaviour (e.g. how much weight should an individual be incentivised to lose?) Again, the published research is silent on this.

1.1.6.1. An economic framework for incentives

It is important to identify which factors determine whether individuals achieve and sustain behaviour change, to enable an improvement in the targeting and success of these interventions in the future and a reduction in health disparities. There is a great deal of research in public health and health psychology examining the causes of unhealthy behaviour and the factors influencing behaviour change; indeed it is a discipline in itself. A number of health behaviour models have been developed such as the Health Belief Model, Stage of Change Model, Social Cognitive Theory, Relapse Prevention Model, Theory of Reasoned Action and Theory of Planned

Behaviour.(174) However, these models are often inconsistently applied and evidence does not recommend any one over another.(175)

Incentives have been studied extensively in the field of business and management, primarily with a focus on the relationship between pay and performance. A number of studies have considered frameworks to capture aspects of incentives (176-179), including the relationship between incentives and motivation and, specifically, the potential for crowding-out of intrinsic motivation (180-183), and the impact on the principal-agent relationship.(184) A formal and comprehensive economic framework for incentives in health would be a valuable tool for researchers and policy makers but is, as yet, unavailable. Such a framework, proposed for development here, could incorporate the pricing of incentives, impact on health inequalities, potential for crowding out and incentive cost-effectiveness taking into account these factors.

1.1.7. Aims and Objectives

The aim of the PhD research was to generate a framework that would help describe and predict the impact of, and inform the design and analysis of, financial incentives within the context of cardiovascular disease prevention. To achieve this, a programme of research was undertaken with a number of objectives that were split into those relating to cardiovascular disease prevention and those that were more generally related to the use of financial incentives in health:

Objectives relating to financial incentives for cardiovascular disease prevention:

a) Conduct a configurative, structured review of the literature to identify neo-classical and behavioural economic theories that have been employed to explain behaviour change or that might be useful in describing the impact of financial incentives.
b) Based on the synthesis of theories identified by the review, propose a theoretical framework that describes the effect of financial incentives on the process of behaviour change for CVD prevention and the factors that might determine effectiveness.
c) Using information from the review and theoretical framework, generate and test a contingent valuation survey. Gather data relating to the acceptability and pricing of incentives and capture information relating to key concepts and theories from the proposed theoretical framework.

d) Conduct regression modelling on the survey data to identify optimal levels of incentives, incentive acceptability and the determinants of these.
e) Using weight loss as a case study, conduct an aggregative, systematic review and meta-analysis of financial incentive studies to provide synthesised estimates of effectiveness and other parameter values for use in a decision-analytic model.
f) Analyse individual patient-level data of incentives in weight loss to explore the relationship between financial incentive levels and effectiveness, taking into account heterogeneity.
g) Generate a decision-analytic model to estimate the cost-effectiveness of financial incentives in weight loss using information from objectives d), e) and f) to parameterise the model.

Broader objectives relating to financial incentives in health:

h) Based on the literature reviews, propose a generalised theory of how financial incentives influence behaviour change.
i) Examine the relationships between minimum incentive levels required and factors such as perceived difficulty of behaviour change, individual characteristics and attitudes.
j) Examine the extent to which required incentive levels may change over time.
k) Identify methodological issues relating to decision-model-based economic evaluations of financial incentives in health.
l) Make general recommendations for future research, analysis and design of user financial incentives in health.

Chapter 2 reviews the literature on neo-classical and behavioural economic frameworks that have been used to explain health behaviour and behaviour change (objective a). It provides a description of the process of behaviour change (relating broadly to behaviours which increase the risk of cardiovascular disease) and the potential effects of financial incentives and uses these to evaluate whether the frameworks identified would be useful in describing the impact of incentives. They are also employed to identify additional behavioural theories that might be useful. Chapter 3 then considers and synthesises aspects of these models and theories into a framework for financial incentives in health (objectives b, h). The framework aims to describe the important factors and processes that determine behaviour change; how financial incentives fit within this and their likely mode of effect; and, finally, factors that influence the potency of this effect. Chapter 4 uses the factors and relationships hypothesised in Chapter 3 to develop a contingent valuation survey to both determine acceptable incentive levels and explore what influences these (objective c). The survey data analysis is reported in Chapter 5 (objectives d, i, j), providing some test of the relationships set out in the framework.

Chapter 6 moves on to introduce the cost-effectiveness of financial incentive schemes, using weight loss as an exemplar. Chapter 7 reports the analysis of data from a trial of incentives in weight loss and a systematic review and synthesis of incentive schemes in weight loss (objective e, f) which provide estimates of effectiveness for the economic evaluation. Chapters 8 and 9 present the decision-model based economic evaluation of incentives in weight loss (objectives g, k). Finally, Chapter 10 considers the work streams and makes recommendations for the design and analysis of incentive schemes, discusses the future of incentives and highlights the priorities for future research (objective l).

2. Literature reviews

There are several definitions of what constitutes a systematic review and these have evolved over time. For example, some organisations (e.g. The Campbell Collaboration) now require user involvement in the review process. Broadly speaking, though, systematic reviews are considered to require a clear research question and transparent, explicit, reproducible methods in searching and data extraction. Ideally they should be completed by two independent researchers and also include a synthesis of results. Gough and co-authors provide a useful typology of systematic reviews, distinguishing between ‘aggregative’ and ‘configurative’ reviews.(185) The former being research aimed at combining and averaging information to make empirical statements (such as reviews of treatment effects and meta-analyses) and the latter aimed at understanding theories, arranging information and developing concepts. Configurative reviews are more exploratory and accept that methods may be adapted in an iterative manner during the research.(185) It was this latter type of review method that appeared to suit the study objectives.

A configurative review was conducted to: identify neo-classical and behavioural economic frameworks currently used in economics to model and explain health behaviour change; and to evaluate the suitability of the identified theories for explaining the effect of incentives and for use in an incentive framework. The review reported in this chapter was considered to be ‘configurative’ since it had a broad scope and used an iterative approach to identify relevant theories. These theories were used to propose an over-arching theory of incentives in behaviour change rather than being aggregated in a quantitative sense. Given the nature of the review it was impractical for the study selection to be completed by two researchers and it was not possible to have a uniform data extraction form or to synthesise data and thus the review cannot be considered to be systematic. However, while acknowledging these limitations may limit the prospect of reproducing the results, the review was considered structured as the aims, searches and inclusion and exclusion criteria are described explicitly.

2.1.1. Aims and research questions

The purpose of the literature review was to establish the extent to which traditional economic theories and models and behavioural economic theories have been employed in attempts to explain health behaviour change. More specifically, to identify the contexts in which economic frameworks have been employed to describe and explain the decision of individuals to continue with unhealthy lifestyles such as smoking, poor diet, sedentary behaviour or excessive alcohol use, or to attempt to change their behaviour. The review also sought to identify how and where in these frameworks incentives could plausibly fit and whether the frameworks were suitable for explaining how financial incentives may bring about change. Finally, the review aimed to identify other theories – from traditional and behavioural economics - that could potentially be important explanatory factors in incentive pricing, impact and effectiveness.

2.1.2. Research questions:

1. What neo-classical economic frameworks have been employed to explain health behaviour and health behaviour change?
2. How might these frameworks incorporate the impact of financial incentives to encourage behaviour change?
3. What behavioural economic theories may be relevant in explaining the impact of incentives?
4. What theories may help inform the design and pricing of incentives?

2.2. Methods

2.2.1. Literature search

2.2.1.1. Search terms and databases

Before beginning the full searches, scoping searches were completed to identify key studies and review papers in order to identify relevant concepts in the field and search terms typically used by other reviews. Searches of PubMed, EconLit, Google Scholar (which now incorporates IDEASrepec) and health economics textbooks were conducted to identify relevant economic frameworks that had been proposed to explain and predict health behaviour change and a targeted search using the models identified as search terms was conducted subsequently. In addition, search terms used in previous incentive reviews were consulted and incorporated here.(116, 121, 135, 136)

Three sets of search terms were generated that included both general terms and specific framework names and concepts that had been identified *a priori* as important or had been included in previous reviews. Sets of search terms were generated for: health frameworks; incentives; and health behaviours. The economic framework search terms included: “economic framework”, “economic perspective”, “utility maximisation”, “grossman model”, “health capital” and “rational addiction”. The incentive search terms included: “financial incentive”, “monetary reward”, “deposit contract”, “contingency management” and “contingency payment”. While the health behaviours search terms included: “obesity”, “weight loss”, “diet”, “physical activity”, “exercise”, “smoking” and “alcohol”. The full initial (wave 1) search terms are included in Table 1. Any additional frameworks and concepts identified during the review process were used in targeted supplementary (wave 2) searches, shown in Table 2. Wave 2 was conducted to ensure that applications of the theories identified early in the review were captured, acknowledging that the more general search terms in wave 1 may not have been sufficiently sensitive to achieve this. For example, the theory of ‘ego depletion’ was not included in wave 1 as it was unknown to the researcher but identified as being potentially relevant during the review of wave 1 search results. The targeted searches in wave 2 helped identify publications that used the concept that otherwise would have been omitted.

The search strategy was an iterative process, at first testing several approaches until the results yielded appeared sufficiently sensitive but specific enough to be manageable. For example, searching for incentive terms alone in titles, abstracts and keywords yielded several thousand results that were sensitive but not sufficiently specific thus the requirement was added that one of the framework terms was also present in these fields. Similarly, when the framework terms were included only in the title, the results were considered too few when combined with the other search term sets and so was broadened out to keywords and abstracts. The searches were conducted in April 2011 and updated in August 2014.

Table 1: Search terms – wave 1

Incentive terms	**General economic framework terms**	**Specific economic framework and concept terms**	**Health behaviour terms**
“financial incentive”	“economic framework”	“utility-maximi*”	obes*
“financial disincentive”	“economic model”	“utility theory”	overweight
“monetary incentive”	“economic perspective”	“consumer choice”	diet*
“non-monetary incentive”	“behavioural economic”	“rational choice”	"weight loss"
“financial reward”	“behavioural finance”	“rational addiction”	smok*
“monetary reward”	“behavioural model”	“health investment”	tobacco
“deposit contract”		“investment in health”	cigarette
“commitment contract”		"health capital"	nicotine
“contingency management”		“demand for health”	alcohol
“contingency payment”		“grossman model”	exercis*
“cash transfer”		“time preference”	"physical activity"
		“intertemporal choice”	"physical inactivity"

		“intertemporal decision” “future discount*” “crowding in” “crowding out” “intrinsic motivation” “internal motivation” “extrinsic motivation” “external motivation” “deferred gratification” “delayed gratification”	“unhealthy lifestyle” “sedentary behaviour” “sedentary lifestyle” “cardiovascular risk”

Table 2: Additional searches - wave 2

Incentives terms	**General economic framework terms**	**Specific economic framework and concept terms**	**Health behaviour terms**
“financial incentive”	“economic framework”	“mindspace”	obes*
“financial disincentive”	“economic model”	nudge	overweight
“monetary incentive”	“economic perspective”	“self control”	diet*
“non-monetary incentive”	“behavioural economic”	“Self regulat*”	"weight loss"
“financial reward”	“behavioural finance”	Willpower	smok*
“monetary reward”	“behavioural model”	“ego depletion”	tobacco
“deposit contract”		“bounded rationality”	cigarette
“commitment contract”		“hyperbolic discount*”	nicotine
“contingency management”		“dynamic inconsisten*”	alcohol
“contingency payment”		“delay discount*”	exercis*
“cash transfer”		“reward discount*”	"physical activity"
		“multiple selves”	"physical inactivity"
		“future self”	“unhealthy lifestyle”

		Picoeconomics “mental accounting” “myopic addiction” “primrose path” “prospect theory” “loss aversion” “default bias” “status quo bias” “cognitive bias” heuristic	“sedentary behaviour” “sedentary lifestyle” “cardiovascular risk”

The review included the databases listed in Table 3; these were chosen as it was thought they would yield studies with health, psychology and more economic and business orientations. The search covered:

- English language papers only
- Human studies only
- Grey literature (e.g. reports and working papers)
- Conference abstracts
- All years (no date restrictions)

Table 3: Databases and Sources searched

Database	**Provider**
Medline	Ovid
Embase	Ovid
PsychInfo	Ovid
Business Source Premier	EBSCO
Econlit	EBSCO
Google Scholar	N/A

The final search strategy (Table 4) was arrived at via an iterative process of testing the targeting of terms, results and limits.

Table 4: Search strategies

EBSCO - EconLit and Business Source Premier; OVID Medline, Embase and PsycINFO		
[INCENTIVE TERMS, TITLE, KEYWORD, ABSTRACT]	AND	[GENERAL FRAMEWORK TERMS, KEYWORD, ABSTRACT]
OR		
[GENERAL FRAMEWORK TERMS, TITLE, KEYWORD, ABSTRACT]	AND	[HEALTH BEHAVIOUR TERMS, TITLE, KEYWORD]
OR		
[SPECIFIC FRAMEWORK/THEORY TERMS, TITLE, KEYWORD]	AND	[HEALTH BEHAVIOUR TERMS, TITLE, KEYWORD]
Google Scholar		
[INCENTIVE TERMS, TITLE]	AND	[HEALTH BEHAVIOUR TERMS, TITLE]
OR		
[GENERAL FRAMEWORK TERMS, TITLE]	AND	[HEALTH BEHAVIOUR TERMS, TITLE]

2.2.1.2. Review methods

The inclusion and exclusion criteria were as follows:-

Inclusion criteria:

- English language, human study publications that either:
- Presented an economic or behavioural economic framework or theory relevant to health decisions and behaviour or incentives

or

- Reported an application of a framework or theory to behaviour change related to tobacco or alcohol use, obesity or physical activity or incentives

Exclusion criteria:

- Non-English language publications
- Animal studies
- Individual studies reporting the application of frameworks or theories to the behaviours outlined but not considering behaviour change
- Studies reporting on health psychological models of behaviour change only or on employment-related applications of incentives only

Abstracts yielded by different databases were pooled and duplicates removed. Abstracts and titles were reviewed to identify potentially relevant studies. Full papers of shortlisted studies were obtained and read for relevance and their bibliographies searched for other relevant references. There was no data extraction form for the review given the disparate nature of the results and since this was a configurative review where the interest lay in general concepts rather than specific study results. The identified economic frameworks were briefly described and their applications in health behaviour change assessed. The suitability of each framework and theory for capturing the impact and effectiveness of financial incentives was appraised. Consideration was given to whether the identified frameworks and theories could explain the potential for incentives to encourage individuals to initiate and also maintain behaviour change (as all the behaviours in question are complex rather than 'one-off' tasks). The discussion covers how characteristics of incentives and their interaction with characteristics of the individual might affect incentive efficacy. A summary section is devoted to summarising the strengths and weaknesses of the available frameworks and the degree to which their predictive validity has been evidenced. For the latter, the literature review results were searched specifically for studies that explored the predictive ability of the framework. The following terms were used for this purpose: "predictive", "prediction", "validation", "out-of-sample", and "model performance".

To enable an assessment of whether the frameworks and theories are useful in describing behaviour change (specifically, weight loss, healthy eating, physical activity, smoking cessation and reducing alcohol consumption – the main causes of cardiovascular diseases) and the impact of incentives, it was necessary first to broadly define the process of behaviour change and what the impact of incentives might be.

2.2.1.3. Defining the process and impact of behaviour change

Individuals endeavouring to change their health behaviour will potentially incur a number of costs and benefits.

1. The health behaviours under consideration are complex in that (unlike a vaccination or a screening test visit) they require sustained effort. There are many theories (mostly from health psychology) about how and why behaviour change is enacted and about the process of change.(186, 187) However what is unarguable is that; a) some people start behaviour change and some do not; b) of those who start, some achieve sustained change and some do not. Thus it seems sensible to consider the framework and theories in terms of a) initiation; and b) maintenance.

2. There are often financial costs to be borne by the individual in changing behaviour such as travel, gym membership fees or sports gear purchases(188), nicotine replacement therapies and healthier diets.(189, 190) There may not be cost savings to individuals except for smokers who will potentially save a non-trivial proportion of their income (depending on the level of their usage) by not smoking (See Table 8: Costs of smoking).(191)

3. There may also be a time cost to individuals of behaviour change although, again, this will depend on the behaviour. There may be little time cost associated with smoking cessation but more with diet change, especially in switching from processed food to meals prepared with fresh ingredients.(192, 193) Physical activity may bear the highest time cost as travel to a sports venue is often needed in addition to exercising time.(194, 195)

4. Individuals will experience ‘physical’ (dis)utility associated with the change process. The cravings experienced after smoking cessation(196, 197), withdrawal from alcohol(198), sugary, salty or fatty foods(199) or the physical pain and tiredness when exercise regimes are commenced all represent potentially significant sources of disutility. The marginal disutility of these may diminish over time although this is likely to depend on the type of behaviour –

for example, exercise gets easier as the individual becomes fitter.(200) Conversely, behaviour change may lead to utility associated with health benefits. For example, former smokers may feel generally healthier and be more able to exercise; those becoming physically active or eating healthier foods may feel generally better, have higher energy levels and improvements in sleep and mood.(201, 202) As with the disutility experienced, it is possible that the marginal utility gains will diminish over time. Individuals commencing diets and physical activity programmes may find that weight loss is greater to begin with as are gains in fitness levels but that these tend to plateau after a certain time (or amount of progress) and greater efforts are required for the same increases in benefit.(200, 203-205) The shape of the marginal utility curve may be different for each behaviour over time.

5. Behaviour change bears a ‘cognitive cost’; the effort or willpower required to exert self-control and avoid giving in to temptation. This willpower may be depleted over time making it more difficult to maintain healthier behaviours.(206, 207) Additional cognitive effort may be required in making consumption choices; whereas previously these were in part determined by habit and default behaviour now conscious consumption choices must be made(208), especially in relation to weight loss and healthy eating.

6. The psychological impact of behaviour change may be significant. There will be utility or disutility associated with success or failure in behaviour change which emanates from the human intrinsic reward and punishment system.(209) Failure may carry an emotional cost of the embarrassment, stress, humiliation, guilt and a deleterious impact on self-esteem.(210-212) Success will bring the opposite and boost self esteem and emotional well-being.(212, 213) These effects – positive and negative – may be greater if commitments to change were made publicly or if there is an impact on a group (e.g. group incentives).(214) In addition, the utility impact of success or failure may depend on the level of resources invested in change. For example, failure will be particularly hard felt if the individual ‘gave their all’ in trying to achieve change.

7. There may also be a social impact of behaviour change although this may depend to some degree on the particular social norm that the individual is subject to. This may be positive if it moves the individual in line with social norms (215) or negative if the behaviour is contrary to these norms, for

example, leading to the person being judged by peers for ‘self-advancement’ efforts.(216)

8. Even where behaviour change is achieved in the short run, in the long run individuals often revert back to their previous unhealthy lifestyle for one or more of any number of reasons.(186) Sustained behaviour change may come about if the individual continues to experience the benefits of change, for example, if they find they enjoy exercising or have redirected their tobacco budget to other utility-yielding consumption. Sustained change may also be aided if individuals make their healthier lifestyle a ‘habit’ - that is, their behaviour no longer requires conscious effort or willpower even if they do not find the behaviour ‘pleasant’.(217, 218)

2.2.1.4. Defining the impact of incentives

1. The most obvious expected effect of incentives is to increase the motivation for the initiation and/or maintenance of the incentivised behaviour.(161) The level of effect will depend on individual, behaviour and incentive characteristics (see Table 6 for these considerations).(158, 160)

2. Incentives may also (or only) remove financial barriers to behaviour change - for example, by enabling the individual to afford gym attendance, healthier diets or travel.(188, 219) If the individual had the intention to change behaviour and were sufficiently motivated at the outset but were deterred by cost, the incentive level may only need to equal the monetary cost of behaviour change to be effective. This might be achieved with subsidised healthy foods, nicotine replacement therapies or free gym memberships rather than financial rewards. However, it is considered unlikely that most of the group of particular interest (low income) would have sufficient motivation at the outset.

3. Incentives would increase the income of individuals, albeit by a small amount and in the short run, assuming that most incentive schemes have a maximum duration (for example, 12 months). In the case of smoking cessation and reduced alcohol consumption, the behaviour change would also free up a - probably non-trivial - proportion of income. This income could be diverted from unhealthy to healthy consumption or from one type of unhealthy consumption

to another depending on the relationship of the goods (i.e. if they're substitutes).(220)

4. Schemes often require the individual to undergo an assessment to confirm that they are adhering to the required behaviour change; this may mean monthly clinic visits for nicotine tests or weigh-ins which may bring a time and financial cost (e.g. for travel).

5. Incentives may 'crowd-out' behaviour in two ways: a) if the incentive level is insufficient it may reduce the motivation of the individual to a level below what it would be in the absence of an incentive(162); b) after the incentivised period has elapsed, the individual may experience a 'relapse' such that their motivation reduces to a level below that had no incentive been offered initially.(157)

6. Conversely, incentives may 'crowd-in' behaviour.(221) This could manifest in a number of ways: a) the individual adopts more healthy behaviours that were not incentivised – for example, stopping smoking and then also joining a gym or reducing consumption of complementary unhealthy goods(222, 223); b) unincentivised peers of the individual may adopt healthy behaviours either to help the individual or due to observing any positive effects of behaviour change in the individual(224, 225); c) the incentivised behaviour becomes self-sustaining (or habitual) after the incentive period has elapsed.(115, 226)

7. Incentives may encourage 'strategic' or 'gaming' behaviour; that is, they may encourage people to take up an unhealthy behaviour to make them eligible for incentives while others may delay behaviour change in order to qualify for schemes. This is considered unlikely however and there is little evidence of this phenomenon.(116)

8. It is possible that the mere offering of an incentive provides a signal to the individual that the incentivised task or behaviour is desired and valuable; this would amount to an increase in information. However, it is likely given modern media coverage of unhealthy behaviours and their consequences that individuals would already have this information.

It is possible to postulate that a number of factors known to influence health behaviour may not be affected by incentives:

- Information (except possibly for point 8 in section 2.2.1.4)
- Skills or education
- Social norms or peer effects (except possibly for point 7 in section 2.2.1.3)
- Attitudes to risk and risk perception
- Environmental effects

Table 5 includes factors that have been suggested as potential explanatory factors in the effectiveness of incentive schemes. They have been included here either because they have been reported in reviews as key components of incentives, found to be important covariates or design features in predicting incentive effectiveness or found to be significant predictors of stated preferences for, or willingness to accept, incentives. In addition, other, more general concepts in behaviour change are included (e.g. social norms). Pre-specifying these – although they may be supplemented post review – facilitates the identification of related theories. Recently a formal framework for characterising incentives has been published (227) although it describes incentives in narrower terms than is done below.

Table 5: Factors likely to affect incentive efficacy

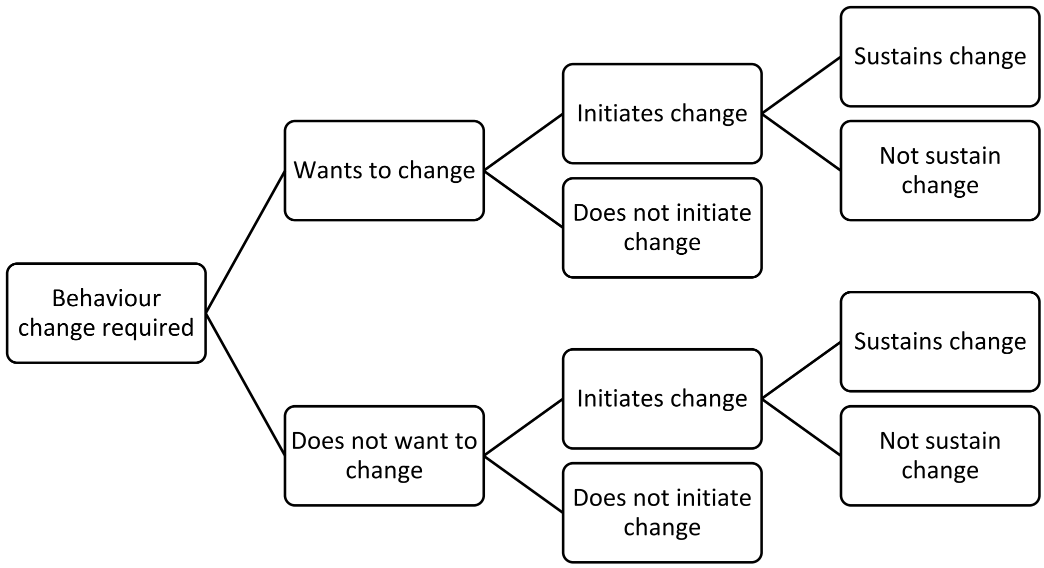
Individual characteristics	**Behaviour characteristics**	**Incentive characteristics**
Age (e.g.(228))	Stopping (e.g. smoking) vs. starting (e.g. exercising)(e.g.(161))	Level (i.e. price) (e.g.(162))
Gender (e.g.(170))	One-off (e.g. Dr visit) or complex (e.g. weight loss, smoking cessation) (e.g.(160))	Frequency of receipt (e.g.(171))
Income level (e.g.(170))	‘Strength’ (e.g. number cigarettes smoked, weight)(e.g.(170))	Timing of receipt (e.g.(171))

Social group (norms)(e.g.(65))	Knowledge and skills required (exercising and diet change) or not (smoking cessation) (e.g.(229))	Immediacy (i.e. how soon they are received after behaviour) (e.g.(160))
Internal motivation (e.g.(230))	Cost saving (smoking cessation) or not (exercise and healthy diet)(e.g.(161))	Duration of receipt (e.g.(231))
Education and skills (e.g.(188))		Individual vs. group (e.g.(232))
Risk perception (e.g.(233))		Disincentive vs. incentive (e.g.(114))
Perceived control and likelihood of success (e.g.(234))		For disincentives – where does lost money go? (e.g.(235))
Mood(188)		Monetary vs. non-montetary (e.g.(171))
Time-preference or discount rate (e.g.(236))		Tasks required for verification (e.g. monthly testing (237))
Self-control or willpower (e.g.(238))		What is incentivised (participation vs. behaviour vs. outcomes) (e.g.(239))
Current health and future health expectations (e.g.(240))		Incentive framing (e.g. ‘reward’ vs. ‘payment’(149))
		Certainty of pay-off (certain vs. lottery)(e.g.(114))

		Who pays (e.g. NHS vs. private vs. co-workers)(e.g.(228))

Figure 5 illustrates in simple form the potential outcomes for an individual who is at risk of cardiovascular disease and requires behaviour change. This basic decision tree helps clarify the process of change. The distinction between wanting to change and not may be important for discussions about rationality and the role of government paternalism and intrinsic and extrinsic motivation. The dichotomy simplifies reality as we might expect individuals to vacillate on a continuum of desire to change.

Figure 5: Behaviour change decision tree

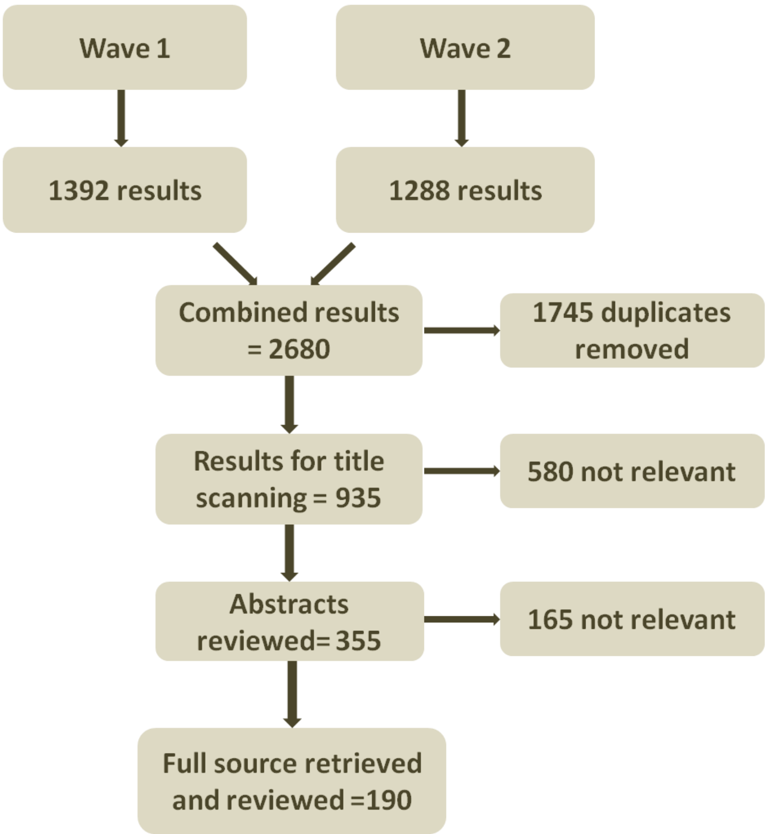


2.3. Results

2.3.1. Literature search

Initial search results from OVID and EBSCO were 1634 and 1046, respectively. After de-duplication 935 results remained for title and abstract scanning. In the Google Scholar [title word] searches with “financial incentive” and “health”, “smoking”, “diet”, “weight”, “alcohol”, “exercise” or “physical activity” returned the following results: 18, 3, 1, 8, 0, 0, 3, respectively. In total 355 results were selected for abstract review and 190 published papers, working papers, reports and book chapters were retrieved for review. See Figure **6** for full search results.

Figure 6: Framework literature search results



2.3.2. Overview

The review is split into sections covering theories which could be considered ‘neo-classical’ in as far as they make strict assumptions about the rationality of man; and those which could be considered ‘behavioural economic’ as they relax the rationality assumptions. The literature review revealed attempts to explain health behaviour using neo-classical economic frameworks generally fell into one of three types: those employing standard consumer choice/utility-maximisation frameworks; those using the health production/capital/investment in health frameworks; and models of addiction, although the latter two are essentially specific types of utility-maximisation frameworks. Addiction studies are dominated by those employing the rational addiction model proposed by Becker and Murphy (1988)(75) and the health capital studies dominated by the human capital model proposed by Becker (1964)(76) and later Grossman (1972)(77) and Wagstaff (1986, 1993).(241, 242) These models, their variants and their applications - where relevant - are described below. The suitability of these for describing health behaviour change is then briefly discussed. A number of behavioural economic theories were also identified which offer alternative explanations for choices in health; these are described as they may be of use in understanding the mechanisms by which incentives work and factors that may influence their efficacy.

2.4. Neo-classical theories

The consumption of certain goods (to excess) and particular behaviours represent a risk to health and as such this consumption or behaviour appears inconsistent with the fundamental tenet of neo-classical economics: that humans are rational and aim to maximise their utility. Despite this, risky health behaviours persist in a high proportion of individuals, even in those who desire and attempt behaviour change and especially in the lowest income groups. There is a body of work employing rational choice and utility-maximisation theories to the issue, hypothesising and occasionally providing empirical evidence for the - seemingly counter-intuitive – notion that people engaging in these risky behaviours may actually be behaving rationally.

2.4.1. *Consumer choice theory and utility-maximisation*

The concept of consumer choice and utility-maximisation is a core theme of both neo-classical and behavioural economics; people behave in ways and consume (quantities of) products such that their 'utility' is maximised. Further, that this utility-maximisation is their main goal in life. In doing this individuals are assumed to employ deliberative decision-making processes in weighing up the costs and benefits of behaviour and consumption options (over a lifetime) and choose accordingly. It is worth providing a detailed exposition of utility-maximisation here as the concepts are transferrable and used as the basis of several other relevant theories. The level of utility, U, attained is shown as a function of combinations of various goods and services, X:

$$U = U\ (X_1, X_2, \dots .X_n)$$

The utility that is derived from any good is subjective and personal and relates to individual preferences. Utility is defined here as *decision utility* or *preferences* as opposed to benthamite utility or utilitarianism proposed by John Stuart Mill (which might be considered a measure of overall happiness).(243) In seeking to maximise their utility, consumers are assumed to be rational agents acting in self-interest. Rationality means that consumers' decisions are consistent with their aim of maximising their *expected* utility in the presence of uncertainty. This concept originates from Daniel Bernoulli's work in 1738 and was developed by von Neumann and Morgenstern in 1947(244) while working on game theory. They provided a set of expected utility theory (EUT) axioms which describes how people make choices in the face of uncertainty:

1. Axiom of *completeness*: individuals have well defined preferences for bundles of goods and services which they can express. Thus given two states, A and B. A is preferred to B; B is preferred to A or the individual is indifferent between them.
2. Axiom of *transivity*: preference order is consistent across >2 products. So if A is preferred to B and B is preferred to C, it follows that A is preferred to C.
3. Axiom of *continuity*: if state B is between A and C in preference order, there is a lottery where an individual will be indifferent between certain B and p probability of A + (1-p) probability of C.
4. Axiom of *independence*: individuals do not change their preference order between two goods if a third good is offered. That is, if A is preferred to B and subsequently C is offered, A will still be preferred to B (regardless of the order of preference for C).

Additional laws have subsequently been described such as *non-satiation*: consumers' wants cannot be fully satisfied and greater consumption leads to greater utility; and *substitution*: individuals only care about the end outcome and are indifferent between simple and complex lotteries as long as the expected utility is the same. Consumers are limited by their budget constraint which is determined by their income and the prices of the goods under consideration. This is given by:

$$\sum_{i=1}^{n} P_i X_i \leq I$$

Which is the sum of the prices (P) and goods (X) less than or equal to their income (I). Many analyses assume that expenditure beyond income (debt) is not possible although this clearly is not reasonable given the ease of attaining credit. The indifference curve isoquant is concave in shape due to diminishing marginal returns and denotes equal levels of utility derived from different bundles of goods. The slope of the indifference curve is the marginal rate of substitution (MRS) or, to put it another way, the quantity of one good that must be exchanged for another in order that utility levels are unchanged. MRS is always negative and expressed:

$$MRS_{xy} = -\frac{\delta y}{\delta x}$$

In the case of two goods, a combination of goods is chosen where the ratio of prices (which represents the slope of the budget constraint) is equal to the ratio of marginal utilities (which represents the indifference curve slope):

$$MRS_{xy} = -\frac{\delta y}{\delta x} = \frac{MU_X}{MU_Y} = \frac{P_X}{P_Y}$$

In plainer terms, utility maximisation occurs when the indifference curve is tangential to the budget constraint. The above equation explains that individuals will maximise utility when the price of an additional unit of X is the same as that for an additional unit of Y; i.e. the marginal cost and benefit is equal.

2.4.1.1. Income and Price Elasticity

Elasticity represents the relative sensitivity of changes in one factor to changes in another – for example, the change in demand (for goods or health, for example) after a price increase. It is a useful concept in understanding how choices may react to changing circumstances. The price elasticity of demand (PED) is the percentage change in quantity demanded (Q) divided by the percentage change in price (P):

$$PED = \frac{\Delta Q\%}{\Delta P\%}$$

Elasticities of <1 mean that PED is relatively inelastic while elasticities of >1 indicate a relatively elastic demand. The income elasticity of demand (represented by the Engel curve) measures the responsiveness of demand to changes in income. The income elasticities can be used to define types of goods; the demand for normal goods increases if consumer income increases while the demand for inferior goods decreases when income increases. Normal goods can be further defined as either necessities, where the increase in demand is proportionately smaller than the increase in income; or luxury goods, where the demand increases by a greater proportion than income.

2.4.1.2. Applications in behaviour change

Utility-maximisation and consumer choice theories are the dominant paradigm and backbone of modern economic analysis. Where the assumptions behind these theories are rejected and alternative theories offered, the concept of an individual making consumption decisions with a goal of maximising the value they derive is common place. These core theories also represent the building blocks of more complex frameworks such as Grossman's health investment model and Becker and Murphy's rational addiction model. Thus there are relatively few examples of generic utility-maximisation applications as analysts have been attracted to the 'off-the-shelf' frameworks. There are many potential variants of a utility-maximisation framework thus only two are described in any detail here. Binkley uses a lifetime utility-maximisation model to evaluate smoking starting and quitting decisions in low income individuals.(245) The Binkley model is represented as:

$$U_L = U_1(x,Z) + \theta(s)\, P(x)\, U_2(g(M))$$

Where U_1 and U_2 are utilities in periods 1 (today) and 2 (tomorrow); Z is all other goods; M is today's income; $\Theta(s)$ is the discount rate at time s within period 1; g(M) is the expected income tomorrow which assumed to be positive or 0; and P(x) is the probability of survival in the next period (with $P(x) < P(0)$). The author focuses on the question of whether an individual chooses to begin consuming an unhealthy good (x) or not and whether to decide to quit, creating two equations. One of these includes the utility yielded today from consumption of x and the other for the utility of 'tomorrow' which includes the health effects (disutility) of the consumption of x. His model is similar to Grossman's (described later) in that total future income is considered a source of utility. Using US data on smoking behaviour from the Behavioral Risk Factor Survey (1994 to 2007), the study finds evidence for the idea that low income groups make unhealthy choices because the potential future costs – namely, loss of future earnings and associated utility due to illness – are lower for them (relative to high income groups). While the framework has been applied elsewhere (e.g.(246)) its predictive ability outside the original development studies has not been established.

In a theoretical study, Cawley uses a time allocation perspective model of utility-maximisation to understand diet and physical activity.(247) Cawley's Sleep, Leisure, Occupation, Transportation and Household (SLOTH) model estimates how individuals allocate time across activities. Here utility is maximised given three constraints of budget, time and biology (for weight gain and loss). The framework explains how individuals must make purchasing and consumption decisions within these constraints to reach targets of energy and fat content assuming higher costs and time inputs are required for healthier consumption. SLOTH improves on the Binkley model as it incorporates hedonic aspects of utility (happiness) rather than just the utility of income. It goes beyond typical utility-maximisation and Grossman models by adding constraints on time and targets for dietary intake that must be met and formally acknowledges that healthy eating and exercise have costs and that they improve health. It has since been used as a theoretical framework to consider potential interventions.(248)

The original paper did not empirically test the theory but variants of the model have been applied in empirical work. Humphreys & Ruseski (2006)(249) adapted the SLOTH model by differentiating between participation and duration decisions in sport and between different types of activity. They improved the model by including the costs incurred in participating in activity. The dual-level model was achieved using the Heckman approach.(250) Predictions of the theoretical model include that those with higher income may be more likely to engage in physical activity as they have the financial means to secure access. However, given that they earn more, the opportunity cost is greater for them and thus the model predicts they will engage for less time. They conducted empirical tests of these predictions using data from the US Behavioral Risk Factor Surveillance Survey and this appeared to support the theory relating to income and its relationship with participation and duration of engagement. Having children reduced participation as did getting older although the duration of engagement in exercise regimes increased with age. They found that women spent less time participating in physical activities than men but this difference could not be explained by the model. There was a differential too by education level with higher educated people spending less time participating in physical activity. Again, we may suppose that the higher educated have more demanding and busier jobs, less time and also have greater opportunity costs of exercise. However, unless there was a differential in exercise intensity, this concept runs counter to most of the neo-classical theories which suggest that the higher educated both have more to lose by unhealthy behaviour but also have a greater understanding of the health risks of inactivity.

In support of the model theory, another study also found that more educated people are more likely to participate in sports; however, demand for activity dropped with earnings due to the higher opportunity cost.(251) Participation dropped with the increase in number of school-age children - presumably due to lack of time available to engage. Engagement increases around retirement age which may reflect the increased desire to invest in health and/or increased time available to be active. It also increases at the weekend, again, probably due to people having more time. Good health appears to decrease the demand for sport which may reflect activity conducted in a desire to improve health status. The analysis highlights several factors which influence participation that are not described in the model, including personal characteristics (age and health), marital status and children, time of year, day of week, the region and the level of urbanization. Indeed the authors ask for caution in over-interpreting their results and concede: “*the explanatory variables only explain a small part of the total variation of individual time allocated to physical activity*”. Eisenberg and Okeke also employed the model to explore the impact of weather and seasonality on physical activity.(252) They found that a five degree decrease in average temperature caused a 2.5% drop in those meeting recommended minimum levels of physical activity. This effect was 2-3 times larger for some lower education and income groups; the authors hypothesised that this effect occurred because these groups may not be able to make the switch to indoor activities (presumably because of cost) when weather was poor.

Price elasticity is a vital determinant of the impact of fiscal policies employed to try and bring about changes in health behaviour. Establishing the PED for different goods in different income groups helps to understand the likely impact of ‘sin taxes’. The application of this concept is covered in the fiscal policy options section in the Introduction. A common finding is that the PED for unhealthy goods is relatively inelastic (as might be expected with goods that might be considered addictive)(39, 48, 253) but perhaps paradoxically that lower income groups are more responsive.(50) This may be because price changes will be represent a higher proportion of their overall income. Analysis by Bask and Melkerrson (254) on alcohol and cigarette demand found that long-run own-price elasticities are negative but that the demand for alcohol was more elastic than cigarette demand, suggesting that tobacco is more addictive than alcohol. The cross-price elasticities were also negative, suggesting that alcohol and cigarettes are complementary goods.

2.4.1.3. Usefulness for incorporating financial incentives

The utility-maximisation framework allows us to represent the question of behaviour change as an individual weighing up the costs and benefits of continued unhealthy behaviour against the costs and benefits of a healthier lifestyle, taking into account the disutility of changing behaviour and the attendant future health risk of choosing not to do so. In a simplistic sense the decision is then an intertemporal one; between having benefits now (cigarettes, cake, sitting and watching TV) and costs in the future (ill health) versus incurring costs now (tobacco withdrawal, no cake, physical activity) and benefits in the future (improved health). Table 6 provides a simple illustration of the types of pros and cons an individual considering smoking cessation might have to weigh-up in making a decision to stop smoking or not. This is intuitively a choice between the health and monetary benefits of cessation against the difficulty in giving up, the disutility of which has been shown to be significant.(255) Framed as a problem of utility-maximisation under constraint, all factors in the table could be considered in a utility context - that is, that their value can be expressed in terms of utility, including health status, time and money. Where there is uncertainty in terms of outcomes then von Neumann's and Morgernstern's theory of expected utility under uncertainty may be applied.

Table 6: Arguments for and against smoking cessation

Arguments for not attempting smoking cessation	**Arguments for attempting smoking cessation**
Smoking is relaxing and relieves stress	There may be immediate and future health benefits for me and others
Withdrawal and cravings may be very unpleasant	I would save money
Nicotine replacements are expensive	I may be able to exercise more
Social situations may be more difficult	Get rid of the bad smell
I may gain weight	
I may fail	
Health risks may be small	

Intuitively, utility-maximisation and EUT appear useful for capturing decisions to change behaviour although it is unclear whether price elasticity of demand would have a function in helping to understand behaviour change or incentive impact. As we can convert monetary terms into utility we can consider what impact a financial incentive may have on overall utility. Hence, the concept of marginal utility of money might shed light on the responsiveness of different income groups to different levels of financial incentive. It is assumed, due to the property of diminishing marginal utility of money (256), that utility gains will be higher for low income individuals compared to high income individuals and thus incentives (of the same value) should provide relatively greater motivation for the former.

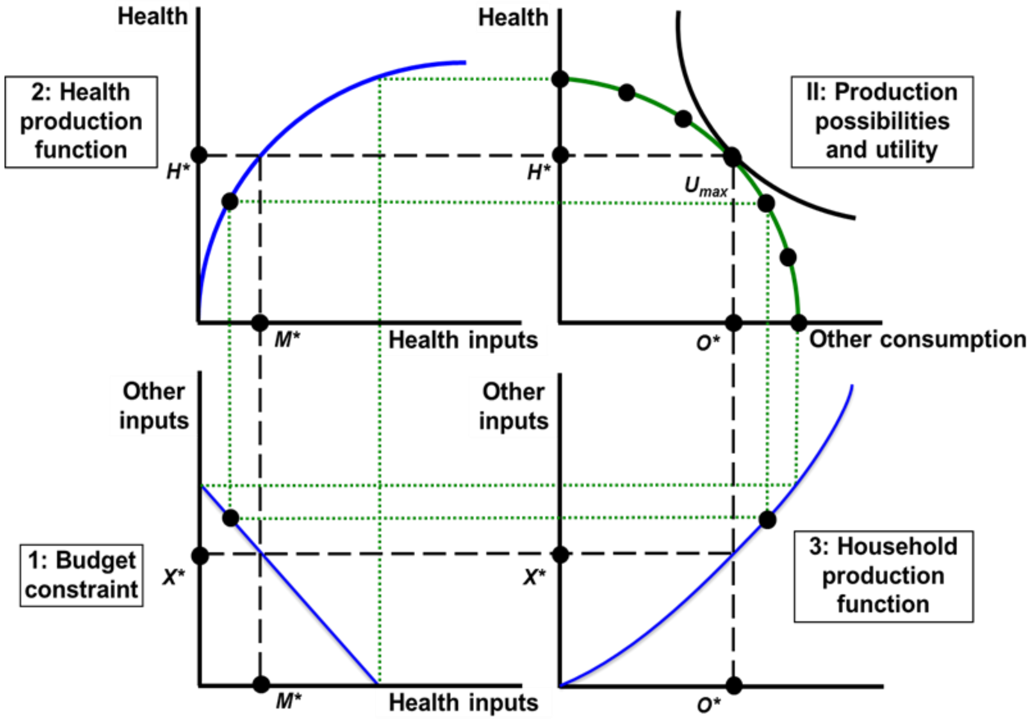
The concept of *homo economicus* – economic man - is based on the key assumptions that when individuals make consumption decisions, they are rational and driven by self-interest. The assumption of rationality denies uncertainty in that individuals are assumed to have perfect information about the utility they will derive from the good (and all possible combinations of other goods) and can predict their future preferences. While EUT and rationality are the cornerstone of modern decision analysis, there is growing evidence indicating that humans are not rational when it comes to weighing up costs and benefits, under uncertainty or otherwise. The choices of individuals are influenced by an array of cognitive biases and heuristics such that individuals may not have full autonomy over 'choices' at all, instead following a series of unconscious defaults and norms.(80)

2.4.2. The Demand for Health and Investment in Health

Grossman's 'human capital model of the demand for health' (1972)(77, 257) uses the neo-classical economic framework of utility-maximisation and rational choice to explain how individuals make decisions about their health and healthcare. In essence it postulates that health is a good that is produced, demanded and consumed by individuals. Health is demanded because it enables the production of income and wealth and generates utility in itself. Individuals produce or invest in health via health behaviours (diet, exercise, consumption choices) and medical care. The model considers healthcare a derived demand since it is not demanded for its self but for the improvements in health that it provides. Further, that health itself is a derived demand since when we are healthy we are able to work and earn money. Individuals enter the model with a 'stock' of health which, like any other capital good, depreciates over time but can be increased with investments. The efficiency of these investments is a function of the individual's age, education and knowledge.(258)

The Grossman model has seen widespread application in research since its publication. In the 1980s Wagstaff presented a geometric representation of the Grossman Model (Figure 7 (258)) with a view to illustrating its principles and mechanisms (Wagstaff 1986 a, b)(242). Represented in the southwest quadrant (I) of the figure is the budget constraint which shows the possible combinations of medical care (M) and all other consumption products (O) that can be obtained with available resources taking into account income and prices. The northeast quadrant (II) shows the indifference curve indicating the combinations of health (H) and all other consumption products (O) that yield the same level of utility (U). The northwest quadrant (III) enables us to understand the relationship between the consumption of healthcare and health and health-related utility. A production function illustrates the level of health output yielded per healthcare unit input. The southeast quadrant exists only to connect shifts in budget constraint and indifference curves via 45 degree identity line. The figure illustrates how any given level of health investment or input leads to a corresponding level of health. The production function is convex due to diminishing marginal returns of production; that productivity yields from inputs increase with increasing inputs up to a point after each additional unit of input provides less output. The figure suggests that utility will be maximised at U_{max} which is yielded through the consumption of H^* of health and O^* of all other goods. To achieve this, an individual would need to spend their income on M^* of healthcare. In Grossman's model, individuals opt for a combination of health and non-health goods to consume to maximise utility and the derived demand for a given level of healthcare results from this. Theoretically this framework can be employed to estimate the impact of changes in, for example, consumption good prices, income, health productivity as well as health shocks.

Figure 7: Grossman Model



[Wagstaff (1986) revised by Morris et al (2012) – Figure taken from Morris et al](258)

At its simplest level the demand for health begins with the utility function:

$$U = U\,(H,O)$$

Which indicates that utility (U) is that derived from a combination of the consumption of health (H) and all other fundamental commodities (O). Fundamental commodities are generated with time and other market goods. In this case H is the number of healthy days in a lifetime and is determined by the level of health stock (HS). HS at any given time (HS_t) is determined by HS in the previous period (HS_{t-1}) plus any investment in health the person has undertaken (I_t) and minus any depreciation in HS in the same period (d_t). This can be expressed formally as:

$$HS_t = HS_{t-1} + I_t - d_t$$

Health capital can depreciate with age or by damaging health behaviour such as smoking, overeating, excessive alcohol intake or physical inactivity. Investment can be made by adopting healthy behaviours such as exercising or a healthy diet. I_t and O_t are produced at any one time by a combination of factors and are subject to production functions.

The production functions can be represented as:

$$I_t = I(M_t,\ T_{Ht},\ E_t)$$

$$O_t = O(X_t,\ T_{Ot},\ E_t)$$

Where M = medical care and X = all other goods; T= time spent producing health or other goods and E = human capital which is invariably considered to be represented by level of education. The constraints to the production function are in time (T); which is necessarily limited to 365.25 mean days a year and incorporates time spent working, investing (or being ill) and spending (S) which is determined by time spent working, wage rate and the prices of the goods – health and otherwise – to be consumed.

To maximise utility given these constraints and the production functions requires equilibrium where the marginal benefits of health capital are equal to the marginal cost. Marginal benefit (MB) is comprised of two parts; one relating to the utility gained from health investment (MB_H) and one relating to the monetary gain from health investment (MB_M). The output of these investments is measured in the marginal product of health (MP_H) in units of healthy days provided by a unit of health stock. Healthy days provide utility in itself but they also enable us to engage in paid employment which in turn yields income and utility. Since at equilibrium these factors are equal to marginal costs, they are expressed in monetary terms. The utility-maximisation problem is over the lifetime of the individual and therefore a discount rate - $(1+r)^t$ - is used to reduce future values. We arrive at the following where MU_H and MU_w represent marginal utility of healthy days and income, respectively.

$$MB_{Ht} = MP_{Ht} \times (1+r)^t \times \frac{MU_{Ht}}{MU_{Wt}}$$

The benefit of health capital investments are given by multiplying the marginal product of health by the wage rate:

$$MB_{Mt} = MB_{Ht} \times W_t$$

The marginal cost of health capital is the marginal cost of investment in health (MCI) multiplied by the opportunity cost of investment (which is taken to be the rate of interest) and by the level of depreciation (d). The interest rate is the real rate minus the change in rate over time in the marginal cost of investment ($\Delta\mathrm{MCI}$). The equilibrium condition is represented thus:

$$MB_{Ht} + MB_{Mt} = MCI_{t-1} \times [(r - \Delta MCI_{t-1}) + d_t)]$$

This equilibrium derived from the Grossman model describes how individuals invest in their health capital to the point where the marginal benefit (comprised of consumption and investment benefits) are equal to the marginal cost of investment.

There have been many revisions of the model since its development. These include a demand for health framework with the addition of a physiologically optimal level of health (259) and a revision such that the family unit is the producer of health.(260) Gjerde et al (2005) revised the model by incorporating adaptation to ill health (261) while Benitez-Silva and Ni incorporated a longevity production function.(262) The original model assumed that death was reached when health capital fell below a certain threshold; this was revised in later versions of the model. Ehrlich and Chuma (1990) showed that life expectancy and its demand should be modelled just as the demand for health and consumption goods is.(263) Dias (2010)(264) combined the

Grossman model with a model of health inequality based on the framework of inequality of opportunity proposed by Roemer, where a distinction is drawn between circumstance (parental socio-economic status and childhood health) and effort (lifestyle) variables in health. The addition of uncertainty was modelled by Clark and Etile (2002) evaluating the impact of changes in information on smoking behaviour over time (265). This approach was also taken in a theoretical paper by Laporte and Ferguson (2007)(266) focusing on the uncertainty of investment in the Grossman model and by Asano and Shibata (2011) reformulating the deterministic Grossman model into a stochastic one.(267) Galama and Kapteyn produced an alternative form of the Grossman model relaxing an assumption that people can change their health investments instantly to a new optimal level.(268) Other work by Galama also calls into question the results of the Grossman model previously presented in the literature as they find evidence to support the notion of decreasing returns to scale in health investment in contrast to many previous studies that have based analyses on the assumption of constant returns.(269) Other studies have also examined behavioural aspects of the demand for health. For example, one study developed a theoretical model that explained the demand for health as stemming from the need for status and identity but also something to which people adapted over time.(270) Another study has introduced the concepts of social pressure, status and trust as important determinants of the demand for health.(271)

2.4.2.1. Applications in behaviour change

The Grossman model has seen significant use in health economic research (257) with its most common applications being in exploring the relationship between education and health and in understanding healthcare demand. There was mixed empirical evidence to support its predictions and debate over its usefulness has continued.(272, 273) Summarising the criticisms Laporte highlights significant doubts over the predictive ability of the model.(274) She points out that Grossman fails to predict that health declines in line with lowered socio-economic status. In addition, the model predicts a positive relationship between health status and health investment but usually this relationship is negative in empirical tests. Despite the popularity of the model there have been few examples of its application to research on behaviour change specifically. Studies have tended to use the model to explore investments in health and their outcomes (e.g.(275)). Zhao et al used the model to explore the impact of information (e.g. new diagnosis of high blood pressure) on health choices (276) finding that those with higher income were more responsive in terms of behaviour change. This finding is in line with the model theory and therefore provides some evidence of its predictive validity. Lindgren et al evaluated the impact of obesity history on future health investments (277) however the methods applied do not help elucidate behaviour change decisions. Elsewhere, van Kippersluis and Galama empirically tested the suitability of the Grossman model for explaining why rich individuals engaged in more moderately unhealthy behaviours (e.g. drinking alcohol) compared to low income individuals who engaged more in severely unhealthy behaviour (e.g. smoking).(278) Although richer individuals have more income with which to consume unhealthy goods, the authors submit that they demand less unhealthy consumption as the costs to them (in terms of the financial consequences of future ill-health) are relatively greater than those that lower income individuals would face. Bolin and Lindgren applied the model to identify the demand for physical activity with consideration for a physiologically optimal level.(279) An analysis by McCarthy evaluated whether the model could be used to evaluate the likelihood of decisions to start and quit health capital investments such as exercise regimes.(280) He hypothesised that a significant increase (above one that is rationally required) in health capital (profit) is needed from a health investment before such a regime is initiated, thus, if only small improvements are expected, the regime may not be initiated. McCarthy introduced uncertainty in investment and employed Dixit's 'hysteresis effect' (281) which explains why regimes may be difficult to initiate (perhaps due to inertia, barriers or higher 'start-up' costs) but when started are easier to maintain. While interesting, McCarthy presents only theoretical work and the predictive ability of the model has not yet been evidenced (or tested).

Clark and Etile (265) examined the impact of health shocks on people who smoke. According to the predictions of the Grossman model, an increase in the health costs associated with unhealthy consumption should be met by decreased consumption of that good. The authors do find evidence that smoking is reduced and quit attempts are higher in those who have had a health shock. They believe that the health event provides information about the relationship between smoking and health damage which was previously uncertain. However, they also found quitting was negatively correlated with consumption – those who smoked more were less likely to quit. This is counter to the Grossman model which would predict that those with the greatest costs would adjust their consumption most. Furthermore, lung check-ups were uncorrelated with quitting. According to Grossman, individuals will make a rational decision that is consistent with their long term preferences based on revised information – in this case relating to the costs of their behaviour. However, we do not know what motivates the behaviour change attempts observed in the data. Following a health shock, individuals will have been implored by healthcare professionals to quit and given access to smoking cessation interventions (e.g. nicotine replacement products); thus the costs of behaviour change are reduced and they are following other people's preferences. Hence we should be cautious in accepting the results of empirical research based on large panel datasets as evidence of the predictive ability of such theories due to the threat of exogeneity.

2.4.2.2. Usefulness for incorporating financial incentives

The Grossman model predicts that low income individuals may persist with unhealthy behaviour because they have low returns on health investments, either because they have low lifetime income earning capability or because they have low education and are inefficient at creating capital. In this case individuals do not see extended or enhanced life as beneficial or at least worth investing in. In the context of the model, unhealthy behaviour would be seen as disinvestment in health or leading to a higher rate of health stock depreciation (253) and behaviour change viewed as increased investment in health. An individual chooses the level of investment or disinvestment such that the marginal costs are equal to the marginal benefits.

The Grossman model is a theoretical framework and it is valuable as long as it is a useful tool to explain individual or population health behaviour and predict the impact of policy changes. The model is based on a number of assumptions which have drawn criticism. It assumes that individuals have perfect information and foresight about their health, health capital depreciation rate and the impact of health investment, healthcare and consumption behaviour on their health. A literal interpretation of the model assumptions suggests that individuals deliberate and choose a rate of health investment (or disinvestment) until their health stock reaches 0 (or a minimum threshold level) and they die. Crucially, the original model does not permit uncertainty or allow 'irrationality' in consumer behaviour. In addition it fails to recognize that individuals are unable to adjust their health stocks instantaneously. A number of modifications of the model make it more palatable as a representation of health behaviour. Studies have allowed individuals to adjust their health capital slowly, a more intuitive form as health behaviour change and its positive impact takes time. Similarly, health investments are uncertain and individuals do not know, for example, what impact a healthy diet will have on their health stock; thus the addition of uncertainty into the model is an improvement. Certainly in its strict rational form the

Grossman model would not appear to fit with the general behaviour of low-income individuals who engage in risky health behaviours. In reality it is unlikely that such individuals plan, deliberate, decide, choose and achieve particular amounts of 'health stock' over a lifetime. In the case of behaviour change initiation (health investment), the uncertainty about success and accompanying level of improvement may be important factors in determining whether change is initiated at all. Thus the addition of uncertainty in investment (by Asano and Shibata) is appropriate; as the authors note, when uncertainty is high, investment is less likely to occur.

The original model assumed that there are constant returns to scale of health capital investment, an assumption relaxed in subsequent studies.(269) This modification also appears to have face validity and better reflect reality. For example, during weight loss and fitness regimes, weight loss and fitness gains become more difficult over time (200, 203-205) and health gains from behaviour change, such as blood pressure reduction(282) and efficient oxygen uptake(283), eventually reach a plateau after which more intensive investment yield limited or no marginal benefit. This is captured by the theory of marginal efficiency of capital (MEC) where the phenomenon of diminishing marginal returns can be observed. Employing this neo-classical theory we expect that as investment in health is increased and health stock rises, it becomes increasingly difficult to add to the stock per unit of health investment, hence a convex shape of the marginal efficiency of capital curve is observed. The curvature of the MEC and idea of diminishing utility benefits from health behaviour may be apposite for explaining failing motivation and high failure rates in those attempting to sustain behaviour change.

Focussing on incentives, it can be seen that a financial reward would increase the value of investment and make investment (behaviour change) more likely. However the strength of this effect in the model may be weak as investments in health are determined by lifetime earning potential which of course will be unchanged. Incentives would be expressed as increased income although only in the short run and in the case of tobacco use, cessation would also free up income to spend on other consumption – thus the budget constraint would move out. With this comes the risk for consumption to switch to other unhealthy products – e.g. away from tobacco to increased intake of sugary or fatty foods. The income increase would be counteracted by the cost (time and money) required to invest in behaviour change.

As with a general utility-maximisation framework, future health consequences of current risky behaviour may be undervalued either due to uncertainty, a risk-seeking attitude, poor health knowledge or high discount rates (or any combination of these).

In this case the incentive works to bring the reward or pay-off of healthy behaviour forward in time thus avoiding the discount rates and/or making the payoff more certain (depending on the incentive design). Consideration of the MEC and diminishing marginal returns may prove useful in capturing both the dynamic nature of behaviour change feedback; and, in relation to incentives, the need to tailor the rewards to the level of difficulty the individual faces during the change process bearing in mind it is likely to fluctuate. In addition, the hysteresis effect, although unrelated to the Grossman model, may provide a novel perspective on the initiation of behaviour change and information about the level of incentive required to persuade individuals to initiate change.

2.4.3. Rational Addiction

The rational addiction model (75) is the dominant paradigm employed to model addictive behaviour. The model was first proposed by Becker and Murphy (1988) and has been applied, tested and modified many times since. A key principle of rational addiction is that a consumer is said to be addicted if an increase in past consumption ('habit stock') causes present consumption to rise. Reinforcement occurs because an increase in past consumption increases the "craving" for the addictive good today (consumption of cigarettes at different time periods in time can be considered complements). Tolerance also occurs since the satisfaction of present smoking is lower when past smoking is greater. This is akin to the opponent process theory in psychology where increased consumption of an addictive good disrupts the opiod reward homeostasis in the brain requiring greater and greater consumption to achieve 'highs' that were felt previously. The model is described below.

Where H_t is a habit stock that measures the degree of addiction at time *t,* the concept of habit stock can be expressed as:

$$H_t = C_{t-1}$$

The habit stock in the present period is equal to the amount of smoking in the previous period (or cumulatively as all the previous periods combined). U_t is instantaneous utility at time t of consuming an addictive good and consuming a bundle of non-addictive goods, which are represented by C_t and Y_t, respectively:

$$U_t = U(C_t, H_t, Y_t)$$

It can be inferred that tolerance is a manifestation of diminishing marginal utility and hence - using the smoking example - smoking one extra cigarette today increases utility but the rate of increase in utility reduces with the amount of cigarettes smoked. As Andersson et al (284) illustrate: the marginal utility of smoking 5 cigarettes instead of 4 is larger than that of smoking 11 cigarettes instead of 10. The habit stock is assumed to affect instantaneous utility negatively and at an increasing rate. Due to the phenomenon of reinforcement, the level of past smoking or habit stock, increases the marginal utility of present smoking. As in all consumption choices, the consumer faces a budget constraint but since the model assumes that consumers are forward thinking, the constraint also includes (constantly discounted) future prices of the goods to be consumed. Subject to habit stock and the budget constraint, the consumer chooses combinations of C and Y that maximise the sum of instantaneous utility:

$$Max\ C_t, Y_t \sum_{t=1}^{\infty} (1+\sigma)^{-t}\, U(C_t, H_t, Y_t)$$

Where $\sigma > 0$ is the constant rate of time preference. The maximisation problem solution allows the derivation of a demand function for the non-addictive and addictive goods. Assuming that the discount and interest rates are equal (i.e., $\sigma = r$) the demand function for an addictive good would be represented(258):

$$C_t = \beta_0 + (1+r)\beta_1 C_{t-1} + \beta_1 C_{t+1} + \beta_2 P_t$$

Individuals in the model weigh up the costs and benefits of continued consumption or quitting and decide accordingly with a view to maximising utility. The main difference from general utility-maximisation models is the mechanism of the habit formation and the influence of habit stock on current and future consumption. Becker and Murphy went on to use the model to predict sudden withdrawals and binges, and illustrated how stressful events (for example divorce and unemployment) can be the catalyst for addictions.

2.4.3.1. *Applications in behaviour change*

Since being developed the rational addiction model has seen a broad application in economics and has become the main economic theory used to explain addictive behaviour.(285) Variants of the model have included an allowance for uncertainty (286), binge consumption (287), chaotic consumption (288), assessed the impact of ‘health shocks’ on health behaviour (289), and estimated the optimal death age and its impact on health investment with relation to healthy and unhealthy consumption.(290) Tregeagle adapts the rational addiction model into a health depletion model where the concern is not with habit stock but with remaining health stock.(291)

Rational addiction in public health has generally focussed on smoking as the addiction although studies have applied the framework to other unhealthy behaviours such as alcohol abuse and obesity (overeating). Andersson (2006) applied the model to two addictive goods (smoking and Snus) (284) as did Bask and Melkersson (254) while a number have applied the model to smoking (e.g. Baltagi and Grifin, 2001(292); Gruber and Koszegi, 2001(293); Escario, 2001(294); Becker, 1994(295)), smoking in pregnancy (Bradford, 2003,(296)) and alcohol (Baltagi, 2002 (297); Baltagi, 2006 (298); Fenn, 2001(299); Skog, 2006(300)). Dragone (2009) and others have applied the model to obesity, diet and overeating (301-303) and Liu and Lopez to fizzy soft drinks.(304) Notwithstanding the model criticisms there is some empirical support for its application, however this varies from study to study. Bask and Melkersson found the model suitable for describing alcohol addiction but not smoking as individuals who smoke were found unresponsive to changes in tobacco prices. One of the key pieces of empirical support for the model stems from studies showing consistently that future price increases (of tobacco products) lead to a reduction in current consumption (e.g.(292, 295)) although others have found contradictory results.(e.g.(305))

There is empirical support for another prediction of the model – that going ‘cold turkey’ is an effective way to quit.(285) Notwithstanding this, most studies address the continuation of risky behaviour, rather than specifically focussing on behaviour *change*. Jones accounts for the additional costs incurred when trying to stop smoking and the impact of withdrawal.(306) In earlier work the same author (307) considered quitting an addiction (smoking) a ‘double hurdle’ problem; one of initiation and then success or failure in the long term. This approach was repeated by Feng (308) who considered rational addiction equivalent to the ‘motivation’ to quit smoking and ‘self-control’ the probability of success in the quit attempt. The author refers to this latter factor as ‘ability’ although qualitatively a different concept. The two ‘hurdles’ are modelled with separate equations with the second probability conditional on the first. Results from the study include the finding that heavy smokers are less likely to try to quit even though they have a bigger financial incentive to do so. In addition, there was no evidence that smokers explicitly consider their chance of quit success when making their decision to quit and heavy smokers are not less likely to succeed once they decide to quit.

2.4.3.2. Usefulness for incorporating financial incentives

The rational addiction model has been heavily criticised by some, with one economist referring to it as an ‘absurd’ theory.(309) There is mixed evidence for the explanatory power of the model with one study suggesting that even non-addictive goods (such as milk and eggs) can be shown to be rationally addictive.(310) It has been found to have structural uncertainty (311) and, in a survey of economists who had employed the model, doubts were expressed about its validity.(312) A publication reporting the use of the model usefully describes the challenges that it faces in trying to model addiction:

“*substance use of any type or pattern and abstinence are best considered as being nonlinear, complex, dynamic, multidimensional, phase/level structured, and bounded (culture, time, place, etc.) phenomena. They are not simplistic, linear, cause and effect outcomes*.”(284)

One author believes that the RA framework is inconsistent with the desire for increased self-regulation that is often displayed by many addicts.(313) Another study highlighted the lack of consideration of peer or social influence in smoking and biological dependence (314) although one recent model has introduced this, using the case of obesity and considering ‘weight stock’.(315) Tomer provides a criticism of the concept of addiction as rational and presents an alternative socio-economic model.(316) Work has also been conducted evaluating the impact of low health and social capital and low expectations for future capital as an explanation for the initiation of unhealthy behaviours.(317) One review of addiction models could not conclude that the imperfectly rational have more evidence to support them than rational addiction models (318), however a more recent review concluded that imperfectly rational models were most appropriate.(285)

As with most neo-classical models of behaviour, a number of limiting assumptions are made in the rational addiction model. It assumes that addicts are forward looking, considering past consumption and its consequences and future product prices, future preferences and then making deliberative consumption choices with autonomy. In doing this it assumes that addicts can predict their future preferences accurately, which has been shown not to be the case.(319) Further, that future utility and costs are discounted at a constant, exponential rate.

In the model everyone who decides to change is successful; there is no breakdown of willpower or motivation and behaviour change is deterministic not stochastic. In reality, many people who want to change do not attempt this in any given year and many of those who do initiate an attempt to change, fail. According to UK figures in 2010: 66.4% of smokers want to quit; 35.9% attempted to quit in the previous 12 months; and only 4.8% of smokers quit in the last 12 months.(320) As the model omits failure it also omits regret, both in consumption and in failed quit attempts.

Incentives in this model would function as they do in the Grossman model, bringing the reward forward temporally and potentially tipping the balance of cost and effects in favour of quitting or changing. An additional potentially useful application of the addiction framework is a reconstitution of the ‘habit stock’ function. In Becker and Murphy’s model it represents unhealthy behaviour but it could be applied to habit formation in healthy behaviour. A model structure that encompasses the phenomena whereby past behaviour increases the likelihood of future behaviour might be useful in capturing the hypothesised long term effects of incentives. This might be particularly apposite in physical activity and healthy eating which may become ‘good habits’ after a certain period. Of interest too is the modelling by Jones (307) and Feng (308) on motivation and ability to quit. Casting behaviour change as a ‘double hurdle’ fits with some psychological theories of intention and motivation and the *a priori* specification of the change process made at the beginning of this section. This approach may prove useful in considering the effect of incentives which may be differential for change initiation and then maintenance.

2.4.4. Time preference and discount rates

“*The State should protect the interests of the future in some degree against the effects of our irrational discounting and of our preference for ourselves over our descendants*” (Pigou (40) I.II.7)

It is a generally accepted rule that humans would prefer to have benefits sooner rather than later and would rather defer costs further into the future. The reason for this phenomenon is disputed but is likely to include uncertainty around our health and survival and wealth in the future. Time preference is integral to most economic frameworks involving intertemporal choices – where the costs and benefits of decisions are incurred at different times(321) – and especially where we want to make choices with future consequences and wish to weigh up those consequences now. Time preference refers to the degree to which individuals ‘discount’ future costs and benefits. A high positive time preference means that an individual would much prefer satisfaction now than in the future. A high positive time preference necessarily means that the individual employs a high 'discount rate'. The discount rate is calculated as a percentage of the required increase in payoff that would bring about deferral of satisfaction.(321)

Paul Samuelson proposed the discounted-utility model in 1937 and this was subsequently accepted and became embedded in standard economic analyses.(322) He introduced the idea that *homo economicus* seeks to maximise the sum of future utilities with the assumption that: "*The individual discounts future utilities in some simple regular fashion which is known to us*". The higher the discounting of future costs and benefits, the more highly current costs and benefits are valued, relatively speaking. Thus a 'present-biased' (or 'oriented') individual who discounts 'future' costs and benefits highly puts greater weight on current consumption. This is argued to be one of the main reasons for the continuation of unhealthy behaviour: individuals employ high discount rates to the future financial and health costs of unhealthy behaviour. Intuitively, the direction of causality would appear to be from individual to payoff as we assume that people with higher time preference may be more impulsive and show greater disregard to future health consequences. However, as Becker and Mulligan argue, the reverse could plausibly be the case – that, in view of either poor health prognosis or expectations and/or poor anticipated earning potential, a decision is made to be more present-biased, or to 'live for the moment'.(323)

The discount rate is a metric measured using intertemporal choices, either revealed or stated. However, conceptualising and measuring it is very challenging. Attempts to capture this have included asking people to trade off between (monetary or health) benefits (or losses) now (or sooner) in return for higher benefits in the future. More simplistic – and less desirable(324) - attempts to capture time preference use proxy questions relating to risky behaviours (e.g. driving without seatbelts, having unprotected sex) and level of savings.(325) In the UK the TEMPUS study endeavoured to identify a societal discount rate for future health benefits using a number of methods. With caveats over the study methods, the authors reported median annual discount rates ranging between 3.8% and 6.1% depending on the methods used, delay period and whether own health or that of others was being discounted.(325) In contrast the UK's National Institute of Health and Care Excellence (NICE) requires future costs and benefits to be discounted at a rate of 3.5%.(326) However, large variations in discount rates have been reported.(327)

There are several types of discounting models (328) but the standard assumption in economics, including in technology evaluations considering costs and benefits beyond one year, is that individuals have a constant, exponential discount rate. The exponential discount rate is given below, where r = discount rate and t = time:

$$(1+r)^t$$

2.4.4.1. Applications in behaviour change

A key role is played by time preference or individual discount rates in both neo-classical and behavioural economic models. They can have a major impact on estimates of lifetime costs and benefits. Time preference has been found to have a significant association with various health behaviours such as smoking(329-334), choosing an unhealthy diet (335), obesity (336, 337), addiction (338) and alcohol consumption.(339) Axon et al, studying time preference and its relationship with preventive health behaviour in hypertensive adults, found that a 1% increase in discount rate increased the likelihood that respondents did not check their blood pressure by 3.5%.(236) Those with the highest quintile of discount rates were the least likely to change their diet and exercise behaviour after hypertension diagnosis compared to the rest of the sample (6.8% vs. 12.4%). There is some evidence that time preference explains the gradient in smoking (a proxy for health inequalities).(340) However, some studies do not find that time preference is important in health behaviour (341, 342), has only a weak relationship with health indicators such as BMI (343), or that it is dependent on gender (344) or age (345). One meta-analysis found time preference to be more explanatory in addictive behaviours than non-addictive behaviours.(342) The potential link between time preference and life expectancy has been highlighted elsewhere.(346) Findings also suggest that addictive behaviours can be interdependent and are dependent not just on time preference but also on the individual's level of risk aversion.(347) Furthermore, there is the suggestion that health and financial costs and benefits may incur differential discounting.(348) An empirical investigation into this issue by Lazaro and colleagues gave interesting results.(349) They found that social discount rates were lower than private rates and, crucially, that discount rates for health were much higher than for financial gains (39.5 and 14.1, respectively for private values with a 2 year delay). In addition, while there appeared evidence for hyperbolic discounting (discussed later) for health (the private discount rate fell from 39.5 at 2 years delay to 15.2 at 15 years delay), there was little sign of this for financial gains (14.1 at 2 years delay to 12.3 at 15 years delay). However, caution is urged over these results as the sample was a set of students who might have atypical preferences (compared to the general population) regarding health and wealth.

A study by Yi and Landes was particularly interesting as it assessed time preference during smoking cessation.(350) The authors found that smokers employed higher discount rates following smoking abstinence than during periods when they smoked. Thus time preference appeared to vacillate along with physiological state, perhaps due to craving. This may have added significance as it is associated with higher failures in behaviour change attempts, in smoking in pregnant women (351) and smoking in heavy drinkers.(352) Goto et al found, after controlling for alternative possible predictors of cessation, time preference was still associated significantly with relapse to smoking having a hazard ratio of 1.17 (95% CI: 1.10–1.24, $P < 0.001$).(333) Elsewhere, discounting has been shown to be important in weight loss.(353)

2.4.4.2. Usefulness for incorporating financial incentives

Time preference is clearly important in people's health behaviour decisions as it essentially determines the relative value placed on current and future costs and benefits. In the utility-maximisation frameworks, individuals seek to maximize the present discounted value of lifetime utility. One of the key arguments in favour of using incentives is predicated on the idea that people who persist with unhealthy behaviours despite the high risk of significant future health costs, are too present-biased and, consequently, the benefits of current consumption outweigh future costs. Offering incentives in the short term brings forward the reward for healthy behaviour. In addition, a key implication of the role of future discounting is that commitment devices may offer an effective way of trying to deal with high present discount rates. In terms of incentive design it's possible that individual discount rates may play a part in their effectiveness. If incentive rewards are too distant in the future, present-biased individuals (likely to be the target group) may apply a high discount rate and the incentive will not be a sufficient motivator. Thus immediate rewards are likely to be the most effective. It may be that the act of behaviour change may also change the individual's time preference, a conclusion from a recent study of incentives in smoking.(350, 354)

A recent review and meta-regression corroborates previous findings that discount rates for health losses and gains tend to be different (327) with time preference for the latter often being found to be higher than the former.(355) More crucially there is now substantial evidence that discount rates are not constant but depend on the length of delay to the pay-off. For example in the TEMPUS project based on discrete choice elicitation, the implied annual discount rates were 5.0%, 4.6%, 3.8% for own health (private rate) and 6.4%, 5.7%, 3.8% for others' health (societal rate) over 5, 8 and 13 year delays, respectively.(325) Hence, discount rates are often time-inconsistent (or 'dynamically inconsistent'), a theory discussed in the behavioural section of the review. Every assumption behind the discounted utility model has since been empirically tested and shown to be invalid.(321) Time preference and discount rates are clearly important both in terms of understanding health behaviour change and incentive impact but it is unlikely that the rational time-consistent formulation often employed in neo-classical models best represents reality.

2.5. Behavioural economic theories

Neo-classical economic theory as espoused by Gary Becker and the Chicago school, requires that individuals are perfectly informed about all potential consumption options and consumption outcomes (even if they occur many years in the future) and that they have the time and capacity to consider this perfect information before making optimal choices. These conditions, as well as those surrounding expected utility theory, are increasingly being viewed as unrealistic and a large body of research conducted in experimental psychology and behavioural economics casts doubt on the assumptions of rationality upon which such economic theories are predicated.(356, 357)

The growth of behavioural economics has seen a leader in the field, Daniel Kahneman, receive the Nobel Prize for economics in 2002 and greater popularity as indicated by the success of books such as ‘Nudge: Improving Decisions About Health, Wealth and Happiness’ by Richard Thaler and Cass Sunstein (79), Dan Ariely’s ‘Predictably Irrational: The Hidden Forces That Shape Our Decisions’(358) and Daniel Kahneman’s ‘Thinking, Fast and Slow’. Behavioural economics has been embraced as a tool to shape government policy and population behaviour, evidenced by the creation of the ‘Behavioural Insights Team’ in England.(359) Scientists and policy workers are arguing for increased research in, and a greater role for, behavioural economics (360, 361) and it is likely that this relatively new discipline could have a specific role in designing incentive schemes.(173)

The literature searches identified a number of behavioural theories of potential relevance to the design of incentive schemes. A small number are general frameworks relating to behaviour change built upon a collection of theories or biases identifying faults in rationality and others are stand-alone theories. The format is slightly different to the previous section as there was more material to cover hence the theories have been categorised into related concepts and are briefly described with their relevance for incentive design discussed.

2.5.1. General theories and frameworks

2.5.1.1. Bounded rationality

Bounded rationality is a general concept offered as an alternative to the assumption of the perfectly rational ‘homo economicus’. The term is credited to Herbert Simon (362) in the 1950’s and the concept has been adopted widely since.(357) Simply put, bounded rationality posits that humans are unable to maximise their utility due to a number of deficits in information, information processing skills and flawed decision making ability.(363) Instead, the outcomes or payoffs of individuals' choices are 'bounded' by their imperfect capacity. Thus, the theory goes, we make decisions with imperfect information, through a biased filter using error-prone cognitive short-cuts - or heuristics – to arrive at a satisfactory solution rather than an optimal one. In this sense we are 'satisficers'(362) rather than 'optimisers' and several studies were found that proposed models incorporating this approach.(364, 365) Examples of its formal application in health are few and there is little or no empirical evidence to assert its validity. One group of researchers have included bounded rationality separately in models of smoking (366) and dieting.(367) The former relaxes the assumption in addiction models that individuals have fully formed, lifetime consumption paths. The attempts to model each cognitive bias and heuristic are not presented here; it is perhaps sufficient to consider that individuals will make choices such that:

$$U_s \geq U_{min,}\, U_s \leq U_{max}$$

Where U_{min} is the lowest acceptable outcome and U_{max} is the optimal outcome and U_s is a satisfactory level between the two.

Relevance for incentives

It seems that a framework for behaviour change would need to account for the bounded decision making abilities of individuals. Rather than being a utility-maximisation problem, it is more likely that the decisions to start, persist, desist and abstain from unhealthy behaviours and the impact of incentives in this process will be the result of 'satisficing'.

2.5.1.2. Imperfectly 'rational' addiction models

Becker and Murphy's rational addiction model is predicated on rational choice theory (75) and attendant assumptions that individuals carefully weigh-up the consequences of current and future consumption and have exponential time preferences. However, there is evidence that addicts and non-addicts alike are not effective at predicting future preferences (319, 368), that humans do not conform to standard discounted utility assumptions (321) and are influenced by factors excluded from rational addiction models such as social norms.(316) A number of other addiction models have been proposed which relax these assumptions. Sloan (285) describes these models of addiction as being 'imperfectly rational' as they may assume that individuals (i) have time-inconsistent preferences (e.g. employ hyperbolic discount rates); (ii) underestimate the risks of their current behaviour; (iii) have cognitive difficulties in estimating risk levels or in learning from the experiences of others; and/or (iv) have imperfect information about their own risk of addiction.

The Myopic model of addiction (Pollack, 1970)(369), assumes that addicts are not forward looking in their consumption planning. There is evidence – for example in smoking from Gruber and Köszegi - that they do consider future prices in decision making.(293) Elsewhere there are confirmatory studies; a simulation analysis by Frank indicates that addicts may indeed by myopic but that this might also be rational.(370) The 'Primrose Path' model of Herrnstein & Prelec (1992)(371) also assumes myopia and that habit formation is a slow and gradual process; as such, individuals 'sleep-walk' into addiction rather than consciously choose it as the best course of action. This may be explained with an adaptive utility model where individuals constantly adjust their utility to (for example) greater levels of obesity.(372) There have been few economic explorations of this theory and it is possibly only informative about the process of habit formation rather than behaviour change.

Orphanides and Zervos's (1995) model incorporates time-inconsistent preferences and, by incorporating uncertainty in beliefs about addiction, allows for people not to choose to become addicts but fall into it unwillingly and with regret.(373) There is much evidence to suggest that individuals do regret unhealthy consumption (e.g. in smoking (374)). Elsewhere, Suranovic and colleagues present a bounded rational addiction model, which also does not require addicts to be 'happy' and to choose their predicament.(366) Using smoking as an example, they formally include quitting (or adjustment) costs which are higher, the more a person smoked. Incorporating these quit costs they are able to show why an individual might be unhappy with their unhealthy lifestyle yet be unable to change it. Using the National Longitudinal Survey of Youth data, a US study found results that empirically supported the Suranovic et al model. They found that smoking cessation relapses increased when the costs of withdrawal increased (through weight gain).(375)

Rosin presents less an addiction model but a theoretical framework for understanding dieting behaviour and failure which includes social norms, and time-inconsistent preferences.(376) Elsewhere Chen and Petrie model the decision to quit smoking incorporating risk aversion and uncertainty.(377) However, no empirical analyses have been conducted on these propositions hence their predictive ability is undetermined.

Robust empirical comparisons of the predictive power of rational and imperfectly rational (and irrational) models could not be identified in the review. Research suggests that different models can lead to different results and implications for policy thus the relaxing of assumptions in the rational addiction model have a non-trivial impact.(378)

Relevance for incentives

Several competing theories of addiction have been proposed where rationality is not a requirement. These may have a role, not in describing how incentives may influence the decision to change behaviour or the probability of success, but rather in describing how healthy habits may be formed (which may be initiated by incentives). Of note is the fact that most addiction models formulate addiction as a decision about whether to persist or desist with a behaviour accounting for the fact that changing behaviour has costs.

2.5.1.3. Nudge and MINDSPACE

Nudge is a general concept outlined in the eponymous 2008 book by Thaler and Sunstein (79) who define a nudge as:

"...*any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic consequences. To count as a mere nudge, the intervention must be easy and cheap to avoid*." [page 6]

The definition is important as it sets out the boundaries of the theory application and highlights a requirement that interventions should be both cheap to implement and not intrude on people's lives. The philosophy of 'libertarian paternalism', upon which the nudge ethos is based, is seen as a route to "minimal government" and offers an alternative to 'nannying'. This has clearly resonated with some politicians and is likely why the theory has enticed governments in the UK and US (379) and is being exported to other nations such as Australia, France and Canada. While uptake of the concept has been rapid and at the highest levels of public policy making, the danger that policy will advance ahead of evidence has been a cause for concern.(25, 361, 380-384) A recent report by the English House of Lords Science and Technology

Select Committee on Behaviour Change concluded that currently there was limited evidence for the effectiveness of nudges and that the:

"....*central finding is that non-regulatory measures used in isolation, including "nudges", are less likely to be effective [in changing behaviour]*"(385)

The government response conceded this was a fair conclusion and the Behavioural Insights Team have initiated a number of clinical trials of nudge-based interventions with the results pending (359, 386, 387) while studies begin to emerge elsewhere showing positive (387-389) and mixed results.(390, 391)

The MINDSPACE framework developed by the Behavioural Insights Team is inspired by Nudge.(80) The definition of each feature is briefly described in

Table 7.

Table 7: MINDSPACE definition

Messenger	Who delivers the message influences our response
Incentives	We respond to incentives but certain rules can be applied – i.e. we respond more to losses than gains
Norms	We are heavily influenced by what others do (and what we think they do)
Defaults	We have a default bias and often go with it without making a conscious choice
Salience	We pay particular attention to what is novel and relevant to us
Priming	Our behaviour is often influenced by sub-conscious cues
Affect	Behaviour can be driven by emotions
Commitment	We are keen to stick to the commitment we make (especially if made in public) and reciprocate
Ego	We act in ways that make us feel good

MINDSPACE is a collection of existing theories from psychology and behavioural economics. The framework is not generally applied wholesale but represents a behavioural toolkit informing on how particular biases may be targeted to bring about desired changes. The Department of Health outlined in their 2011 report 'Changing Behaviour, Improving Outcomes: A New Social Marketing Strategy for Public Health'(392) instances where a number of studies incorporating these strategies have been initiated. Studies employing the framework currently underway in the health arena include a trial of 'prompted choice' for organ donation which is hoped to increase the number of donor registrations and another study which tackles binge drinking in universities by using social norm techniques. Of the nine case studies highlighted in the Behavioural Insights Team report, three clearly relate to (dis)incentives. One is a collaborative study with Boots pharmacy using financial commitments and incentives to encourage weight loss; another a partnership with a childrens' TV show (Lazytown) where children sign monthly 'energy contracts' committing to a healthy diet and exercise and for which they receive rewards; and in physical activity, evaluating schemes such as 'Step2Get' initiative in London that offers incentives for children to walk to school.

The Behavioural Insights Team has recently proposed what is essentially a revised formulation of this behaviour change framework called EAST - Easy, Attractive, Social, Timely.(393) This was developed as they felt MINDSPACE was too complex and that a simpler framework – which still includes incentives, defaults and social factors - would be more likely to be used in practice. To date, there have been no economic considerations or empirical tests of these theories as a collective framework although the insights team have been conducting trials of interventions that target specific theories in Nudge and MINDSPACE. Examples include encouraging smoking cessation in pregnant women by placing stickers on pregnancy tests and by trialling different website messages for the Stoptober smoking cessation campaign.(394)

Relevance for incentives

Nudge and MINDSPACE are loose collections of ideas for bringing about behaviour change with minimal interference by targeting key behavioural biases. Although nudge does refer to deposit contracts (financial disincentives), there is debate as to whether incentives fit with the concept of libertarian paternalism.(383) Certainly it does not fit with the definition of nudge provided. Others have made a clearer distinction between nudges and incentives:

"*Nudges are ways of influencing choice without limiting the choice set or making alternatives appreciably more costly in terms of time, trouble, social sanctions, and* *so forth. They are called for because of flaws in individual decision-making, and they work by making use of those flaws.*" (Hausman & Welch 2010, 126)(395)

Both Nudge and MINDSPACE contain elements of behavioural theory of potential use for describing incentives; however, the individual decisional 'flaws' are described in more detail below.

2.5.1.4. System 1 and System 2

Thinking, Fast and Slow is a book by Daniel Kahneman (208) that draws together some of his work from previous decades under a general theory about decision making. It proposes that individuals have two systems for decision making; System 1, a fast system based on associative memory which is frequently used, subconscious and automatic; and System 2, a slow system which is deliberative, conscious and logical. It goes on to focus on System 1 describing the biases and heuristics that we rely on and the short-comings of these. The effects of anchoring, framing, priming, optimism and default biases, ego depletion and endowment effect on decision making are discussed. The importance of such heuristics and associative consumption has been corroborated in several studies.(396, 397) Kahneman and colleagues offered results from a brain imaging study showing differential brain activity following different types of decision making in a laboratory test as evidence of the existence of the dual-system.(398) However, no formal (behavioural) economic model encompassing Kahneman's dual-system approach could be identified. As they are dealt with elsewhere, the main components of the theory that are relevant to incentives (such as Prospect Theory) are reviewed later on.

Relevance for incentives

Kahneman's proposition of a dual-decision making system (System 1, System 2) could offer an alternative explanation to the formation of 'habits'. It is possible that the 'decision' to persist with unhealthy behaviours is processed by System 1 and thus is associative or 'hard-wired' and consequently difficult to alter. System 2 may deal with decisions about health behaviour, weighing up the pros and cons of changing. Since new behaviours may be costly (in terms of time and overcoming cognitive and psychological barriers), they may not pass the threshold for action. Should these barriers be overcome and the individual attempts behaviour change, the marginal costs in continuing with the healthy behaviour may be lower as time passes; decisions to engage in it will be shifted to System 1 and hence, after a time, become automatic (and more likely).

This might be an argument for the use of incentives and counter-argument to those who question their sustainability. The role of incentive may only to be to secure participation ("foot in the door" approach) and the remainder of the change process could be a natural shift of desired behaviour to System 1. Should this be the case, it would only be necessary to determine the value of the incentive that would be required to outweigh the additional costs of behaviour change.

2.5.2. Theories relating to motivation

2.5.2.1. Crowding theory

The distinction between intrinsic and extrinsic motivation is key to understanding how and whether financial incentives work. Intrinsic motivation is the aspect of behavioural drive that emanates from innate processes (which may be intrinsic reward or punishment processes). In a general context, people might derive this 'feel-good-factor' utility from pro-social or altruistic acts such as volunteering, recycling, helping others, being creative, achieving something at work, completing a task deemed worthwhile, or fulfilling a commitment (to yourself or others). In the context of behaviour change, individuals may be driven to stop smoking or lose weight because they would feel better about themselves, feel a sense of achievement, receive social approval, etc. (See Table 6). Extrinsic motivation is generated by external pressure, demands or rewards. In the case of incentives for healthy behaviour it takes the form of financial remuneration for achieving health targets which are set by an external agent assumed to be acting in the individual's best interests.

The distinction between the two types of motivation is important because there is evidence that they can be mutually exclusive – particularly, that extrinsic motivation may 'crowd-out' intrinsic motivation. The concept of crowding-out was developed by Richard Titmuss in his book entitled 'The Gift Relationship: from Human Blood to Social Policy'(154) in which he predicted that offering extrinsic rewards for a task may extinguish the intrinsic motivation for it and have the effect of lowering overall motivation. Formerly intrinsically rewarding tasks are altered in the principal's eye to become 'jobs' thus extinguishing their intrinsic value. There is some evidence corroborating the phenomenon in blood donation (155) although this is less clear when non-monetary incentives (e.g. vouchers) are used (156, 399) and there is also evidence to the contrary.(230) There is a substantive body of research indicating crowding-out is a real phenomenon from the fields of education and employment (157, 158) and generally in pro-social behaviour.(400-402)

Bruno Frey posited that crowding-out is dependent on the principal's perception of the incentive; if it is seen as controlling or coercive, intrinsic motivation is reduced, if it is perceived as supportive, crowding-out does not occur.(159, 402, 403) Ariely and colleagues offer an 'image-motivation' hypothesis which holds that people derive utility from being seen publicly to behave pro-socially.(176) One study showed that the level of motivation (or effort) and crowding-out did in fact depend on whether the task was private or public. When an incentive was offered for a pro-social task in public, it actually reduced effort where the reverse was true in private. The highest performance effort was observed for the task when completed in public without an incentive.(176) The importance of this interaction of incentive, visability (or public judgement) and motivation was also raised in a review in blood donation research.(404) Elsewhere, Janssen and Mendys produced an economic model of crowding-out in blood donation distinguishing between altruists and egoists (405) predicting that incentives may crowd-out donations and that this would be exacerbated if incentives were removed after introduction. Perhaps the most commonly cited explanation for crowding-out is Cognitive Evaluation Theory (itself founded on self-determination theory) provided by Deci and Ryan. They suggest that a reduction in intrinsic motivation following extrinsic reward only occurs if the target task is considered to be 'interesting' (i.e. rewarding in itself).(406)

Aside from research on blood donation, there is a dearth of studies exploring crowding-out in a health context. Crane and colleagues found that financial incentives did not reduce – what they referred to as – autonomous motivation for participation in a weight loss programme.(407) Moller and colleagues reported that incentives had no impact during a weight loss trial but was associated with worse weight loss maintenance outcomes when the incentive was removed.(408) In a subsequent analysis the authors concluded that incentives also reduced people's enjoyment of the target activities (such as exercising).(409) In contrast, a recent review could not find any evidence of crowding-out in a health context. The explanation offered for this finding is that crowding only occurs when initial intrinsic motivation is high which is seldom the case in populations that would be offered the extrinsic incentive.(410)

A lesser-reported, but potentially important, phenomenon is crowding-in, a converse proposition to crowding-out where extrinsic rewards not only increase motivation for the principal for the target behaviour but has positive 'spill-over' or 'double-dividend' effects. These effects might include the principal engaging in other, non-incentivised healthy behaviours (which can be considered complementary goods); continuing the target behaviour beyond an incentivised period; or encouraging other, non-incentivised, individuals to change their behaviour. To some degree, the sustainability of incentives for delivering complex behaviour changes may rely on the existence of crowding-in; that, when incentives are removed, as they must inevitably be, motivation remains. A small number of studies suggest that such a process might exist.(115, 223)

Relevance for incentives

Crowding theory may be an important consideration for incentive schemes. Research seems to suggest that whether crowding occurs or not depends on the perception of the individuals participating and/or the target behaviour. It is unclear whether the research in pro-social behaviours or the Cognitive Evaluation Theory generalises to health behaviour where the most obvious benefits are improved future health which is a private ‘good’: although it may save the NHS future costs, it’s unlikely that this public motivation is particularly strong.

A detailed discussion on the nature of intrinsic and extrinsic motivation for health behaviour change is beyond the current research. However, a few points are worth making on the distinction between the two. Intrinsic rewards rely on the principal’s perception of the task; the more self-directed, pro-social, public, selfless and arduous, the higher the rewards will be for completion. Consequently, it is possible to see how intrinsic rewards for the same task may vary from principal to principal. Crucially, it may depend on whether the principal views behaviour change as ‘worthwhile’ which itself may depend on social norms, education, and other factors and go some way to explain why different socioeconomic groups may have different levels of intrinsic motivation for the same behaviour. A simple representation of this is given in Figure 8.

Figure 8: Likelihood of crowding-out

		Behaviour seen as desirable or interesting?	
Behaviour publicly visible?		**Yes**	**No**
	Yes	High	Low/Uncertain
	No	Moderate	Low

Incentive schemes clearly need to consider how the principal views the task and the reward. The suitability of incentives for certain tasks and for certain groups may be questioned on this basis. However, the phenomenon may only be a risk if intrinsic motivation is present at the outset and, if it is, incentives may not be required.

2.5.2.2. Habit formation

Although not strictly a behavioural economic concept, habit formation is studied more often as a behavioural phenomenon. Studies of habit formation are concerned with understanding how behaviours move from being conscious choices which may be infrequent or irregular in occurrence to more automated behaviours, conducted regularly or as part of a routine, the inception of which requires little or no cognitive effort. Examples of bad habits may include buying a doughnut every morning on the way to work, driving to work, watching television for several hours every night. Examples of good habits are taking the stairs instead of the lift at the office, snacking on fruit and nuts at work or cycling to work.

While elements of the addiction models may be useful in characterising habit formation, dedicated habit formation models were not identified in the review. The creation of habits of healthy behaviours is highly desirable.(411) Healthy behaviours often require intention, motivation and self-control which demand psychological effort. The desired behaviours are more likely to occur and be sustained if they are automatic and rely less on the effortful weighing up of pros and cons and consequent intention.(412, 413) A recent study found that habits were more likely to be formed in physical activity if the individual had intrinsic motivation for the behaviour at outset.(411)

Psychological-based models of behaviour change were not part of the review scope. However, most acknowledge habit formation. A commonly used model is Prochaska and Di Clemente's Transtheoretical Model (TTM) of Health Behaviour Change, also known as the 'Stages of Change' model.(187) The model breaks down behaviour change into stages defined by timing: Pre-Contemplation (no intention to change); Contemplation (the individual is thinking about change and weighing up the pros and cons but not ready to take action); Preparation (the individual is making plans to change behaviour); Action (the individual has made specific changes to their behaviour); Maintenance (Following a change in behaviour the individual is endeavouring not to relapse); Termination (the behaviour change initiated by the individual has become normative or associative and there is no longer a prospect of relapse). This has been criticised by some who believe the 'stages' of change as presented are essentially arbitrary and because it relies on the assumption that individuals usually make coherent and concrete plans.(32, 414) Studies have shown however that a majority of – for example – smoking quit attempts were unplanned.(415) In response West proposed the PRIME theory of motivation where the motivational system is conceptualised as chaotic and unstable and where change can occur at any time without planning but is also at risk from after-shocks or small triggers.(32) In contrast to the TTM, the PRIME model also acknowledges that addictive behaviour eventually becomes semi-automated.

Relevance for incentives

Proponents of incentive use argue that a major benefit they may offer is to encourage the formation of healthy habits. Incentives may encourage the initiation of behaviour (that may not occur in the absence of incentives) and motivate behaviour continuation in the short-run. It is hoped that before the incentivised period elapses, the desired behaviour becomes more automatic and habitualised. Thus the impact of the incentive may extend beyond the incentivised period. It is conceivable however, that behaviours that were perceived as leading to disutility prior to attempts are actually, after an initial period, enjoyable and in that sense self-control and motivation are not necessarily required. For example, people may dislike the idea of exercise but after an initial period may enjoy the experience and endorphin rush they get and, similarly, people might stick with a healthy diet, not because of defaults in choice but because they feel in a better mood and have more energy. Self-motivation has been found to depend on the level of positive feeling one derives from exercise.(416) There is also evidence that once weight loss maintenance is achieved at 1 year, then it is easier to maintain between 2 and 5 years which may be attributable to the formation of good habits.(203) Kahneman's System 1 and System 2 framework, which encapsulates themes of the main psychological models, may offer some explanation of habit formation. However, there has been no formal assessment of the framework for this purpose.

2.5.3. Theories relating to willpower and self-control

"*You must bind me hard and fast, so that I cannot stir from the spot where you will stand me and if I beg you to release me, you must tighten and add to my bonds*"

[Homer, The Odyssey, Book XII, (c 800 BC)]

In considering the issue of self-control, Thaler and Shefrin (417) conceptualised the problem as one of intertemporal choice. They refer to earlier work by George Stigler in 1966 (418) where the Christmas Club fund (where individuals put money into none-interest yielding and inaccessible saving funds) quandary is explained by "*another item of preference: a desire of people to protect themselves against a future lack of willpower*". Thaler and Shefrin offer a two-self model of economic man, the farsighted *planner* and the myopic *doer*. The former is concerned with lifetime utility, while the latter's sole interest is in one period and is totally selfish. They go on to propose that the planner has two ways to control the consumption of the doer: "(1) *The doer can be given discretion in which case either his preferences must be modified or his incentives must be altered, or (2) the doer's set of choices may instead be limited by imposing rules that change the constraints the doer faces.*"

The self-control problem is an issue faced by people in many aspects of their life and wherever their good intentions (whether to save money, to eat less or exercise more) are vulnerable they use a number of self-control tactics. In many cases this involves making a commitment or removing options – for example, people will pay gym membership fees to make sure they go enough to ‘get their money’s worth’; heavy smokers or drinkers will try to limit consumption by purchasing one packet or bottle at a time even though it can be more costly and be greater hassle continually having to make new purchases; and heavy spenders cut up credit cards.

Baumeister and Tierney describe willpower, the ability to control our behaviours in the face of temptation, as being like a muscle, which can be depleted after over use but which can be trained to become stronger.(206, 419) They go on to distinguish between four different uses of willpower; to control our performance, our thoughts, our emotions and our impulses. In a series of experiments, Baumeister’s group found that exerting will or self-control is tiring and that people are less able to exert this control in subsequent tasks. This process has been termed ‘ego depletion’ and corroborated in many studies.(420) Ego depletion may be overcome by incentives as it is related to loss of motivation rather than cognitive overload.(420)

There has been much work in psychology on health behaviour and self-control (421), self-efficacy (234) or self-regulation (422) and a number of attempts by economists to integrate these concepts in behavioural models.(423-426) The general concept has been found to be important in weight loss (238, 427), smoking (428), alcohol consumption (429) and physical activity.(238, 430) It appears to improve with age (431) but is at risk when people become depressed or are in a low mood state.(432, 433) Gul and Pesendorfer’s model (434) aimed to estimate the preference for commitment or self-control in dynamically consistent individuals. Their model included, not just choices of consumption, but choices between choice sets and concluded that opting for restricted choices may lead to better outcomes. Miao employed the Gul and Pesendorfer self-control utility model to consider optimal entry and exit investment decisions for a consumer with discount rate and self-control problems and for considering willingness to exercise.(435) The model, in contrast to the hyperbolic discounting model, is time consistent and includes ‘temptations’ that the agent must resist.

In contrast, Fudenberg and Levine present a quasi-hyperbolic discounted, dual-self model of self control (423) where the decision problem is conceptualised as a game between a “*sequence of short-run impulsive selves and a long-run patient self*”. Similar to Gul and Pesendorfer, one prediction of their model is that individuals have a preference for commitment devices to optimise utility. An alternative approach adopted by Brocas and Carillo (436) uses the principal-agent approach to consider the problem of self control. They propose that a forward-looking but unaware system (the principal) must make consumption decisions to maximise utility for itself and a myopic but informed system (the agent). As the principal lacks complete information, some choices are made by the agent although these may be from restricted choice sets which exclude unhealthy options. Here, again, Kahneman's two-system concept of decision making seems to resonate since part of System 2's role is to monitor the actions and choices suggested by System 1:

"*there are vital tasks that only System 2 can perform because they require effort and act of self-control in which the intuitions and impulses of System 1 are overcome*." [*Thinking, Slow and Fast*; page 31]

Relevance for incentives

Willpower and self-control are clearly key in determining the success of behaviour change. The ego depletion work by Baumeister and colleagues (437) appears to suggest that willpower is an exhaustible resource which has important implications for incentive design. The main potential implication for behaviour change is that willpower may become depleted after a time and it may become more difficult for individuals to stick to new behaviours. This would suggest that incentives may need to change in line with this to bridge the willpower or motivation deficit.

There are probably at least four noteworthy components to these general concepts of self-control: 1) Whether an individual believes – in part a function of education, faith in information on risks of unhealthy behaviours – that they have any say in their health (whether it is internally or externally controlled – the "when your time's up, your time's up!" attitude; 2) assuming that they believe 1) to be true, the general extent to which they feel they have the self-control and willpower to change behaviour; 3) how this self-control fluctuates over time and to what degree it becomes 'depleted'; 4) related to 3) is which system is engaged in the decisional process – when behaviour becomes automatic, self-control (and therefore depletion) may no longer be an issue.

According to West (32) the valence associated with addictive substances (or unhealthy behaviours) is chaotic and unstable. It is likely to be in flux throughout the day due to neurological, psychological, physiological cues. For example, a smoker may crave a cigarette first thing in the morning or after a meal and those on a diet may face greater cravings when out with friends for a meal or if they see nice food in a magazine or on television. This being the case, the incentive level (which for practical reasons cannot move in line with these fluctuations) must be high enough to ensure that motivation is retained (that the pros outweigh the cons) at the height of the cravings and cognitive costs that the individual may face.

2.5.4. Theories relating to time-preference

2.5.4.1. Hyperbolic discounting

Traditional models of temporal decisions required that people discounted future utility at an exponential rate. However, Strotz (1955) explored what happened if this assumption was relaxed and preferences were no longer assumed to be consistent over time, that people were 'dynamically inconsistent'.(438) Many studies indicate that individuals do not employ normal (exponential) or consistent discount rates assumed in Grossman and rational addiction models but rather employ what is termed hyperbolic (126, 321, 345, 424, 439-442) or quasi-hyperbolic discount rates.(443) A full description of the different models is available elsewhere.(444) Put simply, given two rewards, one smaller and received earlier than the other, larger reward, people's preferences for the smaller vs. the larger reward often changes as a function of the timing of the choice even though the delay between the two rewards stays the same. This was termed 'hyperbolic discounting' by George Ainslie (445) and describes the phenomenon where individuals have higher discount rates for intertemporal tradeoffs that occur sooner than for those that occur further in the future, expressed formally:

$$V_p = \frac{V}{1 + kD}$$

Where Vp *and* V *are the* discounted and undiscounted rewards, respectively; k is a parameter denoting sensitivity to delay and D is the delay.(446) An example might be that an individual would prefer to receive £100 now rather than £110 tomorrow but would rather have £110 in a year and a day than have £100 in a year. The implied discount rate is the same in both options but a preference reversal means people are inconsistent in their discounting.

It has been shown that hyperbolic discount rates can predict health behaviour.(447) Time preference or discount rates have been argued to be key in health behaviours such as smoking (329, 330, 332, 333, 441) (448), unhealthy diets (335), obesity (336, 337, 449), exercise (447), addiction (338) and alcohol abuse (339) (although not all studies corroborate this finding (341)). Discounting has been found to differ by gender (344) and there is some evidence that it is negatively associated with income levels or social status(323, 450) and mood.(451-453) Research also suggests that the degree of discounting also depends on the size of the reward (the magnitude effect)(454, 455) with small rewards being heavily discounted (the peanuts effect).(456) While there is a clear and commonly found relationship between discounting and health some argue that the direction of causality is from health to time preference – that poor health (or health expectations) lead people to become more present-focussed and employ greater delay discounts.(323)

Relevance for incentives

While some believe that hyperbolic discounting is in fact rational (457) what is less arguable is that it better reflects temporal decision making than exponential discounting. A key interpretation of hyperbolic discounting is that individuals are 'present-biased' and consequently have self-control problems – thus plans to change behaviour are undermined by high present discount rates. Given this, time preference may have a role in explaining both unhealthy behaviours and the success or failure of behaviour change attempts. If, as some studies indicate, those in lower income groups have higher discount rates than higher income groups, then this may partly explain why they are more likely to engage in unhealthy behaviours. We must then ask the question: to what degree is an individual's discount rate an innate quality or a natural and rational response to their life situation – i.e. living in the now because future prospects (including health) look (or are perceived to be) bleak. The implications for incentive design may be that rewards should not be delayed unduly and should be of sufficient value to avoid heavy discounting (the peanuts effect).

2.5.4.2. Picoeconomics and Multiple selves

"*With every day, and from both sides of my intelligence, the moral and the intellectual, I thus drew steadily nearer to that truth, by whose partial discovery I have been doomed to such a dreadful shipwreck: that man is not truly one, but truly two*." (The Strange Case of Dr Jekyll and Mr Hyde, Robert Louis Stevenson)

The conundrum of decision making over time is intertwined with the idea of multiple selves which was discussed earlier; of the individual being different entities in time with different wants. This concept is covered by Thaler and Shefrin's theory of multiple selves (the farsighted *planner* and the myopic *doer)* used to explain self-control (417) and by Schelling (458) describing the internal fight a smoker may experience:

"*Everybody behaves like two people, one who wants clean lungs and long life and another who adores tobacco or another who wants a lean body and another a dessert. The two are in a continual contest for control; the 'straight' one often in command most of the time, but the wayward one needing only to get occasional control to spoil the other's best laid plan.*"

An influential psychologist in this field was George Ainslie who developed the theory of 'Picoeconomics'.(445, 459) Picoeconomics is the concept that many interpersonal economic phenomena also apply at an intra-personal level; that individuals operate in a market place and make decisions and choices with other intertemporal versions of themselves. Within this, Ainslie thought hyperbolic time preferences dictated that current versions of yourself made choices and decisions that are incompatible with the preferences of future versions of yourself but that the future self had to accept these as they are locked in by earlier choices. Relating back to issues of hyperbolic discounting and self-control, Picoeconomics suggests that there are optimal strategies for dealing with this by making the current self make commitments.

Elsewhere, Laux and colleagues consider unhealthy behaviours and addictions as an interpersonal, intertemporal externality – i.e. costs incurred by the future self due to the consumption of the current self.(460)

Relevance for incentives

Understanding inter-temporal preferences is key to finding a solution to problems of willpower and self-control which are often the beginning and (premature) end of behaviour change endeavours. Issues of self-control and willpower are ignored by traditional economic theory which states an individual decides on the best course of action and then completes the action without fail. While incentive design need not explicitly incorporate ideas of multiple selves, they should be created such that heavy discounting is avoided. The growth in websites offering platforms for commitment (such as SticCK and BeeMinder discussed in the Introduction) indicate that ideas relating to self-control devices have gained prominence.

2.5.5. Heuristics and biases

2.5.5.1. Prospect Theory and loss aversion

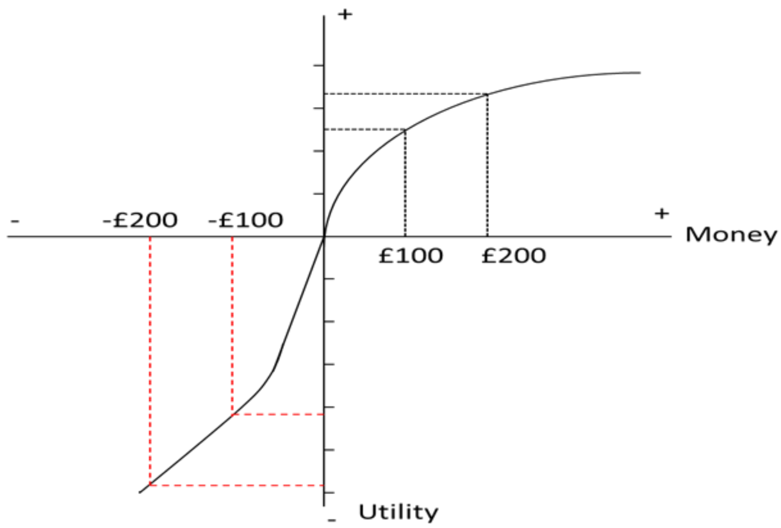
Kahneman and Tversky's Prospect Theory (208, 461) was a key development in behavioural economics. They challenged Daniel Bernoulli's theory on the utility of money and particularly the differences in utility impact between losses and gains. Offered as a challenge to expected utility theory it outlines a number of human flaws in decision making under uncertainty. Kahneman outlined three key cognitive principles that underpinned the theory: that the reference point for decisions matters; that people have diminishing sensitivity to changes in wealth (or other factors); and that people are loss averse. Bernouilli had showed that people did not evaluate gambles in a way consistent with expected utility theory. For example, most would prefer a guaranteed prize of £100 over a gamble with a 10% chance of winning £1050 even though the gamble has a higher expected value (£105 vs. £100). However, prospect theory highlighted the willingness to take a gamble is affected by the alternative options as illustrated in the decision problems below:

Choice 1: would you rather have a guaranteed £900 or have 90% chance of winning £1000?

Choice 2: would you rather lose a guaranteed £900 or have a 90% chance of losing £1000?

While the expected value of both options in Choices 1 and 2 are the same (£900 and 0.90 x £1000), many people would choose the guaranteed £900 gain in Choice 1 and take the risk of losing £1000 rather than losing £900 for certain in Choice 2. Thus, our willingness to take risks is not equivalent in gains and losses. This is illustrated in Figure 9 which shows the utility impact of (monetary) losses and gains. The figure shows the 'S' shape of utility representing diminishing marginal returns (the more we gain, the less utility we obtain from each incremental gain) but, importantly, the curves are not the same shape in the gain and loss parts of the graph. The curve in the loss section is much steeper than in the gain section indicating that losses lead to much greater changes (reductions) in utility than gains of the same value, or "losses loom larger than gains". This finding underlines the importance of loss aversion in decision making and debunks the expected utility theory tenets that reference points are irrelevant and that people only care about absolute wealth, not relative wealth.

Figure 9: Prospect theory - utility of gains and losses



This is given by the following equation:

$$U_e = \sum_{i=1}^{n} w\,(p_i) v(x_i)$$

where U_e is expected utility of decisions, prospects or gambles where p_i is the potential probabilities and x_i the outcome. The functions w and v are weights for assigning values to the probabilities and outcomes, respectively. We can conclude that people are risk averse except when all the prospects on offer are unattractive in which case people become optimistic and risk seeking. This behavioural phenomenon may explain not just our attitudes to financial gambles but to risky behaviour itself. For example, imagine the following choice between:

Option A: Give up salty and fatty food and start going to the gym

Option B: Continue to eat what you like and have a 5% risk of a stroke in next 10 years

It is possible to see how individuals may follow one of the major findings of prospect theory: “In bad choice, where a sure loss (changing health behaviour) is compared to a larger loss (stroke) that is merely probable, diminishing sensitivity causes risk seeking” (Thinking, Fast and Slow; page 285) and go for option B. The theory has been applied in the design of a number of interventions.(462-464)

Relevance for incentives

The implications of prospect theory for incentives are two-fold. Firstly, people would prefer certain rewards (providing they are of a sufficient magnitude) over uncertain ones even if the expected value is the same; secondly, due to loss aversion, people will be highly motivated to avoid losing money as this is felt keenly. Thus, deposit and commitment contracts, where individuals pledge money that is returned to them only if they succeed in agreed behaviour change may on average be a more powerful motivator than positive incentives. However, their suitability for use in low income groups is questionable and – assuming such schemes are voluntary – they would probably suffer from very low participation in these groups which in turn would jeopardise any opportunity to reduce health inequalities.

One criticism of Prospect Theory is that is does not accommodate regret or disappointment.(208) Some psychologists believe that the desire to minimise regret rather than the desire to maximise outcomes may sometimes be the driving force in decision making. When decisions are repeated, this may be a useful tool in incentive design. For example, in one period where the individual failed to achieve their targets, informing them what they could have won may well augment motivation for the next period.(465)

Not unrelated to Prospect Theory and intensively researched by the same author is people's ability to judge the probability of events. Kahneman has concluded from his work and that of colleagues that people overestimate the probabilities of unlikely events. This suggests that, even though people prefer certain rewards, lotteries may be a more cost-effective form of incentive than guaranteed incentives. In addition, research shows that lotteries will be more attractive than certain rewards if the certain reward is small; partly because people over-estimate their chance of winning but also people discount small rewards heavily (the peanuts effect again).(456)

2.5.5.2. Endowment effect

The endowment effect (466-468) describes the phenomenon that people value things more if they own them. This is evidenced by studies showing people are willing to pay more to keep something than they would to buy the same thing from someone else. Like all theories described in this section, it represents a contravention of classical economic theory which states that an individual's willingness to accept should be the same as their willingness to pay. The explanations for this phenomenon are varied but loss aversion is usually offered as the cause – when we own something, giving it up has the effect of a loss and, as outlined previously, losses are keenly felt.

Relevance for incentives

The application for incentives is that promising a reward with the threat of reducing or removing it with failure may elicit a stronger behavioural response than only offering the reward if behavioural targets are met. A recent study by Hossain and List found that worker motivation was higher when they were working to retain a provisional bonus than if they were working to attain a bonus.(469) The authors found that this 'framing manipulation' led to a 1% increase in team productivity and concluded this was driven by 'loss aversion'. No studies of incentives in health have been found to adopt this format.

2.5.5.3. Mental Accounting

Richard Thaler and colleagues developed the theory of mental accounting; the theory that individuals parse out their money into different mental accounts.(470) People may have different accounts for salary, food and clothes and money is not easily switched between them - that is, it is not fungible. A classic study highlighting this phenomenon found individuals may be willing to travel to save £5 on a £15 radio but not to save £5 on a £240 refrigerator.(471)

The theory may explain why an individual might be relatively insensitive to a price increase in some things (e.g. cigarettes) but not to others (e.g. vegetables) and, consequently, why high price increases (e.g. in taxes) have not been met with a commensurate reduction in behaviour (especially in tobacco use). Mental accounts are self-control mechanisms to ensure we have enough sufficient funds to purchase the things we need and not spend too much on one category of need, thus neglecting another. A consequence is that funds for addictive goods may be ring-fenced and protected as this good is a 'necessity'.

Relevance for incentives

This phenomenon may have significance in describing the impact of incentives. For example, due to mental accounting, it is unlikely that individuals considering the level of incentive offered for smoking cessation will also factor in the amount of money they will save by not smoking. Thus incentive pricing for smoking cessation and reduction of alcohol consumption should ignore cost savings to the individual which might be large. In 2013 prices, a pack of 20 cigarettes will cost at least £6.50. If an individual smokes 20 cigarettes a day they will spend £197.71 a month or £2,372.50 a year on the habit. Table 8 illustrates smoking costs as a proportion of income. Given this, smokers may already have a significant financial incentive to quit but still many do not.

Table 8: Costs of smoking

			Expenditure on cigarettes as % of monthly disposable income by income quintile*		
		Monthly disposable income	**Lowest quintile (£840.67)**	**Fourth lowest (£1,499.33)**	**Third lowest (£2,179.67)**
Cigarettes per day	**Annual habit cost**	**Monthly habit cost**			
10	£1,187.55	£98.96	11.8%	6.6%	4.5%
15	£1,781.33	£148.44	17.7%	9.9%	6.8%
20	£2,375.10	£197.93	23.5%	13.2%	9.1%
25	£2,968.88	£247.41	29.4%	16.5%	11.4%

*From Department of Work and Pensions (2013)

2.5.5.4. Status Quo Bias

Status quo bias is the inclination for people to stick with their current situation even though a change in their behaviour would lead to better outcomes.(467, 472) Samuelson thought this bias resulted from: a) rational decision making due to transition costs and uncertainly; b) cognitive biases including loss aversion and the endowment effect; c) psychological commitment relating to the sunk cost fallacy, regret avoidance and a desire for consistency.(472)

Relevance for incentives

This might be particularly important in health behaviour change and explain why it is so difficult to achieve. Status quo biases may highlight that there is a significant ‘cost’ threshold to overcome initially before change is initiated. Consequently, it may be beneficial for incentive pricing to include a signing-up bonus or large enough pay-off at inception to persuade individuals to overcome the initial cost of change threshold.

2.5.6. Social factors

Social factors are key in behaviour change (188) and likely to be important in understanding incentive effect.(80) It is probable that much of what we do is in part driven by what others do and what they expect.(473) Social norms (474) and social networks (475) may drive health expectations and behaviour. We may compare our health behaviour and status with others around us and be less inclined to quit smoking or go on a diet if people around us smoke and are overweight. Similarly, if several of your family or people in your neighbourhood die at 70 of cardiovascular disease you might perceive this as ‘normal’ and lower expectations for your own health in line with this. This would make behaviour change and the short-term costs associated with it, not worth the investment.

Making commitments publicly will also augment motivation because if we fail we may feel we have let people down and that they will judge us negatively (e.g. as lazy or a failure) and, conversely, if we succeed the opposite will occur.(80) This social process which acts to magnify feelings is clearly dependent on the social group we are part of and interact with. If we are trying to stop smoking and most of our friends and family smoke not only will there be more environmental cues for smoking making quitting difficult, there will be no social pressure to quit and attempts to quit may not be judged favourably by others in the social group.

Relevance for incentives

Incentive schemes may capitalise on the issues above. For example, it may pay for behaviour change schemes to involve a public commitment (as is the case with www.StickK.com which asks participants to name witnesses to their commitments), for rewards to be based on group performance and may benefit from inviting other members of the target individual's social group (e.g. partner) to be involved in the scheme. A number of local authorities in the UK have run schemes for smoking cessation where the pregnant woman and her partner are both rewarded for cessation.(476)

2.6. Summary and discussion

The introduction to the chapter set out a hypothesis on the process of behaviour change and impact of financial incentives on that process. The subsequent configurative review has outlined the published models and theories that might formally explain some of these aspects. The review identified a number of economic and behavioural-economic theories that seek to explain both unhealthy behaviour and behaviour change and described these sets of theories separately and discussed their strengths and weaknesses. Traditional psychological concepts of behaviour change were excluded from the review since they present a myriad of competing explanations with no consensus as to which is optimal. Evidence for the predictive power of the identified frameworks was, in the main, limited. The framework search results were searched for studies that presented empirical tests of the models but in most cases this produced few or no results. Consequently, for the main frameworks under consideration, brief searches were conducted of articles that had cited the framework to identify examples of empirical tests. The theories and frameworks and their strengths and weaknesses are briefly summarised again below along with the discussion on their suitability for inclusion in an incentive framework.

2.6.1. Neo-classical economic theories

The review categorised neo-classical theories into either; generalised utility-maximisation models; human capital and health investment models; or rational addiction models. However, this is a false distinction to a degree as all could be thought of as utility-maximising frameworks. Utility-maximisation and rational consumer choice frameworks are the common building blocks of economic theory. Simply put, individuals make decisions and consumption choices that maximise their utility over a lifetime. Binkley et al and Cawley present frameworks based on utility-maximisation relating to health. Binkley's model relates to smoking starting and cessation decisions with the aim to maximise long term utility from income taking into account earnings and potential lost earnings through smoking-related illness. Empirical tests of the theory could not be identified. Cawley's SLOTH (Sleep, Leisure, Occupation, Transportation and Household) model in contrast has been used, adapted and tested on a number of occasions. The SLOTH model estimates how individuals allocate time across activities to reach dietary targets. It improves on the Binkley model as it includes utility relating to well-being and not just income. Acknowledging that people have time and biological constraints as well as an income constraint is a strength of the theory and it is a novel and useful addition to the literature. Predictions from the model include: a reduced demand for physical activity with increased earnings due to the increased opportunity cost; and reduced activity participation in those with children, presumably due to time constraints or since caring for children increases normal activity levels. The usefulness of the model is limited by the fact that it is only suitable for diet and physical activity and would not be relevant for other behaviours such as smoking or alcohol consumption where time and biological constraints are less relevant. Furthermore, empirical tests showed the model had only modest explanatory power.

The Grossman health investment model has been applied many times and remains popular. It has been adapted and many of the shortcomings of the original model addressed; for example, with the incorporation of uncertainty into the model. While some of its predictions are intuitive (e.g. that improved education improves health production efficiency), the predictive power of the model has been criticised. There were supportive studies – for example, findings that people with higher income were more likely to modify their lifestyle following a diagnosis of high blood pressure; and that those who receive a health shock are more likely to change behaviour. However, Grossman fails to predict that health declines with lower socio-economic status and incorrectly predicts a positive relationship between health status and health investment.

The Rational Addiction framework has also been extensively used across several behaviours and the developers claim it predicts unhealthy habit formation and explains phenomena such as binge consumption and cold turkey quitting. Evidence for the predictive ability of the model is mixed with some finding future prices are predictive of behaviour change and others finding that the model erroneously predicts addiction to harmless goods such as milk. Useful augmentations of the model include a Heckman double-hurdle approach where individuals face separate problems of quit attempts and then quit maintenance. However, as with other neo-classical frameworks, empirical tests of the model in behaviour change are scarce. The original model implausibly assumes that addicts choose their path and are content – i.e. there is no regret; this is counter-intuitive since many addicts are unhappy with their predicament and would prefer to quit unhealthy habits. According to rational addiction, addicts would simply choose to quit if they were unhappy with their current lifestyle and be successful in this endeavour. Clearly this does not reflect the situation for most people trapped in a cycle of unhealthy behaviour and these assumptions are a significant weakness of the model.

Since neo-classical models incorporate decisions about future consumption, they employ discount rates of future prices and utility. Traditionally this is incorporated as a constant rate. Despite the methodological difficulty in measuring this factor, it has been found to independently predict both unhealthy behaviour and behaviour change. However, many studies have shown the assumption of a constant discount rate to be inadequate and that time-inconsistent or hyperbolic discount rates better reflect inter-temporal choices.

The neo-classical approaches are limited by restrictive assumptions regarding rationality, perfect information, future consumption planning and constant discounting. Many of these have been relaxed in more recent adaptations but the predictive ability of the models remains mixed at best. Where findings are in line with predictions the underlying mechanism of action and causality is often undetermined as tests have been based on data from national databases of health and consumption which have limited variables available. For example, a change in behaviour following a health shock may relate to new information about health, a reduction in uncertainty in this information, social pressure or interventions from the health service (supply rather than demand). Thus the threat of exogeneity remains a significant weakness of these theories.

The neo-classical models help to frame health decisions as any other consumption or investment decision: a rational human (*Homo Economicus*) simply weighing up the pros and cons of alternative courses of action and making choices that maximise their utility. Viewing health-related decisions in this way allows us to deconstruct the important factors and to try and identify a) causes of behaviour; b) routes to intervening; c) potentially optimal intervention design. Utility-maximisation is not the only theory in welfare economics although it does predominate. Capability theory – where welfare is judged on an individual's ability to produce value - is a competing theory which may have some relevance for incentives. However, reviews of all economic paradigms was not feasible here.

2.6.2. Behavioural economic theories

Many of the adaptations of the neo-classical models have sought to improve on forerunning models by relaxing the assumptions of rationality and incorporating more behavioural aspects. For example, bounded rationality offers the alternative plausible paradigm to utility-maximisation where agents seek only to achieve a satisfactory level of utility. Of the behavioural theories identified, most were individual theories and not cohesive frameworks. For example MINDSPACE is a collection of strategies for targeting biases and heuristics to deliver behaviour change. The exception to this was the imperfectly rational and 'irrational' addiction models. These introduce time-inconsistent discount rates, uncertainty and regret associated with addiction and failure in quit attempts. Robust attempts to compare the predictive ability of rational and irrational addiction models could not be identified; however, the latter appear to offer greater face validity than the former. A particularly useful addition from irrational models is the assumption of greater costs of starting quit attempts due to withdrawal, something that has been empirically validated and is predictive of relapses (in smoking cessation attempts at least).

The behavioural frameworks such as MINDSPACE and Nudge have not been accompanied by formal econometric representations. These are qualitative theories and loose collections of biases and heuristics and the relationships between them have not been described formally or tested empirically which is a significant limitation. In addition to these are individual theories and concepts such as Kahneman's System 1 and 2, hyperbolic discounting and willpower depletion. Again, taken separately, these do not described a process of behaviour change. However, some of these are potentially useful components of a framework for understanding the effect of incentives. The evidence for these theories tend to come in a different form to that of the investment in health and addiction models which have been applied to large panel datasets. Evidence for concepts such as System 1 and System 2 and willpower depletion come largely from laboratory experiments. These represent a more direct and robust evaluation of theory validity but the absence of larger-scale, empirical tests of these in real-world settings represents a limitation.

Time preference was identified as important in understanding why people do not change behaviour and how incentives could influence this. Since the benefits of healthy behaviour are often in the future, those with high discount rates will devalue these benefits significantly and hence current unhealthy consumption will continue. Incentives are assumed to bring the reward forward in time making change more likely. However, hyperbolic discounting has consistently been found to improve on constant discounting in terms of predictive power.

Kahneman's dual consciousness system provides a neat theory to describe the way in which unhealthy behaviours may persist. Given that decisions carry a cognitive burden, choices regarding behaviour often follow a default, a quick and unconscious process. This might explain habits; how they persist and the additional (cognitive) costs in changing them. Since it is assumed that indefinite incentives are unsustainable, the System 1 and 2 theory might provide both information on pricing levels needed to kick-start change and a route for incentives to have a lasting effect by influencing habits. There is growing evidence for the existence of a dual decision making system which comes from brain imaging during decision making tasks in a laboratory setting.

The case for a role of willpower or some aspect of self-control in behaviour change also appears strong. A number of studies have shown a positive relationship between self-control and behaviour change. Furthermore, Baumeister and others have consistently found in experiments that willpower becomes depleted. After, periods of exerting self-control, this resource depletes and individuals are less able to resist temptation in the future. While they are intuitive and attractive, establishing the predictive power of theories such as System 1 and 2 and willpower depletion outside laboratory experiments is challenging since the variables required are quite specific, difficult to measure and thus unlikely to be available (and certainly not in large panel datasets). Furthermore, verifying them in a real-world test of incentives would be difficult.

The review identified a number of other biases that may be important in explaining behaviour change and incentives including the default bias and prospect theory. Evidence supports the existence of these phenomena and they form the core of some of the behavioural economic approaches including Nudge and MINDSPACE. Finally, the concept of crowding was identified as important in understanding the impact of incentives. There is evidence from blood donation that this phenomenon may mediate the effectiveness of incentive schemes. It describes how the utility derived from behaviour change and incentives may be influenced by external factors such as how society perceives the behaviour and whether the behaviour is visible but also internal factors relating to the innate human reward system.

There are several other heuristics and biases excluded from the review that undoubtedly influence people's choices in everyday life such as framing and anchoring effects and confirmation bias. Confirmation bias occurs when we seek out information in our array that confirms our beliefs or what we want to believe. Ignoring all the people in their neighbourhood who died prematurely due to unhealthy behaviours, an individual who smoked or was overweight wishing to avoid cognitive conflict might believe: "Derek smoked all his life, never had a day off work and lived til he was 90 and John never smoked, never drank, cycled everywhere and died of a heart attack at 60". These nuanced biases have not been covered in the review but can conceivably contribute to the same issue in behaviour change – initial costs of change.

2.6.3. Overall summary

There are currently no frameworks which aim to describe and predict the impact of financial incentives for health behaviour change. The review did identify frameworks that have been used to describe behaviour change and other theories which may have a role in an incentive framework. The neo-classical theories are restricted by their assumptions and scope. However, the core principles are worth retaining with some adaptation. Despite widespread use, the empirical tests of these, especially with reference to behaviour change, are few and in those conducted results appear mixed. While neo-classical frameworks can be made more realistic by incorporating uncertainty in both information and investments and by making individuals myopic or present-biased and adding regret, they will still omit important concepts. They are aimed more at a macro level in describing behaviour investments and are not designed to describe the impact of particular interventions in detail. They omit key behavioural principles relating to control and crowding out. Furthermore, a micro-level framework is required to describe the design issues relating to incentives.

It is acknowledged here and elsewhere that it is the combination of economics and psychology that provides the most promise for explaining behaviour.(465, 477) The emergence of behavioural-economic theories allows a more realistic explanation of decisional processes. The consideration of the individual behavioural factors covered in this review have sustained economists and psychologists over decades and produced hundreds of studies and extended econometrics proofs of theorem. It was not possible here to cover each in significant detail but sufficiently to determine whether these factors could explain the effectiveness of incentives and help with the design of the survey and inform the later research themes. The following brief chapter proposes a theoretical form describing the effect of financial incentives taking into account the process of behaviour change outlined previously and the theories reviewed here which underpin this. The theoretical model will be the basis for designing the incentive pricing survey.

3. Theoretical framework of financial incentives in health

3.1. The need for a new framework

A framework is quite a vague concept and can mean different things in different contexts and disciplines. In economics, frameworks are often formal econometric theoretical representations of the relationships between principals, agents and qualities of goods and services in the area of interest - for example, between consumers and the supply and price of goods. These frameworks are useful for introducing behavioural phenomena such as diminishing marginal utility and events such as changes in price or supply or improved information. Frameworks are useful for describing these relationships and for evaluating and predicting how changes and events can impact on demand and consumption; this in turn allows us to plan, create appropriate policy and design interventions. In the absence of a framework for incentives in health, the design of incentive schemes and understanding of their impact is likely to be less certain and more risky. Schemes may be less efficient and research questions in the field not targeted to the areas of greatest uncertainty.

The previous chapter summarised the theories and frameworks that have been used to describe and predict behaviour change and also those that might be useful in explaining behaviour change and the role and impact of incentives. The frameworks identified were not adequate, either conceptually, from a face validity perspective or based on tests of their explanatory power. Several behavioural theories were thought relevant to incentives but did not constitute frameworks and were not presented together in a way so that they could be considered to capture the breadth of factors that are known to be important in behaviour change.

For this reason a new framework is required to help better understand incentives. The framework should build on the idea of an individual trying to make decisions which provide satisfactory utility but capture the behavioural elements and acknowledge that choices are influenced by a number of biases and cognitive systems and that these interact with aspects of the incentive and individual. This chapter aims to achieve this by proposing a framework for capturing the impact of financial incentives. Based on the literature reviews of behaviour change frameworks and behavioural theories relating to health, a theoretical framework is proposed in this chapter that seeks to explain:

a) key factors in behaviour change

b) the role of incentives within this process

c) how features of incentive schemes and individuals receiving them can influence incentive effectiveness

This framework formally conceptualises the hypothesised impact of incentives and helps to inform the development of the pricing survey and parameters within the model developed for the economic evaluation.

The proposed framework is based on a bounded utility-maximisation problem and thus individuals attempt to achieve a satisfactory level of utility without being constrained by the neo-classical assumptions of perfect information and foresight. The framework does assume that consumers are forward looking to a degree but they are present biased and employ hyperbolic discounting. Many studies show that individuals discount in this way and not at a constant rate as presented in neo-classical models. I incorporate the idea that there is a dual-system (in line with Kahneman's System 1 and 2) for decision making. This idea has not previously been incorporated in health economic frameworks but provides an intuitive explanation for why unhealthy behaviour persists. Addiction models have considered habit stock to be a driving force of habits and others have considered the additional costs that are incurred in behaviour change. These still rely on the conscious weighing-up of options, however, and do not consider that behaviours persist because of decisional defaults or unconscious actions.

The neo-classical models unrealistically predict that when the balance shifts and the costs begin to outweigh the benefits of unhealthy behaviour then individuals will choose to change and succeed. Adaptations have added uncertainty to this process without describing a clear mechanism of action. The proposition improves on this by specifying control or willpower as the key to this process with success depending on the degree to which willpower is depleted. Laboratory and questionnaire research would allow this value to be estimated empirically but inclusion here allows us to consider interventions that might target this element of the framework.

The generic frameworks in the review did not consider individual interventions and thus there were several factors relating to financial incentives that are not covered. Thus the proposal below describes not only the process of behaviour change but, separately, attributes of incentive schemes that could be relevant and theories for incorporating these in to scheme design. Thus the proposal goes beyond previous attempts by characterising in detail the components of incentives. To illustrate, the framework can acknowledge that crowding theory may hinder effectiveness and also how decisional flaws may be manipulated to improve design. For example, prospect theory predicts that people over estimate the expected value from lotteries and thus lotteries may be more cost-effective than guaranteed incentives in changing behaviour.

3.2. Proposition

The following presents a descriptive theoretical model of decision making in health. The model is behavioural-economic in the sense that it does not assume 'rationality' and is not deterministic. Within this model a principal is presented as forward looking to a degree but employs high discount rates over future consumption and thus is present-biased. The concept of 'dual selves' proposed by Thaler et al (417) is not formally incorporated but factors consistent with this are.

The framework incorporates the idea that the decision to change or continue a behaviour is to some extent a process of weighing-up the pros and cons of alternatives and choosing that which yields the greatest expected utility. In this sense, it is in the spirit of the utility-maximising theories outlined in Chapter 2. However, applying the behavioural theory of Simon (363), instead of utility maximising, the rationality of the principal is bounded and they seek to 'satisfice' and reach an 'acceptable' level of utility only.

'Decisions' are made by System 1 (S1) and System 2 (S2) based on proposition of Kahneman and colleagues.(208) S1 decisions are not processed but semi-automatic and thus rely less on the weighing-up of the pros and cons of alternative courses of action. S2 decisions are effortful and calculated. Only after behaviour has been engaged in for some (undefined length of) time does it move from S2 to S1. While determined by S2, behaviours are prone to failure due to a fluctuation in any of the contributing factors such as costs. Even in S2 processes, decisions are bounded and utility is not 'maximised'. While strength of motivation is determined by expected utility, behaviour is dependent on decisional process and skills along with motivation.

A principle engaging in unhealthy behaviour has a probability (p_{Δ}) of changing behaviour in the current period (t) or maintaining changed behaviour in the next period ($t+1$). This can be viewed as:

$$\boldsymbol{p_{\Delta\, t} = f(S_{1\delta,2}, M_o, W_p, E, O)} \qquad [1]$$

Where $S_{1,2}$ represents which of the dual-systems makes the 'decision' about behaviour. If it is S1 then it is likely that behaviour in $t+1$ will be equal to that in t since conscious decision making is limited and the principal 'goes with the flow'. This is represented by the weighting factor δ in S1. If it is S2 in control then the weighing-up of other contributing factors becomes more important. The decision system employed depends on the load factor (σ) equivalent to the number of times the behaviour (B) has occurred in the past and whether this is equal to or above a critical (undefined) threshold (x):

$$S_{1,2} = \begin{cases} 1 \; if \;\; B\sigma \geq x \\ 2 \; if \;\; B\sigma < x \end{cases} \qquad [2]$$

M_o is motivation, W_p is a measure of willpower or self-control, E is education and skills and O is a vector of other factors that might have influence such as social norms. E is important as it required for the principal to convert motivation into well-directed behaviour (e.g. knowledge is needed about diets and exercise). Thus an individual can be highly motivated to change but fail because they lack knowledge in how to change.

The term motivation is used broadly here, it refers more generally to volition or demand for change. Overall motivation for behaviour change is M_o. Which, at time t_0 (baseline before change is initiated), can also be used as a measure of intention to change.

$$M_o = \frac{U_\Delta}{U_{\neg\Delta}} \qquad [3]$$

Where U_Δ is the expected lifetime utility of changed health behaviour and $U_{\neg\Delta}$ is the expected lifetime utility of continuing with unhealthy behaviour. If M_o > 1 then behaviour change is more likely to be initiated or maintained; if M_o < 1 then the inverse is true. The greater M_o, the stronger the desire for change.

The utility of not changing health behaviour ($U_{\neg\Delta}$) is given by:

$$U_{\neg\Delta} = \sum_{t=1}^{\mathrm{n}} \widehat{U}((B_{\neg\Delta}, C, H)/(1 + kD)) \qquad [4]$$

Which is the lifetime (n is life expectancy) net present value of the sum of expected utility $(\widehat{U})$ from the unhealthy behaviour ($B_{\neg\Delta}$), from C which is consumption of other goods and from H which represents health. To obtain the net present values, a discount rate is used to discount future utility. As proposed by Mazur and Ainslie, a hyperbolic discount rate is employed where k is the parameter denoting sensitivity to delay and D is the delay.(445, 446) This is contrary to rational economic theory but, as outlined in the review chapter, a better approximation of how people actually behave with regard to future costs and benefits. Thus the discount rate reduces as a function of the time to consumption and the principal is heavily present-biased.

The utility of health (H) is a function of health status (direct 'consumption utility' of health – i.e. 'feeling good') and income ('investment utility' which is indirect utility resulting from the ability to earn income, itself subject to diminishing returns). Income is dictated both by ability to work and wage rate (W). These aspects are similar to the consumption and investment benefits used in the Grossman model covered in the neo-classical economic section of the previous chapter.(77) Health status is driven by physical and mental health components. While both are important determinants of health utility; mental health (and mood in particular) has additional importance as it dictates the expectations and perceptions of the future. Thus those with low mood may devalue future prospects leading to even greater discounting. Health status (H_s) is subject to decrements (H_D) from ill-health relating to unhealthy behaviour which is probabilistic and determined by ($1 - p_e$).

$$H = f(H_s - (H_D(1 - p_e)), W) \qquad [5]$$

Unlike the Grossman model, individuals cannot predict if and when they will be ill; as outlined by Arrow (1963), health is essentially uncertain.(478) In this behavioural model the decisions about behaviour change incorporate people's expectations about future health and their belief about the consequences of their unhealthy lifestyle. Thus their perceived risk p_e is assumed to be a function of their education:

$$p_e = f(E) \qquad [6]$$

Those with poorer (health) education will not fully understand the risks of their health behaviour and have a lower perceived p_e. The utility associated with behaviour change (U_Δ) with financial incentivisation is given by:

$$U_{\Delta} = \sum_{t=1}^{\infty} \widehat{U}\left(\left(B_{c\Delta}, C, H, I\right)/(1+kD)\right) \quad [7]$$

Which is the sum of lifetime expected utility of C and H (as above) and of Bc_{Δ} representing the cost (and benefits) of behaviour change. Bc_{Δ} is given by:

$$B_{c\Delta} = f(F_{\Delta}, T_{\Delta}, W_{\Delta}, P_{\Delta}, Y) \quad [8]$$

Where F_{Δ} represents the financial costs (for example the cost of a healthier diet or gym membership) and benefits (for example, money saved on cigarettes) of change; T_{Δ} is the time costs (for example, the additional time required to prepare healthier meals and to exercise); W_{Δ} is a stock of willpower which is necessary to overcome cognitive cost of having to learn new skills and maintain self-control; and P_{Δ} represents the physical costs (such as withdrawal symptoms and strain of exercising) and benefits (feeling healthier). These costs and benefits will depend on Y which represents the type of behaviour being considered. For example, stopping smoking may save money but exercising will not; there will not likely be any cognitive benefits to any of the behaviour changes. While F_{Δ} and P_{Δ} have the capacity to be positive, overall Bc_{Δ} will be negative. Excepting financial costs, these factors are a positive function of the strength of behaviour; hence, for example: the more an individual smokes, the more 'costly' it will be to stop.

As outlined by Baumeister and colleagues and discussed in the review of behavioural theories, willpower is considered an exhaustible resource.(437) The principal is considered to have a stock of willpower (W_{Δ}) that is depleted over the course of engagement in behaviour change. Willpower in period t is equal to that in the previous period (t-1) minus additional cognitive costs (C_{ct}) in exerting control of temptation in the current period.

$$W_{\Delta t} = W_{\Delta t-1} - C_{ct} \quad [9]$$

The literature review highlighted that status quo bias could result from very high initial costs in changing (467, 472) thus C_{ct} is high initially but may fall over time. Acknowledging that willpower is a limited resource:

$$\theta_w = \begin{cases} 0 \; if \; W_\Delta \; > 0 \\ 1 \; if \; W_\Delta \; \leq 0 \end{cases} \qquad [10]$$

Where 0 is a critical threshold value and θ_w is an indicator of whether willpower or self-control is fully depleted (=1) or not (=0). If θ_w = 1 the overall costs $B_{c\Delta}$ will be unsustainable.

The final component of equation [7], I, is the utility derived from the financial incentive. As I occurs in time t, unlike future benefits of H, it avoids heavy future discounting. I is a function of the incentive level or price (I_p), a vector of factors denoting the incentive format including payment schedule and whether it is a lottery or guaranteed (I_f) and the individual's marginal utility of income (M).

$$I = f(I_p, I_f, M, C_o) \qquad [11]$$

The review of behavioural theories highlighted the importance of loss aversion (467) and prospect theory (461) is people's response to losses and gains. Because of this we can assume that for the same expected value of I_p I for lottery < I for a certain reward which is <I deposit contract. However, this is sensitive to the magnitude effect (e.g. peanuts effect) which may reverse these preferences.(454)

C_o is the degree to which crowding-out occurs, itself a nested function of the task, the individual's perception of the task and whether it is publicly visible or not. If crowding-out does occur the overall effect will be to make C_o negative.

Assuming that education and wages are low and that the discount rate is high, and the principal is consequently heavily present-biased, the net present values of C and H in equations 4 and 7 will approach equivalence and the differential between $U_{\neg\Delta}$ and U_Δ will be determined by (I- $B_{c\Delta}$)$-$ $B_{\neg\Delta}$.

3.3. Discussion

The behavioural-economic theoretical framework proposed here offers a starting point for understanding the potentially important inter-relationships that explain the impact of financial incentives. The framework is useful for isolating the potential importance of different factors and possible factors to target in an intervention. For example, in the model, improvement in education (E) will help individuals appreciate the risk and consequences of unhealthy behaviour (p_e) and be better able convert motivation into useful behaviour changes (equation 1) both of which would have the effect of increasing $p_{\Delta\,t}$. Those who are unemployed or on low wages will have lower future income and thus the value of avoiding future ill health will be low.

Empirical testing of economic frameworks relies on the analysis of large, (often) panel datasets. To the authors knowledge, no datasets are available that include data on incentives and the other factors hypothesised to be important. Incentive datasets tend to include low numbers of participants, from small trials or local government schemes. Datasets from the conditional cash transfer schemes run in developing countries, large insurance companies and large US corporations may have sufficient sample sizes but they will not include data on factors such as time preference and motivation. Hence some aspects of the framework presented here is descriptive in nature. However, other aspects are empirically tested in the following chapters that report results of the incentive pricing survey.

4. Developing a contingent valuation survey

4.1. Background

Despite the sustained and increasing interest in incentive schemes as a tool for behaviour change, a number of key questions regarding their design and efficacy, their affordability, cost-effectiveness and acceptability still remain. These questions include: which health behaviours are incentives most effective for?; what type of incentive structure is most effective and does this vary between social groups or health behaviours?; what is the optimal pricing of incentive schemes? The latter question is the focus of this chapter; despite its obvious importance, little research has been done in this area.(162, 169)

A review of incentives in weight loss trials could not identify in any of the published studies a rationale or justification for the choice of the incentive amount, frequency or method of administration of the financial incentives.(121) There is, however, evidence of some research addressing incentive amount; Cahill and Perera's review of incentive studies in smoking found a weak trend in favour of incentives being more effective when they exceeded 1.2% of individuals' disposable incomes.(116) More recently, a small number of primary research studies have sought to identify optimal incentive pricing. In Australia, Bonevski and colleagues conducted a survey of incentive pricing for smoking cessation finding that the most common incentive level required for 12 months of cessation was either $500 or $1000.(170) Elsewhere, You et al conducted a DCE in the US to identify incentive levels for weight loss (171) finding that an incentive of $98 results in a predicted participation rate of over 90% among overweight or obese men and women. Thus, while research is beginning to address incentive pricing, there are no published UK studies in this area and, hence, is an important knowledge gap worthy of investigation.(115, 116, 160, 172)

In the relatively few trials of financial incentives conducted to date, there has been a wide variation in the level of incentives offered to participants. A US study by Volpp and colleagues offered incentives of up to $750 if smokers joined a cessation programme and quit for 12 months (117) and an ongoing study offers a maximum of £752 (up to 6 months post-partum) for smoking cessation in pregnant women (105). In the UK, a recent pilot rewarded individuals up to £425 per year for weight loss

(131). At the other end of the spectrum a scheme in the US offered just $2.50 for achieving a negative drug test.(479) A recent review of 17 studies found incentives paid ranged from $5.16 to $786.(83) Several websites now in existence (such as Stickk and WeightWins) allow individuals to personally set the (dis)incentive amount they believe will be sufficient to motivate them to change. However, it is unclear whether these personally-set incentive levels are more effective than externally-set incentive amounts in generating the desired motivation and change.

It is a generally consistent finding that the efficacy of incentives is positively correlated with the incentive amount.(83, 123, 124, 480) However the strength of this relationship, whether it is linear, and how it is mediated by factors such as income, is unknown. There is evidence that in the UK several local authorities are introducing incentive schemes but they are doing so in the absence of guidance on incentive design and pricing. Poorly designed schemes are more likely to fail and have the potential to yield worse outcomes than could have been achieved in the absence of incentives. Given this, evidence-based information relating to the design (and, specifically, pricing) of schemes is critical, of real value and a priority for research.

4.1.1. Aims and objectives

The overall aim of the research described in this and the subsequent chapter was to estimate the incentive levels required for health behaviour change and to determine what influences those incentive levels. The research focussed on the key causes of preventable illness: smoking, diet and weight, physical inactivity and alcohol consumption. As well as addressing gaps in current knowledge, the results may also provide information for the decision-analytic model which is described in Chapter 9.

The method selected to estimate incentive levels was a contingent valuation survey. The current survey is a novel and innovative addition to research in the area for a number of reasons: it represents the only attempt in England to value incentive levels; it is the only survey where individuals value more than one behaviour concurrently; it is the only incentive valuation survey to date that directly targets individuals who are compelled to change their behaviour due to a health scare (as opposed to a general need for behaviour change); it is the only incentive survey that includes (for a sub-group of respondents) a follow-up survey, thus allowing the examination of required incentive levels over time.

Data collection via a prospective survey allowed the generation of data that incorporated theories and factors identified a priori (in this instance, during the literature review and framework development) as potentially being important determinants and mediators of incentive levels. The sample was opportunistic as the survey was completed as part of an on-going feasibility trial (described in more detail later) of health advice for those who had experienced a suspected cardiac event. There were certain advantages and disadvantages to using a sample that had experienced such a health scare. The sample was apposite in the sense that they engaged in the target risky behaviours (over-eating, physical inactivity, smoking, consuming risky levels of alcohol). In addition, due to their health scare, they were faced with the real prospect of having to change their behaviours rather than having to imagine the need to do this. This latter fact may mean the survey values have greater validity but also, conversely, that their responses may be less generalisable to the general population who may engage in these risky behaviours but who have yet to experience any health consequences. For example, perhaps following a health scare, individuals will be more willing to change their behaviour and thus require lower incentives. That said, incentives arguably have a clearer role as a targeted intervention in those for whom behaviour change is critical, rather than as a wider public health intervention, and hence, even if the generalisibility of the survey results on a wider basis were questioned, they would still be valuable in the current context.

Specific objectives for the research described in this chapter were to: i) create a contingent valuation survey – including factors identified in the reviews and theoretical framework as being important determinants of behaviour change/incentives - to provide information on minimum incentives required to change behaviour; ii) to pilot test the survey to test it for comprehensibility and practicality.

4.2. Method

4.2.1. Survey design

A contingent valuation survey was developed to capture information relating to the minimum willingness to accept (WTA) incentive level and important covariates in a group of patients with unhealthy lifestyles. The survey - the Valuing Health Change Questionnaire (VHCQ) – was generated with reference to best practice and content informed by the framework proposed in Chapter 3 which had identified key constructs and theories. The hypothesised relationship between incentive and behaviour change and the factors mediating this are illustrated in Figure 10. To elaborate, the incentive effect is determined by the design and the amount offered. Incentives represent external motivation and whether this translates into behaviour change is determined by a number of barriers and facilitators such as social norms and skills. The extent to which the incentive generates sufficient external motivation is thought to be mediated by factors such as attitudes (e.g. acceptance of incentives), income and behaviour type. The survey had a number of sections which are described below in the order they appear in the VHCQ. The pilot version of the VHCQ also contained questions on health-related quality of life and health state preference questions which were dropped as the focus of the research changed direction. These are not described but presented in the pilot version include in the appendix (Appendix 12.1). Questions relating to demographics and health behaviours were not included in the VHCQ as these were planned to be captured in the larger survey of which VHCQ was to be a part.

Direct questions relating to the economic evaluation research package were not included in the survey. This was partly due to the timing of the survey (occurring before it was certain the economic evaluation would take place) and partly due to space constraint in the survey. In hindsight a number of questions may have informed the later analysis, for example relating to time off work, willingness and distance to travel to the nearest pharmacy (for weigh-ins) and direct questions about the cost of their habits. It may also have been useful to have acquired information about the incentive required to achieve the outcome used in the economic evaluation (i.e. 5% weight loss). However, it’s debatable whether this line of questioning would have yielded valid data.

4.2.1.1. Difficulty of change

A number of items were generated to assess how difficult individuals perceived behaviour change to be. Each asked how difficult the respondent thought it would be to achieve specific health behaviour changes and asked for responses on a seven-point scale ranging from '*Very easy*' (0) to '*Very difficult*' (6) (see Table 9). A 'not applicable' opt out was also provided.

Figure 10: Hypothesised relationships between incentive and behaviour change

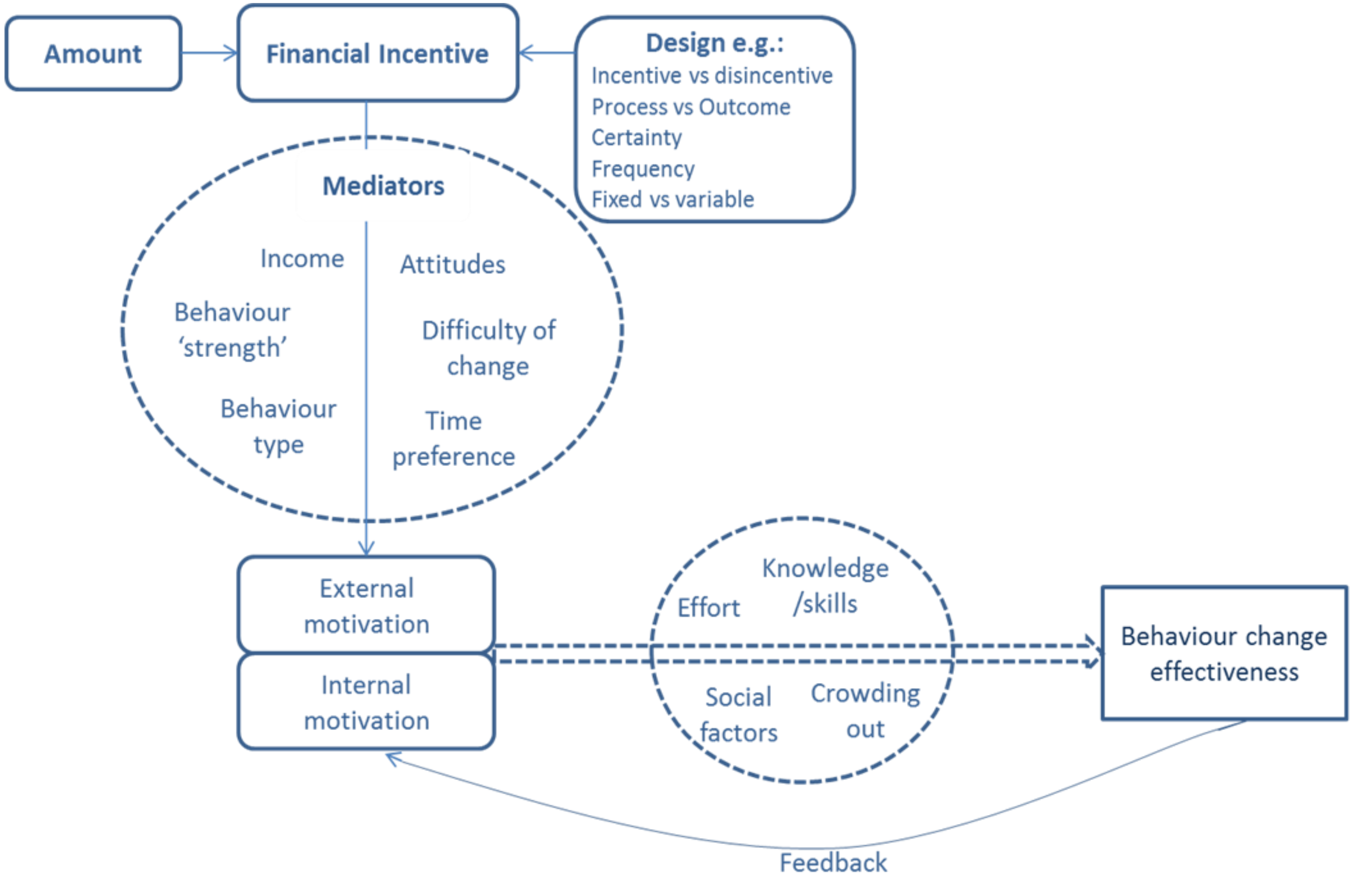


Table 9: VHCQ Health change difficult items

For questions 1 to 5 below we would like you to think about how difficult it would be for you to make certain health changes. Please tick only one box for every row.

How difficult would it be for you to………	**Does not apply to me**	**Very easy 0**	**1**	**2**	**3**	**4**	**5**	**Very difficult 6**
Stop smoking	❑	❑	❑	❑	❑	❑	❑	❑
Lose weight so that you are at a healthy weight	❑	❑	❑	❑	❑	❑	❑	❑
Eat recommended levels (or less) of fat, salt and sugary foods and at least five pieces of fruit or vegetables per day?	❑	❑	❑	❑	❑	❑	❑	❑
Exercise or take part in moderate physical activity (such as gardening, walking or jogging) for 30 minutes, 5 times a week.	❑	❑	❑	❑	❑	❑	❑	❑
Drink alcohol within recommended levels (21 units for men and 14 for women per week)*	❑	❑	❑	❑	❑	❑	❑	❑

*Half a pint of beer or small measure of spirits is roughly equal to one unit and a glass of wine is equal to one and a half units.

4.2.1.2. Contingent valuation

A contingent valuation (CV) stated preference survey (481) was developed to help determine the minimum level of financial incentives required to achieve behaviour change. Best practice methods for CV surveys have been described previously with the recommendations in the report of the National Oceanic and Atmospheric Administration (NOAA) panel on contingent valuation (482) often being the applied standard. The general guidance stated that: a) probability sampling is required in the planning of the survey especially if analyses are to be stratified; b) that non-response should be minimised taking into account the trade-off between survey length, level of information requested and respondent burden; c) that face-to-face interviews be conducted where possible although telephone interviews may be acceptable given the cost-quality trade-off required; d) pilot test experiments be conducted to gauge the extent of any interviewer effects; e) all surveys should report methods and findings in detail including sample size and final versions of surveys; f) CV surveys should be carefully pre-tested prior to deployment in full surveys to check that respondents find the questions acceptable and can understand them. Value elicitation survey guidance are also stated which are more specific to the environmental audience at which the report is aimed and these include: g) the survey should have a conservative design; h) the survey should be in the form of a dichotomous vote for or against a particular WTP value; i) the program of interest must be adequately described; j) include a 'no answer' option; k) follow-up all answers to identify why individuals voted in the way they did; l) include additional items that enable you to interpret responses to the main valuation task, for example on income and attitudes; m) check whether respondents accept and understand the survey and descriptions. The report authors add that these requirements should be met without making the survey too burdensome so as to deter respondents from completing it (in a valid manner).

The degree to which the best practices outlined in the report are applicable in the current context is debatable. It is reasonable to assume that individuals who engage in risky health behaviour can provide relatively accurate approximations of their WTA. In most cases, they engage in the behaviours every day, experiencing the utility from consumption and disutility when they are not consuming (e.g. hunger pangs or nicotine cravings). They also experience the costs everyday, purchasing food, alcohol and cigarettes. Furthermore, most will also have directly considered how much they value changing behaviour as they will have weighed up the pros and cons (in utility terms) and paid for change attempts (e.g. through diets, gym memberships and smoking cessation products). This is unlike many of the scenarios in environmental contexts that the NOAA report addressed - for example, individuals considering what they would be willing to pay to save a species of animal or environmental asset (such as a pleasant beach) that they may never experience or find it difficult to comprehend. In addition, environmental surveys are further distinguished from the one conducted here as the benefits are usually not experienced by the individual and, if they are, not solely so, which further pollutes the values. The CV survey conducted here was directed at individuals who had daily, first-hand experience of the alternatives (continue or change behaviour) and, furthermore, had to change behaviour (to avoid further health issues). Individuals should have a better idea of preferences regarding their own health than of abstract goods which they may never consume or experience.

The NOAA guidelines, and particularly the requirement for dichotomous survey response design, have also been criticised on a number of counts. For example, it has been found to over-estimate WTP due to ‘yea-saying’(483) and be statistically inefficient.(484) There does not appear to be a robust equivalent set of best practices for health scenarios reached by a consensus of experts. However, in the absence of these the current CV survey design relied on a guide book in health and a comprehensive review in the area.(485, 486) In the event, a number of the methods employed were in line with the NOAA guidelines. The survey design was pilot tested and designed to minimise missing data (NOAA points f and d). It was interviewer administered (at baseline and via telephone at three months) (NOAA point c); the results and survey versions are fully reported (NOAA point e). The voting style response options were not feasible due to the constraints of the IMPROVE research project. However, the response option style chosen is widely accepted and preferred to open-ended questions.(487) Similarly, detailed descriptions of the program (NOAA point i) were not considered as crucial as for abstract environmental schemes. Again, due to time and resource constraints, follow-up questions were not asked after each response (NOAA point k). However, additional items were included in the survey to allow cross-tabulation as recommended (point l) and the interviewer made a note as to whether the respondent understood the CV questions (point m). Given the survey was embedded within another project, the risks and costs of different designs had to be weighed up in order to make the survey practicable but to ensure the data were as valid as possible.

The CV survey was necessarily an ex ante enquiry yielding information on compensating variation, or the amount of financial gain required to maintain current utility levels (before behaviour change is initiated). In other words the CV survey sought to identify how much financial compensation a person would require to incur the disutility of behaviour change (e.g. food and tobacco cravings, exercise effort, cognitive costs). The CV method was chosen in preference to conducting a discrete choice experiment (DCE) for a number of reasons. The VHCQ was completed as part of an on-going feasibility trial along with a number of outcome measures and it was felt that the number of choice tasks a DCE would require would have represented too great a burden for respondents. Furthermore, in the context of studies where the aim is to value one factor (as in this study) rather than individual attributes, CV is preferred.(488) A recent comparison of CVs using the payment scale method and DCE found both gave theoretically valid results.(489)

Few studies in a health setting have examined the extent to which the willingness to pay (WTP) values stated by respondents in CV surveys reflect their true values or correspond with their ‘revealed’ WTP.(490) The ‘external validity’ of CV surveys has been evidenced (491) but in the main results in this regard are mixed.(492) Relevant meta-analyses (e.g.(493)) have found that revealed WTP values are higher than those stated; however this is not universally the case and depends on the survey design and setting.(492)

Although it may be minimised through good design and careful testing, there remains a threat of response bias in CV surveys.(486, 494). A common criticism of CV surveys is that they are open to strategic bias such that respondents report higher WTA (or lower WTP) values than they would accept in reality in the belief that (in the current context) incentives may be implemented. Although there is limited evidence of this bias (495) its threat was minimised by clearly stating the exercise was *imaginary* and also that the NHS would pay the incentive and thus sought to appeal to an individual’s sense of fairness. The converse may also be true; that individuals report lower WTA than their true preferences because they experience the opposite of the ‘warm glow’ effect.(496, 497) That is, respondents may feel guilty about accepting money (from the NHS) for behaviours for which they are responsible and report lower WTA as a consequence. This effect increases as more questions are completed (if respondents engage in more than one behaviour) due to ‘cumulative guilt’; this would be the opposite of the ‘fading glow’ effect.(498) To combat this phenomena, clear instructions were added such that individuals were asked to consider each valuation separately (if they engaged in more than one unhealthy behaviour) and independently (rather than cumulatively). The biases that threaten the validity of the results are clearly influenced by the design of the valuation survey.(492) For example, responses may depend on whether open-ended or binary questions are posed or whether a payment card is used.(482, 499) Carson and Groves recommend binary response options to minimise the threat of strategic bias.(500) However, this format was not possible in the current survey due to space and time constraints. Other innovations in CV methods have been offered as a solution to reducing different types of bias such as the use of cheap talk scripts(501) or certainty questions.(502) However, the constraints of the survey within the IMPROVE study meant that adding additional material would have risked over-burdening respondents and increasing non-responses and, again, therefore these could not be included.

Another criticism of CV is that responses may not reflect true preferences but generate random WTA values as individuals do not have well-formed preferences, illustrated by the 'embedding effect'.(503) As previously stated, this criticism is perhaps more justified in the valuation of abstract public goods, for example, environmental damage prevention or species protection. Most individuals are familiar with the amount of (dis)utility associated with behaviour change as they may have experienced it (many times) – for example, the cravings for cigarettes after smoking cessation and the hunger pangs during a diet. Thus we might expect that individuals have well-formed preferences and be better able to estimate to what degree they would require 'compensating'.

The piloted version of the CV survey employed open-ended willingness to accept (WTA) questions. As such it asked what would be the minimum amount of incentive required per month for the respondent to change their health behaviour (e.g. stop smoking, lose weight) and requested participants to write figures on a dotted line. The subsequent version of the survey incorporated a 'payment scale' (see (485)) with tick boxes for incentive amounts between plausible ranges that were reported in the pilot testing. The use of fixed responses is preferred in CV surveys as it is believed to generate estimates that more accurately reflect respondent preferences.(485) Three separate questions asked what is the minimum monthly: guaranteed incentive; incentive if you were entered into a lottery with a 1 in 50 chance of winning; deposit contract you would have to contribute to motivate you.

4.2.1.3. Attitudinal questions

The attitudinal questions covered factors that had been identified by the literature review and theoretical framework as potentially being key determinants of health behaviour and required incentive levels. Each item was in the form of a statement with a seven-point response option ranging from '*Strongly agree*' (0) through '*Neither* *agree or disagree*' (3) to '*Strongly disagree*' (6). The items are included in the table below with a description of the construct/factor they are attempting to capture.

Table 10: Attitudinal items in the VHCQ

Attitudinal statement	**Factor assessed**
I am in control of my health behaviour and am able to change my lifestyle if I want to	Level of willpower/self-control over health
I believe that my health and chances of getting heart disease or a stroke are determined by the type of lifestyle and health behaviours I have	Health education/beliefs
I am motivated to change my health behaviour	Level of (intrinsic) motivation
I think it would be a major achievement if I managed to change my health behaviour	Difficulty of change/intrinsic reward
I am at high risk of having other problems with my heart in the next few years	Risk perception/Health education
I live for today and try not to worry about what might happen in the future	Time preference/Impulsivity
I am usually the type of person that can wait for the things I want	Time preference/Impulsivity
I believe that the NHS should offer financial incentives to help motivate people to change their lifestyles	Acceptability of incentives

4.2.1.4. Time preference

Time preference questions (attitudinal questions - see Table 10 - and questions providing numerical discount rates) were included as it had been identified in the review as an important determinant of health behaviour. For the latter, two versions were included at the pilot stage; one relating to the receipt of an amount of money now or a greater amount in one year's time (236) and another relating to a period of illness beginning in 2 years, or a longer period of illness but beginning in 6 years' time.(325) The financial question asked:

‘*Would you prefer £500 now or £550 in 12 months time? If you said £500 now, how much would you have to receive in* ***Option B*** *(in 12 months) for you to choose that instead? Please write the amount (which would be higher than £550) below*:............’

In the choice between £500 now or £550 in 12 months an annual discount rate of at least 10% is implied for those choosing £500. At three months the same question was asked except that the choice was between £500 in five years or £550 in six years. This was to determine whether hyperbolic discounting was evident.(445)

4.2.2. Pilot testing the survey

The VHCQ pilot testing was conducted with a small group of individuals via interview and postal survey. The sample was a convenience sample recruited via word of mouth by researchers involved in the Improving Prevention of Vascular Events (IMPROVE) study (504) of which the VHCQ was a part. IMPROVE was a randomised feasibility trial of health advice delivered by a trained advisor compared to usual practice in an acute cardiology service.

The pilot sample had a representative mix of educational levels and unhealthy behaviours thus were considered suitable to test the comprehensibility and content of the VHCQ. All of the individuals consented to take part but, as they were not patients, were not recruited via the NHS and were not interviewed on NHS premises, NHS ethics was not required. In the interviews, respondents completed the survey in the presence of the author who was available to clarify any questions and note any difficulties that were experienced. Respondents were then asked if any of the instructions were unclear or if any questions were difficult to understand. They were also asked to justify the minimum acceptable level of incentive they had stated to ensure that they understood what was being asked of them. The author recorded the time to complete the survey to ensure that it was practical to complete. Where the survey was completed by post, respondents were able to record any problems they had encountered on a separate feedback sheet.

In some cases alternative questions (for example on time preference) were presented and the respondents asked to state which they thought clearest. Revisions were made to the survey in light of comments received. The revised survey was completed and reviewed again by a public involvement group (PPI) that was participating in the IMPROVE study set-up and oversight. The PPI group was comprised mainly of elderly people, some of whom had experienced a cardiovascular event. They were asked to review the instructions and questions and feedback any comments at a PPI event. Once again, a number of improvements were made to the VHCQ based on feedback received.

4.3. Results

4.3.1. Survey pilot test

The pilot test was conducted with 13 individuals who engaged in one or more unhealthy behaviours (sample details in Table 11). The perceived difficulty, attitudinal questions and contingent valuations were comprehensible and suffered from little missing data. In general, the VHCQ was well accepted and was not considered too burdensome to complete. However, it was clear from the interviews that some people felt strongly that incentives should not be offered to change behaviour.

Summary data for the incentives required are included in Table 11. Aside from one outlier in the responses to smoking, the range of incentive amounts stated was relatively narrow given that the question was open ended. This allowed a reasonable degree of confidence in creating a payment scale format for the contingent valuation based on this data. The deposit contract question was not well understood but was retained for the main survey with revised instructions. A number of clarifications and improvements to the VHCQ were made on the basis of comments received. For example, items asking people to estimate their own life expectancy and the likelihood they will experience cardiovascular disease were removed as were items asking how willing the individual was to change. ‘Not applicable’ options were also added to the behaviour change difficulty and incentive questions. In addition, following feedback that there was too much text in the survey, the instructions were condensed wherever possible. The original survey expressed the payment vehicle in monetary terms but this was revised to include ‘vouchers’ as these are generally found to be much more acceptable to individuals and thought less likely to ‘crowd-out’ intrinsic motivation. Furthermore, the use of vouchers is more likely in trials and local public health schemes than cash.

The monetary time preference question was overwhelmingly preferred to the health time preference question and was included in the final VHCQ. The data were sufficient to observe a clear positive relationship between the perceived difficulty item and the incentive amounts required providing preliminary evidence that the survey was valid. The final version of the VHCQ is included below. The following chapter describes the administration of the VHCQ is a survey of individuals and analysis and interpretation of the data.

Table 11: Survey pilot test sample characteristics

	N=13
Survey administration	
N Interview (%)	10 (77%)
N Postal (%)	3 (23%)
Age	
Mean (SD)	52 (12.1)
Range	35-73
Gender	
N male (%)	8 (61.5%)
N female (%)	5 (38.5%)
Highest level of education	
University or college or equivalent	4 (30.8%)
Intermediate between secondary level and university (e.g. technical training)	3 (23.1%)
Secondary school	4 (30.8%)
Primary school (or less)	2 (15.4%)
Health behaviours	
N who smoke (%)	6 (46%)
N who considered themselves to be overweight (%)	8 (62%)
N who do not meet the recommended physical activity levels (%)	9 (69%)
Gross monthly household income	
Less than £500	1 (7.7%)
£501 - £1500	2 (15.3%)
£1501 - £2500	1 (7.7%)
£2501 - £3500	7 (53.8%)

£3501 - £4500	1 (7.7%)
More than £4500	1 (7.7%)
Health-related Quality of Life (EQ-5D utility score)	
Mean (SD)	0.80 (0.27)
Range	1-0.09
Incentive minimum required per month to:	
Stop smoking – mean (range)	(n=7) £351 (£10-£2000)
Lose weight – mean (range)	(n=11) £27.50 (0-£100)
Exercise 3xper week – mean (range)	(n=10) £33 (£10-£100)
Reduce alcohol intake to safe level – mean (range)	(n=9) £33.90 (0-£100)

4.4. Final VHCQ

Valuing Health Change Questionnaire

The purpose of this questionnaire is to collect information about how you think about your health and changing your health behaviour

The information you provide will help us understand people's attitudes to health and what helps people to take up healthier lifestyles.

Please answer all of the questions you feel able to. There are no right or wrong answers. All of your responses are anonymous and confidential and **will not** affect any treatment you might receive in the future.

Please enter today's date: d d m m y y y y

For office use	
Q1	
Q2	

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Changing your health behaviour

Firstly we would like you to think about your current lifestyle and health (your weight, your diet, your level of physical activity, whether you smoke or not or drink alcohol).

For questions 1 to 5 below we would like you to think about how difficult it would be for you to make certain health changes.
Please tick only one box for every row.

How difficult would it be for you to………	***Does not apply to me***	**Very easy 0**	**1**	**2**	**3**	**4**	**5**	**Very difficult 6**
1. Stop smoking	❑	❑	❑	❑	❑	❑	❑	❑
2. Lose weight so that you are at a healthy weight	❑	❑	❑	❑	❑	❑	❑	❑
3. Eat recommended levels (or less) of fat, salt and sugary foods and at least five pieces of fruit or vegetables per day?	❑	❑	❑	❑	❑	❑	❑	❑
4. Exercise or take part in moderate physical activity (such as gardening, walking or jogging) for 30 minutes, 5 times a week.	❑	❑	❑	❑	❑	❑	❑	❑
5. Drink alcohol within recommended levels (21 units for men and 14 for women per week)*	❑	❑	❑	❑	❑	❑	❑	❑

*Half a pint of beer or small measure of spirits is roughly equal to one unit and a glass of wine is equal to one and a half units.

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For this section there are three imaginary scenarios about people receiving financial incentives from the NHS. Although the questions may seem unusual please consider your response carefully as the information you give will be useful. (*Please keep in mind this is an* ***imaginary exercise***)

Financial Incentives

Please **IMAGINE** that the NHS would be willing to pay people money or reward them with shopping vouchers (for example for Argos or Boots) to persuade them to change their lifestyles. Imagine the NHS would pay you an amount (in money or vouchers) every month for one year and you would be assessed every month to make sure you maintained a healthier lifestyle.

What is the minimum amount of money or value of vouchers per month that would persuade you to change your behaviour?

If the behaviour does not apply to you (for example if you don't smoke), please state what you think would be the minimum amount of incentive that would motivate someone who did smoke to stop smoking. Please consider each separately as though you could only receive one incentive at a time.

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Please tick one box only per row

To motivate me to do the things below the minimum financial incentive per month would have to be……..	£0a month	£5-10 a month	£11-£20 a month	£21-£30a month	£31-£50 a month	£51-£75 a month	£76-£100 a month	£101-£200 a month	£201-£400 a month	More than £400 a month
a. stop smoking	❑	❑	❑	❑	❑	❑	❑	❑	❑	How much? £…………
b. go on a calorie controlled diet and lose weight	❑	❑	❑	❑	❑	❑	❑	❑	❑	How much? £…………
c. to exercise or do moderate physical activity for 30 minutes at least 5 times a week	❑	❑	❑	❑	❑	❑	❑	❑	❑	How much? £…………
d. to reduce the amount of alcohol I drink to below recommended levels	❑	❑	❑	❑	❑	❑	❑	❑	❑	How much? £…………

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Imaginary Prize Draw

Imagine now that instead of a guaranteed payment each month you would be entered into a free prize draw if you changed your behaviour. Every month you achieved your health target (e.g. not smoking or losing weight) you would be entered into a prize draw and have a **1 in 50 chance** of winning an amount of money or shopping vouchers.

What is the minimum prize that would motivate you to take part and change your behaviour? *Please tick one box only per row*

To motivate me to do the things below the monthly lottery amount (in cash or vouchers) I could win would have to be......	£10-£50	£51-£100	£101-£200	£201-£300	£301-£500	£501-£1000	£1001-£2500	£2501-£3500	More than £3500
a. stop smoking	❑	❑	❑	❑	❑	❑	❑	❑	How much? £…………
b. go on a calorie controlled diet and lose weight	❑	❑	❑	❑	❑	❑	❑	❑	How much? £…………
c. to exercise or do moderate physical activity for 30 minutes at least 5 times a week	❑	❑	❑	❑	❑	❑	❑	❑	How much? £…………
d. to reduce the amount of alcohol I drink to below recommended levels	❑	❑	❑	❑	❑	❑	❑	❑	How much? £…………

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Imaginary Financial Commitment

Imagine you would have to pay an amount of money for every month that you did not achieve your health target (for example not smoking or losing a certain amount of weight) and if you lost your money it would be donated to a charity of your choice.

Please tick one box

To motivate me to do the things below I would have to face losing the following amount of money in a month:	£0-£5	£6-£10	£11-£30	£31-£50	£51-£75	£76-£100	£101-£150	£151-£200	£201-£350	More than £350
a. stop smoking	❑	❑	❑	❑	❑	❑	❑	❑	❑	How much? £…………
b. go on a calorie controlled diet and lose weight	❑	❑	❑	❑	❑	❑	❑	❑	❑	How much? £…………
c. to exercise or do moderate physical activity for 30 minutes at least 5 times a week	❑	❑	❑	❑	❑	❑	❑	❑	❑	How much? £…………
d. to reduce the amount of alcohol I drink to below recommended levels	❑	❑	❑	❑	❑	❑	❑	❑	❑	How much? £…………

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Please state how strongly you agree or disagree with the following statements by ticking one option per question

	Strongly agree 0	1	2	Neither agree nor disagree 3	4	5	Strongly disagree 6
1. I am in control of my health behaviour and am able to change my lifestyle if I want to	❑	❑	❑	❑	❑	❑	❑
2. I believe that my health and chances of getting heart disease or a stroke are determined by the type of lifestyle and health behaviours I have	❑	❑	❑	❑	❑	❑	❑
3. I am motivated to change my health behaviour	❑	❑	❑	❑	❑	❑	❑
4. I think it would be a major achievement if I managed to change my health behaviour	❑	❑	❑	❑	❑	❑	❑
5. I am at high risk of having other problems with my heart in the next few years	❑	❑	❑	❑	❑	❑	❑
6. I live for today and try not to worry about what might happen in the future	❑	❑	❑	❑	❑	❑	❑
7. I am usually the type of person that can wait for the things I want	❑	❑	❑	❑	❑	❑	❑
8. I believe that the NHS should offer financial incentives to help motivate people to change their lifestyles	❑	❑	❑	❑	❑	❑	❑

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1. **Imagine** you won a lottery and the prize was either £500 now **OR** instead you would receive £550 but in 12 months' time. Which would you choose? (*Please tick only one option*)

Option A	£500 now	❑
	OR	
Option B	£550 in 12 months	❑

If you ticked <u>Option B</u> please skip Question 2 and go to Question 3 below

2. How much would you have to receive in **Option B** (in 12 months) for you to choose that instead? Please write the amount (which would be higher than £550) below:

I would have to receive a minimum of **£.............. at 12 months** instead of £500 now to choose Option B.

One last question......

3. Please estimate the <u>**monthly**</u> income of your household (before deducting tax and national insurance). If you receive any benefits or pensions please include them as income.

The answers you provide are completely anonymous and confidential. We are asking for this information because it will help us analyse your responses on financial incentives in health. *(please tick only one)*

❑ Less than £500 ❑ £2501 - £3500

❑ £501 - £1500 ❑ £3501 - £4500

❑ £1501 - £2500 ❑ More than £4500

Thank you for completing the questionnaire. Please take a moment to check that you have responded to all of the questions

This study is funded by the National Institute for Health Research (NIHR)

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5. Contingent valuation survey analysis

This chapter reports the administration of the VHCQ in a sample of individuals compelled to change their health behaviour and analysis of the survey data.

5.1. Objectives

Specific objectives for the research described in this chapter were to: i) conduct a follow-up survey with people who engaged in unhealthy behaviours; ii) identify optimal pricing strategies for incentive schemes taking into account individual characteristics; iii) generate information (e.g. parameter values) that may be useful for the decision-analytic model described in Chapter 9.

5.1.1. Research questions and hypotheses

The key research questions for this part of the study are provided below. These particular research questions were selected as they targeted important evidence gaps in the literature and theoretical framework proposed in Chapter 3. The questions were prioritised following the review of the literature and after discussions with supervisors and experts in the area. Although not a formal prioritisation exercise, the discussions with the experts – who were an academic working in incentives and a Director of a commercial organisation that ran an incentive programme – confirmed that the questions were worthy of pursuit. The answers to these questions would also potentially offer valuable information for subsequent research endeavours in the PhD.

1. What is the minimum incentive level required to secure behaviour change?
2. How is this mediated by demographic and socioeconomic factors, type and ‘strength’ of behaviour, perceived difficulty of change, existing motivation and other attitudes, type of incentive and time preference?
3. Is there evidence that minimum required incentive levels change over time?

Questions 1-3 address key components of equation 11 in the proposed framework in Chapter 3 relating to how incentive levels and incentive design features impact on incentive scheme effectiveness (in terms of producing utility). Question 2 would provide information about how incentive level is influenced by motivation and control (or willpower) as described in equation 1 in the framework. Time preference (appearing in equations 4 and 7) would also be captured by the survey. Finally, Question 3 may provide information about the relationship between the incentive required and self-control over time; this may permit an empirical test of the willpower depletion theory. In addition to addressing these key questions the data would allow an exploration of other aspects; for example, whether incentives are considered acceptable or not and whether the survey methodology is valid and reliable for estimating incentive levels.

Due to the dearth of studies in the area, it is difficult to provide a hypothesis on the WTA values that we might expect to derive using the survey. However, based on the behavioural literature (Chapter 2) and proposed Framework (Chapter 3) it was thought that:

A) there would be a positive relationship between the level, or ‘degree’ of unhealthy behaviour (e.g. smoking levels, how overweight a respondent is and how much alcohol they drink) and the minimum amount of incentive required to change behaviour;

B) there would be a positive relationship between perceived difficulty of change and minimum incentive required;

C) in terms of attitudes, it was hypothesised that those who were less motivated or less in control of their health would state requiring larger incentives to change behaviour.

Very few studies – in any context - have explored the use of contingent valuations by the same individual over time. Given this, hypotheses regarding whether and how these responses might change over time are speculative to a degree. However, it was further hypothesised that D) the required incentive would on average increase over time in those who completed the survey twice. There are a number of reasons for this: i) at first completion the individuals have recently experienced a health shock and may be motivated by this and may be over-optimistic in estimating the likelihood that they will succeed in behaviour change. At follow-up it is possible individuals will revert back to unhealthy habits and re-evaluate the ease of, and necessity for, change especially if their willpower has become depleted; ii) at first completion the respondents are in hospital and may respond in a socially desirable way stating lower incentive amounts - especially as the incentives are described as being provided by the NHS. Follow-up completion took place in the home. As respondents were out of the NHS setting, they were able to respond more freely and thus may state that higher incentives are required; related to this but not necessarily the same issue is argument: iii) that between time-points the individual's environment changed. At baseline respondents were in an environment where their health behaviour was controlled (i.e. in hospital smoking and drinking alcohol is not permitted and diet is controlled) and thus they may have felt more in control of their behaviour. At follow-up however, patients are returned to their usual environ and may, despite good intentions, slip back to unhealthy habits. Again, if this occurs, we might expect the minimum required incentive to increase.

5.2. Method

5.2.1. Survey administration – IMPROVE Study

The VHCQ was completed as part of the IMPROVE (Improving Prevention of Vascular Events) study.(504) IMPROVE was a randomised feasibility trial of health advice delivered by a trained advisor compared to usual practice in an acute cardiology service. Participants (n=132) were individuals who had experienced a suspected cardiovascular event and therefore needed to modify their health behaviour (i.e. they were smokers, alcohol abusers, were overweight or had a sedentary lifestyle). IMPROVE aimed to interview patients engaging in risky health behaviours to identify barriers and facilitators to behaviour change and use this information to identify an optimal referral pathway for them. The control group did not receive an active intervention but were given information (a leaflet) about behaviour change and referred to a health website. The study assessments (including evaluations of health behaviours and the VHCQ) were administered by researchers face-to-face at baseline (in hospital) to consenting patients. Those who completed baseline were invited to complete the survey again at three months. At three months the VHCQ was posted out to participants for completion. If their survey was not received within a matter of weeks, they were sent a reminder and then subsequently asked to complete the survey over the telephone. The study was approved by the committee of the National Research Ethics Service for Yorkshire and the Humber (Leeds East) on 12 March 2012. REC Reference number: 12/YH/0086.

5.2.2. Sample

The eligibility criteria for the IMPROVE study and completion of the VHCQ were the same. Patients were eligible if they were aged between 40 and 74 years; were willing and able to give written informed consent; and had been admitted to hospital with a diagnosis of acute coronary event, myocardial infarction or symptoms of a cardiac nature. Those patients who were receiving specialist behaviour change treatment relating to alcohol in-take, smoking, diet or exercise were excluded as were those who did not engage in risky health behaviours. Those unavailable for follow-up assessment or who were unable either to speak English to the degree that they could not receive the intervention or complete the outcome measures were also excluded. More detail is included in the IMPROVE study protocol.(504)

5.2.3. Analysis

Descriptive statistics were produced for the overall sample and sub-groups based on gender (males vs. females), age (59 years or less vs. over 59 years), income (less than £2000 per month vs. £2000 and over per month), smoking status (Smoke vs. Not), body mass index (less than 25 vs. 25-30 vs. over 30), Audit score (less than 4 vs. 4 and above), perceived difficulty (Easy vs. Difficult) and attitudinal items (Agree vs. Disagree) for the minimum guaranteed ($WTA_{Certain}$) and lottery incentives ($WTA_{Uncertain}$) required. The expected value of the lottery ($\mathrm{WTA}_{\mathrm{Uncertain}}$) was calculated:

$$\mathrm{WTA}_{\mathrm{Uncertain}} = \text{lottery response } \times 0.02$$

For both $WTA_{Certain}$ and $WTA_{Uncertain}$, values were converted to percentage of monthly disposable income (which is assumed to be the mid-point of an income category stated) and analysed again. Due the small sample size the responses to several of the items were collapsed into two or three categories. For example, responses on the seven-point scales were dichotomised into 0-3 versus 4-6. The data from the CV survey were considered both in its presented categorical form and in continuous form by taking the mid-point value of the category response. Thus, if an individual had stated a minimum required incentive of '£21-£30', their response was recoded to £25; there is a precedent for such manipulations in CV analysis (e.g.(505)). Treating the data as continuous was thought acceptable as the response categories were placed in increasing rank order and there were nine points on the payment scale. Health and psychological questionnaires with nine or fewer items are often considered to provide continuous data. Furthermore, there was also an open-ended value which generated greater variability to the data. This approach to payment scale analysis is commonly adopted.(e.g.(506, 507)).

The time preference data was analysed in the following manner to give the annual discount rate (r):

$$r = \frac{(PO_f - PO_p)}{PO_p}$$

Where PO_p is present pay-off and PO_f is the future pay-off. Those who stated that they would be willing to wait 12 months for the £550 reward were assumed to have a discount rate of 10% although it may have been lower (they may have been willing to wait 12 months for less than £550).

Since some individuals completed items relating to more than one behaviour (e.g. they may have been overweight and physically inactive) and completed the survey on two occasions, there was an opportunity to analyse the data in a number of different ways – as is or by creating multiple observations across behaviours and time-points. Thus, data were analysed with baseline health behaviours considered individually; individually but with multiple (two) observations over time; with baseline health behaviours pooled (thus an individual could contribute four responses if they engaged in all unhealthy behaviours); and with both behaviour and time-point data pooled where an individual could contribute up to eight responses (four behaviours over two time-points). This meant that there were a much greater number of observations available for analysis, increasing the power of the study.

For the categorical data analysis, results are presented as proportions of respondents who chose each incentive category. Logistic regression was used to predict a response of '£0' WTA and multinomial logistic regression was used to predict the categorical WTA response. For the continuous data analysis, correlations were conducted to determine the relationships between WTA values and factors such as perceived difficulty and motivation. Mean and median WTA between groups (i.e. demographic, behaviour change difficulty, behaviour 'strength', attitudes, time preference) was explored using parametric and non-parametric tests, respectively. Paired and unpaired t–tests compared $WTA_{Certain}$ and $WTA_{Uncertain}$ at baseline vs. three months. In addition, the changes in WTA over three months were compared according to key outcomes of the IMPROVE trial – namely, whether or not the individual had attempted and/or succeeded in changing their behaviour.

Univariate analyses were employed to identify key predictor variables for inclusion in the main analyses. In the event, the data were heavily positively skewed with large numbers of zero WTA reported. Linear regression with log-transformation was applied but the distribution plots suggested that this did not provide a remedy. Zero $WTA_{Certain}$ and $WTA_{Uncertain}$ values are likely to be from a mix of individuals who: do not feel that they require an incentive to change behaviour (either because they feel it will be easy or that they have sufficient internal motivation) - 'true' zeros; and individuals who do not believe that incentives should be provided for behaviour change (regardless of how easy or difficulty they perceive change or how motivated they are) – 'protest' zeros. True zeros are those who have a zero marginal utility for financial incentives for behaviour change. It is important to try and distinguish between these two and estimate the impact of including 'protest' zeros in the analysis. Individuals providing protest responses may weaken any relationships in the data – for example the one hypothesised between perceived difficulty and WTA values.

Analysts often simply remove protest responses from their analysis (508), assuming they can identify them. Identification may be made, for example, by asking if individuals would accept any value at all or would not due to a general disagreement with the concept being valued. The approach taken here was to analyse the data with and without the protest zeros to see if they made a substantive impact on the results. Unfortunately, a direct question was not included in the survey that would perfectly identify (if that is possible) protest zeros however an indicator was created with available data. An individual was considered to have provided a protest response if they had reported zero for *both* $WTA_{certain}$ and $WTA_{Uncertain}$, and stated that they strongly disagreed that incentives should be provided. Since people may disagree with incentives *because* they are motivated (and, hence, be 'true zeros'), a further requirement was made: that individuals were also either a) not motivated to change behaviour; or b) stated that behaviour change would be difficult.

Notwithstanding the protest zeros, the data were still skewed positively and specific analytical approaches were used to address this. There are a number of alternative modelling approaches that might be used in this scenario. Tobit regression is often employed to handle skewed contingent valuation data. It is valid when the target variable can theoretically be considered censored (509) but is inappropriate where negative values are not possible.(510) While negative WTA values were not possible on the survey, considering WTA as a latent variable on a continuum, it is possible to conceive that those who provide zeros may be willing to *pay* for behaviour change. Given this, the Tobit model was explored. Recently, the generalized linear model has gained favour in skewed data analysis.(511) This was applied to the data using a Gamma family distribution and log link function as this distribution reflects the positive right skew and long tail of the observed data. Alternative distributions were also trialled within the GLM analysis before deciding on the aforementioned combination; these included Identity and Log links paired with Binomial, Poisson and Negative Binomial families.

Several methods have been proposed to analyse data that include excess zeros (and protest responses) (512); these include the 'spike' model (513), the double-hurdle approach (514), symmetrically-trimmed least squares estimation (515) and least absolute deviations estimation (516). In addition to the Tobit and GLM analyses, this analysis adopted several other approaches: a two-part model, standard negative binomial and zero-inflated negative binomial regression. Zero-inflated negative binomial regression is used to model count variables with excessive zeros where data is over-dispersed (where the variance exceeds the mean value – as in this case). Furthermore, the model theory is predicated on the idea that the excess zeros are generated by a separate process from the count values and that these excess zeros can be modelled independently. This model was compared to a two-part model where zeros are predicted using logistic or probit models and positive scores predicted separately. For the two-part, the negative binomial and zero-inflated models, marginal effects were used to interpret the coefficients.

A number of model diagnostic tests were conducted specific to the model being employed. For the GLM, Stata's Linktest and Modified Park test were utilised to respectively determine whether: the model specification was acceptable or not; and whether the correct family had been used. Stata's ovtest was used to test whether variables have been omitted from the models and the variance inflation factor (VIF) checked to determine whether multicollinearity was present. As a rule of thumb, a variable whose VIF values are greater than 10 may merit further investigation. The Akaike information criterion (AIC) (517) and the Bayesian information criterion (BIC) (518) were also used to judge the models. Both are measures of model fit (smaller values generally denote better fit) that allow inter-model comparison. In addition to these, homoscedasticity was assessed in each case by plotting residual against predicted (fitted) values in a scatter plot and R^2 values compared across models. Since the analyses employs robust standard errors [vce(cluster)] heteroscedasticity did not require formal assessment.

For the analysis of pooled time data and pooled health behaviour data, time-point and health behaviour were respectively entered as dependent variables. In both cases, a random effects model or allowance for clustering of errors at the individual level was used to account for multiple observations from the same individual. No imputation of missing data was made but as missing data was minimal (excepting the discount rate question) it is not thought that it would impact significantly on results. For example, there were 153 attempts at completing the perceived difficulty section out of a possible 168 over the two time periods. Of the total 560 responses where the behaviour was applicable, only 4 were missing. In the financial incentive section, there were 149 completions out of a possible 168 over the study period and only 19 were missing out of 596 applicable questions (<0.5%). In the attitudes section (with eight questions) there were only 7 missing responses out of 1224 over the two time-points. Logistic regression was used to ascertain whether there were any significant differences between those recruited to the study vs. those who completed the baseline VHCQ; and between those who completed baseline vs. 3 month VHCQ.

The internal validity of the values yielded by the CV survey was assessed by comparing WTA cross-sectionally by perceived difficulty and by strength of unhealthy behaviour.

5.3. Results

5.3.1. Sample characteristics

The IMPROVE study screened 887 patients for inclusion in the study and 132 patients met the criteria for inclusion. From these, 112 completed the VHCQ at baseline and 56 at three months (see Table 12 for sample details). There were significantly fewer completions at three months due to deaths, study withdrawals and failure to achieve contact with the participant.

Univariate and multivariate logistic regression was used to compare the sample characteristics of those who were recruited into the study and those who completed the VHCQ at baseline; and between these individuals and those who completed the VHCQ at three months. The regression explored whether personal characteristics and baseline responses significantly predicted missingness (see Appendix 12.2.1 for the univariate results). Comparing the recruited and baseline VHCQ completers, univariate analyses using gender, age, education level, baseline health status (EQ-5D), health behaviours (whether the individual was a smoker, overweight or obese, exercised or drank alcohol) and IMPROVE trial arm, did not find any statistically significant predictors of baseline VHCQ completion. The multivariate regression did not find any significant predictors of VHCQ completion at baseline (results not presented). The results suggest that there were no significant differences between the samples of those recruited and those who completed the baseline VHCQ. Data on attitudes to incentives and income was not available for those who didn't complete the survey; it is possible that these may be explanatory factors in survey non-completion.

Comparing baseline and 3 month VHCQ completers, univariate analyses were conducted using the same variables as above but also including income group and mean responses for all baseline behaviour change difficulty items and $WTA_{Certain}$. In this case, there were a few significant differences in the sample characteristics. Those who completed the 3 month follow-up were significantly more likely to have higher education (intermediate, college or higher; p=0.034) and had reported lower WTA incentives at baseline (p=0.049). In the multivariate analyses (not reported) only education was still a significant predictor of 3 month completion. In the main then, the samples can be considered equivalent and any differences in WTA estimates over time may not solely be explained by a change in sample make-up. It is unclear why education might predict successful follow-up it may reflect a lower relative burden of completion of surveys for this group. Regardless, this finding is in line with previous survey studies which have found a significant relationship between deprivation and loss to follow-up (e.g.(519)).

Table 12: Sample characteristics of VHCQ respondents

	Baseline	**3 months**
	N=112	N=56
Age		
Mean (SD)	58.8 (8.98)	59.71 (9.34)
Range	40-74	40-74
Gender		
N male (%)	67 (59.82)	34 (60.71)
N female (%)	45 (40.18)	22 (30.29)
Highest level of education		
University or college or equivalent	16 (14.29)	3 (5.36)
Intermediate between secondary level and university (e.g. technical training)	27 (24.11)	26 (46.43)
Secondary school	60 (53.57)	17 (30.36)
Primary school (or less)	9 (8.04)	10 (17.86)
Ethnicity		
Asian or Asian British	4 (3.57)	2 (3.57)
Black or Black British	1 (0.89)	1 (1.79)
Mixed ethnicity	1 (0.89)	0
White	104 (92.86)	52 (92.86)
Other ethnic group	2 (1.79)	1 (1.79)
Employment status		
Employed	36 (32.14)	16 (28.57)
Full-time homemaker	2 (1.79)	1 (1.79)

Pensioner	39 (34.82)	22 (39.29)
Unable to work	25 (22.32)	8 (14.29)
Unemployed	7 (6.25)	6 (10.71)
Other	3 (2.68)	1 (1.79)
Gross monthly household income		
Missing	7 (7.22)	1 (1.79)
Less than £500	14 (14.43)	6 (10.91)
£501 - £1500	25 (25.77)	25 (45.45)
£1501 - £2500	19 (19.59)	8 (14.55)
£2501 - £3500	11 (11.34)	10 (18.18)
£3501 - £4500	9 (9.28)	2 (3.64)
More than £4500	12 (12.37)	4 (7.27)
Health-related Quality of Life (EQ-5D utility score)		
Mean (SD)	0.61 (0.32)	0.67 (0.27)
Range	-0.29-1	-0.24-1
Do you smoke?		
Yes	34 (30.36)	11 (21.15)
No	78 (69.64)	41 (78.85)
Do you exercise?		
Yes	39 (34.82)	N/A
No	72 (64.29)	N/A
Body Mass Index		
Mean (SD)	29.50 (5.67)	30.06 (6.46)
Range	16.5-48.2	16.53-44.65
AUDIT Score		
Mean (SD)	4.37 (3.97)	4.45 (4.14)
Range	0-12	0-12

5.3.2. VHCQ descriptive statistics

5.3.2.1. Perceived difficulty of behaviour change

Table 13 includes the descriptives for perceived difficulty at baseline. A majority of smokers reported that stopping smoking would be ‘Very difficult’. The opposite was true of responses to reduce alcohol intake where a majority reported this behaviour change as ‘Very easy’. Responses to the other questions were more evenly spread across the response range.

Table 13: Perceived difficulty of behaviour change

		Very easy 0	1	2	3	4	5	Very difficult 6
Stop smoking	N	1	2	2	2	3	4	17
	%	3.2%	6.5%	6.5%	6.5%	9.7%	12.9%	54.8%
Lose weight	N	11	7	10	13	11	7	19
	%	14.1%	9.0%	12.8%	16.7%	14.1%	9.0%	24.4%
Maintain healthy diet	N	26	13	14	13	12	4	8
	%	28.9%	14.4%	15.6%	14.4%	13.3%	4.4%	8.9%
Be physically active	N	22	11	8	8	9	7	29
	%	23.4%	11.7%	8.5%	8.5%	9.6%	7.5%	30.9%
Drink alcohol within recommended levels	N	35	4	8	7	3	3	3
	%	55.6%	6.4%	12.7%	11.1%	4.8%	4.8%	4.8%

5.3.2.2. Contingent valuation

Responses to the CV questions are included in Table 14. Responses are highly skewed with a high proportion stating that '£0' incentive would be required.

Table 14: Baseline contingent valuation responses*

Amount required:		**£0**	**£5-£10**	**£11-£20**	**£21-£30**	**£31-£50**	**£51-£75**	**£76-£100**	**£101-£200**	**£201-£400**	**> £400**
Smoking	**n**	13	0	2	2	1	2	5	3	2	1
	%	41.94	0.00	6.45	6.45	3.23	6.45	16.13	9.68	6.45	3.23
Diet	**n**	32	5	8	6	10	5	4	1	5	2
	%	41.03	6.41	10.26	7.69	12.82	6.41	5.13	1.28	6.41	2.56
Exercise	**n**	39	6	5	7	11	2	7	2	6	4
	%	43.82	6.74	5.62	7.87	12.36	2.25	7.87	2.25	6.74	4.49
Drinking	**n**	35	3	6	2	4	0	7	4	1	0
	%	56.45	4.84	9.68	3.23	6.45	0.00	11.29	6.45	1.61	0.00

*These data do not correspond exactly with data provided in Table 12 as some individuals completed demographic and health behaviour questions but missed VHCQ items.

5.3.2.3. Attitudinal questions

For each attitudinal question, a high proportion of respondents chose the maximal option (Table 15). In each case, ‘Strongly agree’ was the most common response except for the item asking whether the NHS should offer incentives in which case ‘Strongly disagree’ was the most common response.

Table 15: Responses to attitudinal questions at baseline

Attitudinal item		**Strongly agree**			**Neither**			**Strongly disagree**
		0	**1**	**2**	**3**	**4**	**5**	**6**
Control	**n**	48	11	7	12	8	2	9
	%	49.48	11.34	7.22	12.37	8.25	2.06	9.28
Health belief	**n**	56	13	5	12	3	4	4
	%	57.73	13.4	5.15	12.37	3.09	4.12	4.12
Motivation	**n**	48	16	9	16	2	3	2

	%	50	16.67	9.38	16.67	2.08	3.13	2.08
Major achievement	**n**	55	17	6	10	3	2	3
	%	57.29	17.71	6.25	10.42	3.13	2.08	3.13
Risk perception	**n**	41	15	10	22	1	4	4
	%	42.27	15.46	10.31	22.68	1.03	4.12	4.12
Live for today	**n**	33	9	7	21	4	6	16
	%	34.38	9.38	7.29	21.88	4.17	6.25	16.67
Can wait for things	**n**	39	11	7	16	6	8	10
	%	40.21	11.34	7.22	16.49	6.19	8.25	10.31
Accept incentives	**n**	15	2	2	15	4	3	55
	%	15.63	2.08	2.08	15.63	4.17	3.13	57.29

5.3.2.4. Time preference

The responses to the time preference questions and mean discount rates that these imply are included in Table 16. A majority of respondents would rather take the £500 now than wait 12 months. Although there were very high responses for the amount they would have to be offered in order to wait for the reward, these were not considered outliers and were retained in the analyses. The range in implied discount rates is noteworthy and, assuming the question was correctly understood, suggests some individuals would only be willing to forgo the £500 now if the future reward was significantly higher. This is picked up later in the discussion.

Table 16: Time preference and discount rates at baseline and three months

	Baseline		**3 months**	
Would you prefer:	**n**	**%**	**n**	**%**
A) 500 **B) £550 in a year**	69 27	71.88 28.13	37 16	69.81 30.19
	Mean (SD)	Range	Mean (SD)	Range
If A) how much to choose B	£1764 (£2168)	£600-£10,000	£1387.50 (£2038)	£600-£10,000
	Mean (SD)	Range	Mean (SD)	Range
Implied annual discount rate	163% (363%)	10%-1900%	110.5% (324%)	10%-1900%

5.3.3. Contingent valuation analysis – categorical data

5.3.3.1. Regression – individual health behaviours

A random effects logistic model was run to predict whether respondents would choose an incentive amount of £0 or whether they would choose a positive value. These results are only briefly described below with the main focus of the chapter being the analysis of the data as continuous. The logistic analysis was run for each health behaviour and independent variables were selected based on the strength of relationships identified in the descriptives by sub-group, correlations and univariate analyses. All models were significant except for weight loss. There were few significant independent variables but this may have been related to the small sample size. The attitudinal item relating to perceived control over health was consistently found to be a significant predictor (except in the alcohol model) with the coefficient sign indicating those reporting less control as requiring a positive (>£0) incentive. Income and gender were not found to be significant predictors of a '£0' response. Age group and education were significant in the alcohol model with those aged under 59 and those with at least a college education being more likely to state a required incentive over £0. In three of the models the item asking whether the NHS should offer incentives was found to be significant (borderline in the weight loss model). In each case those who disagreed with incentives being offered were more likely to respond with a '£0' response. Finally, 'Visitcycle' (baseline vs three months) appeared to be an important predictor in smoking and alcohol. The coefficient sign suggests a non £0 response is more likely at three months. Time preference and 'strength' of health behaviours (i.e. BMI and AUDIT score) were not found to be significant.

A multinomial logistic (MNL) regression was run on the categorical financial incentive response data with £0 used as the base and clustering of standard errors used for multiple observations. The confidence intervals for the coefficients on the other models were wide and in most cases ranged from negative to positive. To combat this, responses were collapsed such that £0=0 (base); £1-£30=1; £30-£100=2; >£100=3. These data did not generate results that added significant insight to that provided by the logistic regression and thus are not reported in detail. However, results tables for this and the logistic regression are included in Appendix 12.2.2.

5.3.4. Contingent valuation analysis – continuous data

5.3.4.1. Descriptive statistics

Table 17 and Table 18 include the descriptive statistics for the $WTA_{Certain}$ and $WTA_{Uncertain}$ respectively at baseline and three months when responses were analysed as 'continuous' data. A significant proportion of individuals reported that the level of incentive they would accept would be '£0'. Although the samples are small and variances large, a number of interesting patterns are apparent in the results. At both time-points and for both sets of incentive questions, smoking has the highest minimum required incentive value. This was in the order of at least twice the magnitude of the other required incentive means. The reported values for diet were similar to those for exercise. As samples at three months are small the results are suggestive only but there are noticeable increases in required incentive from baseline to 3 months for smokers and drinkers. This was further explored by calculating the baseline to 3 month change in WTA for $WTA_{Certain}$, $WTA_{Uncertain}$ and $WTA_{Commitment}$ which is included in Table 56 in Appendix 12.2.4. In all behaviours for all WTA questions, except for the lottery question for diet and exercise, the average WTA increased over 3 months.

Table 19 includes the descriptive statistics for the financial commitment questions. The feedback from the interviewer was that this question was very poorly understood and that the values returned should be treated with caution. For this reason, and to avoid presenting too many results, reduced sets of results are presented in the main thesis with additional findings reported in the appendix (Appendix 12.2). The issues with this item and potential ways of improving data collection are picked up later in the discussion.

Table 20 and Table 21 show change in WTA according to participation in a behaviour change programme and by observed behaviour change, respectively. The results in Table 20 suggest that after people have begun the process of change they may require additional incentives. However, this finding was not consistent and statistical tests for differences in WTA changes over time were not significant. To some extent the same was true of the between-group changes in WTA presented in Table 21 where it appears that those who have started exercising and reduced alcohol intake require lower incentives (than those who haven't) but those who have lost some weight require increased incentives (compared to those who haven't). The small sample sizes must be noted here as these do not permit any confidence in statements about the patterns in the data. Figure 11 is the demand curve for incentives and the steeper slope indicates that smokers require higher incentives to change.

Table 17: Financial incentive descriptive statistics – baseline and 3 months

	n	Mean	SD	Min	Max
Baseline					
Stop smoking	31	£88.15	£187.62	£0	£1,000
Diet	77	£45.71	£91.30	£0	£500
Exercise	88	£56.51	£109.80	£0	£500
Reduce alcohol intake	62	£29.60	£55.58	£0	£300
3 months					
Stop smoking	13	£140.77	£146.92	£0	£500
Diet	43	£49.59	£75.32	£0	£300
Exercise	51	£47.89	£70.96	£0	£300
Reduce alcohol intake	37	£71.96*	£133.27	£0	£600

*p<0.05 for unpaired t-test vs. Baseline;

Table 18: Lottery incentive descriptive statistics – baseline and 3 months

	n	Mean	SD	Min	Max
Baseline					
Stop smoking	27	£14.60†	£24.09	£0	£70
Diet	73	£8.02††	£16.00	£0	£70
Exercise	82	£6.98††	£14.75	£0	£70
Reduce alcohol intake	56	£6.25††	£16.17	£0	£70
3 months					
Stop smoking	12	£14.63††	£21.81	£0	£60
Diet	40	£7.06††	£14.66	£0	£60
Exercise	45	£7.61††	£14.47	£0	£60
Reduce alcohol intake	33	£15.22*†	£23.60	£0	£60

*p<0.05 for unpaired t-test vs. Baseline; †p<0.05 for unpaired t-test vs. guaranteed incentive; ††p<0.01 for unpaired t-test vs. guaranteed incentive

Table 19: Financial Commitment descriptive statistics – baseline and 3 months

	n	Mean	SD	Min	Max
Baseline					
Stop smoking	29	£25.05	£37.12	£2.50	£175.00
Diet	74	£31.32	£56.21	£0.00	£275.00
Exercise	85	£37.69	£66.44	£0.00	£275.00
Reduce alcohol intake	58	£30.91	£49.72	£2.50	£275.00
3 months					
Stop smoking	11	£81.36	£107.46	£2.50	£275.00
Diet	38	£46.91	£73.03	£2.50	£275.00
Exercise	45	£43.67	£76.09	£2.50	£275.00
Reduce alcohol intake	33	£67.02*	£115.19	£2.50	£500.00

*p<0.05 for unpaired t-test vs. Baseline

Table 20: Baseline to 3 months change in WTA by IMPROVE trial outcome*

Participation in behaviour change programme	Financial incentive		Lottery incentive		Financial commitment	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Smoking cessation						
No change	4	£18.75 (£134.44)	3	£14.87 (£32.37)	3	£71.33 (£102.34)
Initiated	3	£110.83 (£115.66)	3	£2.27 (£3.74)	3	-£12.50 (£21.65)
Diet						
No change	9	£1.94 (£28.44)	9	-£0.07 (£4.66)	8	-£5.21 (£20.38)
Initiated	15	£16.50 (£114.68)	14	£1.06 (£23.84)	14	£55.81 (£119.82)
Exercise						
No change	18	-£11.11 (£79.74)	18	-£3.51 (£14.62)	17	£14.13 (£85.36)
Initiated	13	£40.96 (£93.81)	12	£2.16 (£20.29)	12	£7.71 (£59.10)
Alcohol reduction						
No change	5	£46.88 (£158.50)	5	£11.40 (£26.33)	6	-£39.40 (£45.46)
Initiated	8	£143.50 (£264.57)	5	£26.28 (£32.52)	5	£54.58 (£178.61)

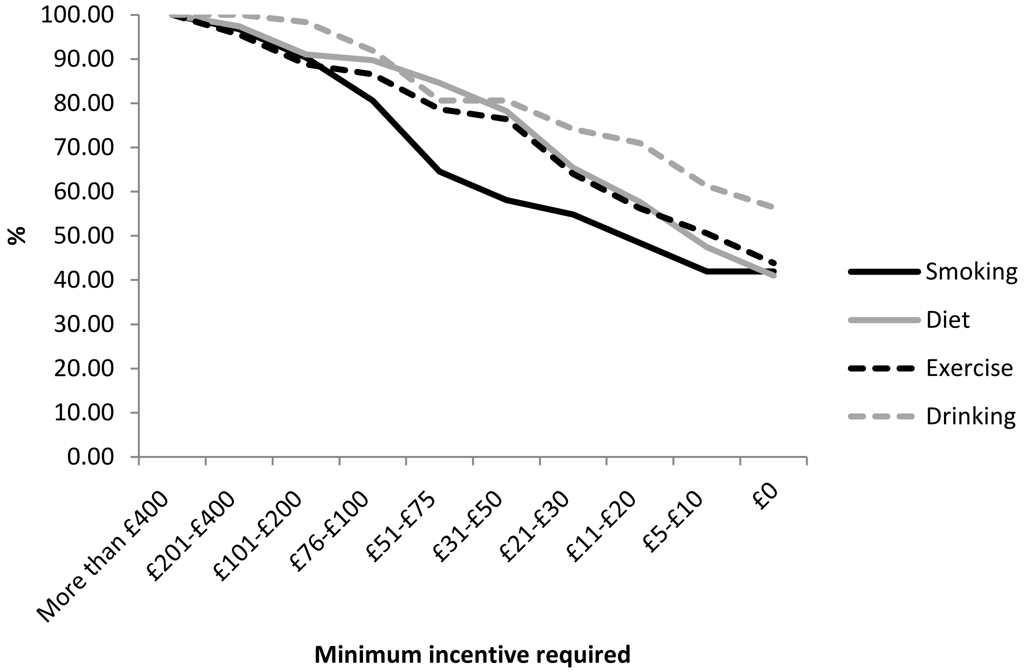
*Positive values are increases in WTA/WTP over time; **There are no significant differences between groups according to t-tests

Table 21: Baseline to 3 months change in WTA by reported health behaviour change at 3 months*

Change in health behaviour	**Financial incentive**		**Lottery incentive**		**Financial commitment**	
	N	**Mean (SD)**	**N**	**Mean (SD)**	**N**	**Mean (SD)**
Smoking cessation*						
No change	9	£59.17 (£113.66)	8	£0.55 (£29.64)	8	£55.44 (£109.75)
Stopped smoking	0	--	0	--	0	--
Weight change						
No change or weight gain	16	£5.63 (£79.80)	16	-£0.79 (£11.47)	6	£6.25 (£18.17)
Lost weight	7	£39.64 (£114.19)	6	£10.82 (£21.94)	16	-£4.75 (£38.71)
Exercise						
No change or stopped exercising	22	£11.14 (£101.49)	21	£1.40 (£13.55)	8	£22.19 (£103.67)
Started exercising	9	-£11.67 (£29.61)	8	£0.61 (£8.44)	21	£3.40 (£56.83)
Alcohol						
No change or increased units	3	£226.67 (£319.83)	3	£20.3 (£33.87)	2	£0.00 (£0.00)
Reduction in units consumed	2	£0.00 (£0.00)	2	-£29.25 (£39.24)	3	£85.00 (£162.62)

*Positive values are increases in WTA over time; **There are no significant differences between groups according to t-tests

Figure 11: Incentive demand curves by health behaviour



There were significant differences between the minimum required $WTA_{Certain}$ and the minimum $WTA_{Uncertain}$ with the former being between 4.7-9.6 times the magnitude of the latter. This has important implications of the costs of incentive schemes. The correlations between guaranteed and lottery incentive ranged between 0.27 and 0.53 indicating that there were moderate levels of agreement (correlation coefficients of 0.25-0.50) between the survey questions. This adds to the confidence we can place in the stated values. In the comparison of baseline and 3 month WTA values, only significant differences were found in the alcohol question and only when unpaired tests were conducted. No significant baseline-3 months differences were found for either $WTA_{Certain}$ or $WTA_{Uncertain}$ when paired t-tests were used although the sample sizes were noticeably reduced (e.g. to n=9 for smoking and n=25 for alcohol consumption).

Table 22 and Table 23 include the respective descriptive statistics for $WTA_{Certain}$, $WTA_{Uncertain}$ and $WTA_{Commitment}$ based on data pooled across time in absolute terms and as a percentage of monthly income, respectively. As some respondents provide multiple observations, adjusted standard errors are presented (clustered on respondent). T-tests indicated the guaranteed incentives required for smoking cessation were statistically significantly higher than those required for dieting (99% level), exercising (95% level) and reducing alcohol intake (95% level). There were no other significant differences between behaviours. This was also the case for the lottery incentive with the exception that no difference was found between smoking cessation and alcohol reduction. The only significant difference when % income data were analysed (for both $WTA_{Certain}$ and $WTA_{Uncertain}$) was between smoking cessation and dieting. There were no significant differences in $WTA_{Commitment}$ across behaviours in either absolute or percentage income terms.

Table 22: CV descriptives – pooled time-point data

	n	Mean	SE	Min	Max
Financial incentive					
Stop smoking	44	£103.69	£28.32	£0	£1,000
Diet	120	£47.10**	£7.95	£0	£500
Exercise	139	£53.35*	£8.36	£0	£500
Reduce alcohol intake	99	£45.43*	£9.66	£0	£600
Lottery					
Stop smoking	39	£14.61	£4.03	£0	£70
Diet	113	£7.68**	£1.54	£0	£70
Exercise	127	£7.20*	£1.30	£0	£70
Reduce alcohol intake	89	£9.58	£2.00	£0	£70
Financial commitment					
Stop smoking	40	£40.54	£12.20	£2.50	£275.00
Diet	112	£36.61	£6.51	£0.00	£275.00
Exercise	130	£39.76	£6.58	£0.00	£275.00
Reduce alcohol intake	91	£44.01	£9.02	£2.50	£500.00

*p<0.05 for unpaired t-test vs. Smoking; †p<0.05 for unpaired t-test vs. Diet; incentive; $^{\Delta}$p<0.05 for unpaired t-test vs. Exercise; $^{\theta}$p<0.05 for unpaired t-test vs. Alcohol; **p<0.01 for unpaired t-test vs. Smoking; ††p<0.01 for unpaired t-test vs. Diet; incentive; $^{\Delta\Delta}$p<0.01 for unpaired t-test vs. Exercise; $^{\theta\theta}$p<0.01 for unpaired t-test vs. Alcohol

Table 23: CV descriptives as % of income – pooled time-point data

	n	Mean	SE	Min	Max
Financial incentive					
Stop smoking	41	17.88	6.32	0	200
Diet	113	5.55*	1.58	0	120
Exercise	133	8.23	2.23	0	200
Reduce alcohol intake	96	8.42	3.46	0	240
Lottery					
Stop smoking	36	2.43	0.99	0	24
Diet	108	0.69	0.17	0	14
Exercise	122	1.03	0.31	0	24
Reduce alcohol intake	87	1.17	0.40	0	24
Financial commitment					
Stop smoking	37	6.73	3.76	0.06	110.00
Diet	106	3.47	1.11	0.00	110.00
Exercise	124	4.90	1.44	0.00	110.00
Reduce alcohol intake	89	5.94	2.86	0.06	200.00

*p<0.05 for unpaired t-test vs. Smoking; †p<0.05 for unpaired t-test vs. Diet; incentive; $^{\Delta}$p<0.05 for unpaired t-test vs. Exercise; $^{\theta}$p<0.05 for unpaired t-test vs. Alcohol; **p<0.01 for unpaired t-test vs. Smoking; ††p<0.01 for unpaired t-test vs. Diet; incentive; $^{\Delta\Delta}$p<0.01 for unpaired t-test vs. Exercise; $^{\theta\theta}$p<0.01 for unpaired t-test vs. Alcohol

5.3.4.2. Descriptive statistics by sub-group

Non-parametric Mann Whitney tests for two groups and Kruskall Wallis tests for three groups were conducted to test for differences between $WTA_{Certain}$ responses by perceived difficulty, attitude and other factors (Table 24; see Appendix 12.2.5 for equivalent tables for lottery and financial commitment). Exercise and alcohol WTA values were significantly different (95%) by difficulty group when data were analysed as a percentage of income. However these are unadjusted both for repeated observations and multiple testing. There were large differences according to grouped responses on the sense of control and NHS offering incentives questions. No statistically significant differences were found between the difficulty groups when lottery incentive data was used. Many of the differences approached significance but p values exceeded 0.05. It is possible that the lack of significant findings relates to the small numbers in some of the analysed groups and the wide confidence intervals around the means. There are no significant differences in WTA by strength of health behaviour (BMI, AUDIT score) or between people grouped by discount rates (time preference) (

Table 25). However, there is a trend that those with higher discount rates require higher incentives, except for smoking - again, which may relate to the small samples in each group.

Table 24: Incentive descriptive by sub-group – Demographics and attitudes

	Smoking	Diet	Exercise	Alcohol
Socio-demographics				
Age group				
<=59	£117.11	£51.73	£50.41	£62.32*
>59	£67.92	£42.16	£56.69	£24.32
P value	0.369	0.083	0.128	0.016
Sex				
Female	£53.67	£61.90	£69.12	£30.00
Male	£129.57	£36.54	£42.38	£53.14
P value	0.329	0.758	0.407	0.861
Income group				
<£2000 pm	£95.90	£46.11	£69.81*	£68.35
>=£2000 pm	£125.94	£44.92	£35.85	£30.82
P value	0.487	0.179	0.012	0.108
Attitude questions				
I am in control				
Agree	£43.08	£33.21	£41.53	£24.78
Disagree	£191.25**	£74.33*	£80.70*	£93.75**
P value	.001	.000	.001	0.006
My lifestyle determines health				
Agree	£111.32	£39.25	£45.77	£47.47
Disagree	£77.75	£74.17	£83.39	£36.84
P value	.989	.041	.058	.630
I am motivated				
Agree	£80.67	£41.31	£45.58	£33.02

Disagree	£153.04	£62.36	£74.42	£78.52*
P value	.021	.280	.353	.320
Major achievement				
Agree	£110.35	£53.54	£56.95	£43.88
Disagree	£73.75	£28.71	£44.02	£50.58
P value	.161	.688	.851	.874
I am at high risk				
Agree	£120.40	£43.20	£58.87	£59.64
Disagree	£63.85	£54.49	£45.74	£22.22
P value	.292	.914	.236	.063
I live for today				
Agree	£88.27	£42.63	£56.55	£56.55
Disagree	£125.97	£51.83	£51.15	£37.24
P value	.541	.425	.935	.518
I can wait for things				
Agree	£93.90	£45.03	£46.85	£39.22
Disagree	£116.58	£50.43	£64.90	£55.39
P value	.350	.645	.334	.972
NHS should offer incentives				
Agree	£104.22	£64.20	£81.56*	£58.79
Disagree	£103.39	£36.87	£38.61	£39.20
P value	.070	.006	.000	.041

P values relate to non-parametric tests; *Significant at 95% level (t-test); **Significant at 99% level (t-test)

Table 25: Incentive descriptive by sub-group – Health behaviours and perceived difficulty

	Smoking	Diet	Exercise	Alcohol
Health behaviours				
BMI				
<25	-	£28.96	£59.09	-
25-30	-	£53.49	£71.70	-
>30	-	£41.06	£34.57	-
P value		0.439	0.575	
AUDIT Score				
<4	-	-	-	£30.10
>=4	-	-	-	£50.61
P value				0.917
Difficulty of change				
Easy	£64.58	£29.43	£35.51	£18.96
Difficult	£109.87	£57.27	£66.50	**£116.02
P value	0.241	0.045	0.065	0.000
Discount rate				
<20%	£255.00	£37.28	£28.78	£29.91
20%-100%	£65.56	£49.73	£60.85	£28.31
>100%	£92.63	£53.23	£65.91	£79.92
P value	.265	.780	.061	.342

P values are non-parametric tests (Wilcoxon for two groups, Kruskal Wallis for three groups); *Significant at 95% level (t-test for two groups, ANOVA for three groups); **Significant at 99% level (t-test for two groups, ANOVA for three groups)

5.3.4.3. Regression - individual health behaviours

Since the sample for individual behaviour analyses was small it was decided to run only the GLM model as analyses applied separately to the zero responses reduces the sample available for predicting the positive values. Results from the GLM regression of individual behaviours pooled by time are included in Table 26. The GLM passed the linktest in all but the alcohol question. However, GLM was still applied to this question for comparability of results. The results of the Modified Park test are included in Appendix 12.2.7. A number of combinations of family (including Gaussian, Gamma, Poisson and Inverse Gaussian) and links (Identity and Log) were tested and either a Gamma or Poisson family appeared appropriate. The Gamma family was chosen as this is more commonly used with the Log link in health economics (especially for analysing skewed cost data). For parsimony, only $WTA_{Certain}$ analyses are presented in detail here with the results for $WTA_{Uncertain}$ and $WTA_{Commitment}$ provided in Appendix 12.2.8.

In each health behaviour the sense of control attitude question was a statistically significant predictor of WTA values. In each case those who stated having less control over their health required a higher minimum incentive to change their behaviour. Perceived difficulty of behaviour change was a significant predictor in weight loss and alcohol consumption reduction with those perceiving greater difficulty in changing requiring higher incentives. The attitudinal variable indicating acceptance of incentives from the NHS was only borderline significant for weight loss but the direction of the coefficient indicates those who disagree with incentives stated lower WTA values. Sex was a significant WTA predictor in exercise and alcohol (borderline). The coefficient direction was the same in both and of a similar magnitude and indicated that females required higher incentives. In alcohol and smoking, age has an inverse relationship with WTA with older people reporting lower required incentives. Finally, the visit variable (baseline vs 3 months) approached significance in smoking and alcohol and in both cases higher incentives were required at the later time-point.

Time preference, other attitudinal questions and behaviour strength variables (e.g. AUDIT scores) were not found to be significant predictors of WTA response. However, data on number of cigarettes smoked was unavailable. The fact that BMI was not significant in weight loss but is in exercise is notable; it is possible that BMI may be perceived by some to prevent exercise.

Table 26: GLM regression of individual health behaviour $WTA_{Certain}$

Smoking			**AIC =**	**10.398**	**n = 43**	
Log Pseudo likelihood =		**-217.57**	**BIC =**	**-93.314**		
	Coef.	**SE**	**z**	**P > z**	**L 95% CI**	**U 95% CI**
Difficulty stop smoking	1.377	1.096	1.260	0.209	-0.770	3.524
Control	1.284	0.527	2.440	0.015	0.252	2.317
EQ-5D VAS	-0.018	0.016	-1.180	0.240	-0.049	0.012
Age	-0.116	0.062	-1.880	0.061	-0.237	0.005
VisitCycle	2.002	1.150	1.740	0.082	-0.251	4.256
Constant	7.208	2.540	2.840	0.005	2.229	12.186

Weight loss			**AIC =**	**9.367**	**n = 117**	
Log Pseudo likelihood =		**-541.98**	**BIC =**	**-413.70**		
Control	0.966	0.329	2.930	0.003	0.320	1.612
NHS should offer incentives	-0.506	0.355	-1.430	0.154	-1.201	0.189
Sex	-0.642	0.425	-1.510	0.130	-1.474	0.190
EQ-5D VAS	0.009	0.007	1.290	0.198	-0.005	0.023
Difficulty weight loss	0.746	0.327	2.280	0.023	0.104	1.388
Constant	3.029	0.548	5.530	0.000	1.955	4.103

Exercise			**AIC =**	**9.509**	**n = 126**	
Log Pseudo likelihood =		**-593.09**	**BIC=**	**-469.73**		
Control	0.937	0.326	2.880	0.004	0.299	1.575
NHS should offer incentives	-0.518	0.296	-1.750	0.081	-1.099	0.063
Sex	-0.974	0.403	-2.420	0.016	-1.763	-0.185
BMI group	-0.410	0.188	-2.180	0.029	-0.778	-0.042
Difficulty	0.503	0.354	1.420	0.156	-0.192	1.197
Constant	4.629	0.581	7.960	0.000	3.490	5.768

Alcohol			**AIC =**	**8.446**	**n = 97**	
Log Pseudo likelihood =		**402.63**	**BIC =**	**-322.19**		
Control	1.132	0.421	2.690	0.007	0.306	1.958
Sex	-0.930	0.476	-1.950	0.051	-1.863	0.003
EQ-5D Index	1.235	0.771	1.600	0.109	-0.276	2.747
Age	-0.079	0.023	-3.440	0.001	-0.124	-0.034
Difficulty alcohol	1.747	0.378	4.630	0.000	1.007	2.487
VisitCycle	0.761	0.395	1.930	0.054	-0.014	1.535
Constant	5.670	1.205	4.710	0.000	3.309	8.032

In Table 62 and Table 63 in Appendix 12.2.8, GLM models are presented predicting $WTA_{Uncertain}$ and $WTA_{Commitment}$, respectively. In the analysis of $WTA_{Uncertain}$, there were no significant predictors in the weight loss model but elsewhere findings were consistent with those in the $WTA_{Certain}$ analysis. For example, lower control and greater perceived difficulty (exercise model only) of change required greater expected lottery incentives. Those with poorer quality of life (assessed on the EQ-5D VAS) also required greater lottery incentives in the smoking and alcohol models. In the latter and in line with expectations, those who drank more (higher AUDIT score) also required greater value lotteries to entice behaviour change. There were some inconsistencies between the health behaviour models. For example, in exercise, those who had higher education needed greater value lotteries to incentivise them while the reverse was true in the alcohol model. This may be a cost of time issue with higher educated (and, we can assume, higher income) respondents needing more money to compensate them for time lost exercising while behaviour change in alcohol requires relatively little time commitment. The income variable corroborated this theory as the beta sign was reversed in these two behaviours.

In the analysis of $WTA_{Commitment}$, similar trends were apparent with higher financial commitments required to motivate behaviour change at 3 months (statistically significant in smoking and alcohol) or if the respondent had lower control or higher perceived difficulty of change. Trends were also apparent indicating that those with higher income and higher education were willing to commit more money to such an incentive scheme. In terms of health behaviours, those who drank more (according to AUDIT) and were more obese (BMI) were willing to commit more money to change behaviour which allows confidence in the survey validity. There was a suggestion that those with lower motivation were willing to commit less (significant in smoking and alcohol consumption) which may reflect lower desire to participate in such a scheme or belief that they would not be able to achieve change and regain the committed money. A consistent finding not present in the analysis of $WTA_{Certain}$ and $WTA_{Uncertain}$ data was that those who believed they were at lower risk were willing to commit less money than those who thought they were at higher risk. Finally, in all behaviours, those with higher discount rates were willing to commit less money. It is unclear why this might be the case but may reflect an underlying increased uncertainty in the return of the money captured in the question or reflect the lower value placed on returned money in the future due to high discounting.

5.3.4.4. Pooled health behaviours

Table 27 and Table 28 include summary statistics and means for WTA by subgroups.

Table 27: Pooled health behaviour - WTA descriptives

	N	Mean	SD	Min	Max
Guaranteed incentive	402	£55.04	£106.01	£0.00	£1,000
Lottery incentive	371	£16.72	£90.55	£0.00	£1,000
Commitment incentive	373	£39.93	£70.25	£0.00	£500
Guaranteed incentive % income	381	8.56	27.33	0.00	240
Lottery incentive % income	354	1.37	4.63	0.00	50
Commitment incentive % income	350	5.00	17.63	0.00	200

Table 28: Mean WTA by sub-group

	Guaranteed	Lottery	Commitment
Socio-demographics			
Age group			
<=59	£63.28	£13.77	£43.63
>59	£44.78	£20.38	£35.27
P value	0.0004	0.0167	0.006
Sex			
Female	£56.97	£7.96	£30.65
Male	£53.84	£22.04	£45.77*
P value	0.7533	0.8398	0.0017
Income group			
<£2000 pm	£66.82	£9.72	£38.04
>=£2000 pm	£44.43*	£22.88	£43.39
P value	0.000	0.008	0.155
Attitude questions			
I am in control			
Agree	£34.98	£6.90	£29.24
Disagree	£96.76**	£34.05**	£59.60**
P value	0.000	0.000	0.000

My lifestyle determines health			
Agree	£51.30	£18.67	£39.04
Disagree	£69.23	£9.05	£43.41**
P value	0.045	0.066	0.105
I am motivated			
Agree	£44.84	£10.23	£35.81
Disagree	£81.28**	£32.33*	£50.69
P value	0.014	0.001	0.932
Major achievement			
Agree	£59.46	£18.00	£44.58
Disagree	£43.93	£13.53	£28.31
P value	0.342	0.034	0.206
I am at high risk			
Agree	£61.96	£21.65	£44.58
Disagree	£44.20	£7.55	£28.31
P value	0.038	0.047	0.148
I live for today			
Agree	£56.79	£22.46	£43.71
Disagree	£53.99	£11.54	£36.46
P value	0.495	0.182	0.198
I can wait for things			
Agree	£49.17	£11.28	£39.41
Disagree	£64.61	£25.41	£40.79
P value	0.242	0.059	0.547
NHS should offer incentives			
Agree	£73.81	£23.98	£46.25
Disagree	£45.19*	£12.77	£36.73
P value	0.000	0.000	0.028
Annual discount rate			
<20%	£44.60	£17.81	£42.37
20-99%	£53.87	£7.73	£55.63
>=100%	£70.67	£10.60	£35.32*
P value	0.043	0.242	0.000

P values are non-parametric tests (Wilcoxon for two groups, Kruskal Wallis for three groups); *Significant at 95% level (t-test for two groups, ANOVA for three groups); **Significant at 99% level (t-test for two groups, ANOVA for three groups)

The data were reanalysed but with responses pooled across health behaviour and time-point thus increasing the sample and power of the analyses. The GLM model returned control, perceived difficulty, the EQ-5D VAS and highest education level (versus primary school only) as being significant predictors of incentives required with acceptance of incentive, the item on ability to wait for things and VisitCycle exhibiting borderline significance. These results were largely the same when protests responses were removed. However, both analyses failed the linktest and could not be improved by using other families or link options. Thus other modelling approaches were explored.

The Tobit model (censored at £0) was significant with the variables on control, acceptance of incentive and perceived difficulty returned as significant and VisitCycle borderline significant. However, the model predicted WTA values ranging -£154.29 to £192.93 with over 50% being negative. The model remains significant (although with a reduced pseudo R^2) when protests (n=87) are removed and, with the exception of the attitudes to incentive question, the same variables remain significant predictors. Subsequently, the proportion of negative WTA predicted values were reduced to 25%. However, the prediction of such a high number of negative values seems a poor theoretical fit for the data thus the Tobit was not considered the most appropriate model.

There was very little difference between the two-part model and zero-inflated model. The log-likelihoods were similar and similar variables were returned as significant - although the zero-inflated model appeared to have greater power. The Vuong test indicated the zero-inflated model was preferred to the standard negative binomial model. For these reasons results from only the zero-inflated model are reported. The marginal effects for the final $WTA_{Certain}$ model are included in Table 29 - the model for $WTA_{Uncertain}$ did not converge and is not reported. As there were very few zero responses to $WTA_{Commitment}$, a GLM analysis is presented (gamma with log link function) in the appendix (Appendix 12.2.8).

Table 29: Zero-inflated negative binomial model predicting $WTA_{Certain}$

	Number of obs =	392				
	Non zero obs =	224				
	Zero obs =	168				
Inflation model = logit	**LR chi2(15) =**	66.37				
Log likelihood = -1412.093	**Prob > chi2 =**	0.000				
	dy/dx	**SE.**	**z**	**P>z**	**L 95% CI**	**U 95% CI**
Sense of Control	49.85	10.16	4.91	**0.000**	29.95	69.76
Female Vs Male	-15.24	9.47	-1.61	0.107	-33.80	3.31
Age	-0.70	0.46	-1.53	0.127	-1.60	0.20
Perceived difficulty (Easy)						
Vs Moderate	27.67	8.09	3.42	**0.001**	11.82	43.52
Vs Difficult	41.33	11.68	3.54	**0.000**	18.44	64.22
NHS should offer incentives	-9.56	8.34	-1.15	0.252	-25.91	6.79
Education (Primary)						
Vs Secondary	-79.57	43.13	-1.84	0.065	-164.11	4.98
Vs Intermediate	-92.81	42.95	-2.16	**0.031**	-176.99	-8.63
Vs University	-72.80	43.41	-1.68	0.094	-157.88	12.29
Baseline vs 3 months (VisitCycle)	16.59	8.80	1.89	0.059	-0.66	33.84

Health Behaviour (Smoking)						
Vs Diet	-25.28	16.95	-1.49	0.136	-58.50	7.94
Vs Exercise	-17.67	17.19	-1.03	0.304	-51.36	16.03
Vs Alcohol reduction	-14.94	18.44	-0.81	0.418	-51.09	21.21
EQ-5D VAS	-0.30	0.20	-1.47	0.142	-0.69	0.10
I can wait for things	-16.00	9.94	-1.61	0.107	-35.48	3.48

As with the analyses by health behaviour, control and perceived difficulty of behaviour change were the most important predictors of incentive response. The analyses suggest those with low self-control require £49.85 more than those in control of health to change behaviour. There appears to be a linear-type relationship between required incentive and perceived difficulty of change; those who perceive change as neither easy nor difficult require £27.67 more per month than those who perceive change as easy and those who state that change will be difficult require £41.33 more than those reporting change as easy. The upper and lower confidence intervals for this comparison and for the control coefficients, although relatively wide, are all in the same direction giving confidence in the importance of these factors. The other attitudinal items did not prove to be significant predictors of incentive and were excluded from the model. However the surrogate attitude item on time preference (I can usually wait for things I want) and the attitudes towards incentives variable were retained in the model as they were either approaching significance or theoretically key.

The coefficients for the demographics and visit variables were in the main non-significant but there is a suggestion that people who attained a higher level of education than primary school required less incentive than those whose highest level of education was primary school. This might be a reflection of social class, income or education. Although not significant, the coefficient for the visit variable suggests that the required incentive is £16.59 higher at three months compared to baseline. Males appear to require on average £15.24 less in incentive than females and the minimum monthly incentive required per month declines by £0.70 with every year of age. There is no clear association between age and acceptance of incentives but exploration of an interaction between the two suggests older people who do not agree with incentives report significantly lower WTA values. The discount rate variable is borderline significant in univariate and multivariate analyses but its introduction and consequent reduction in sample size (due to missing data on this item) has a disproportionate impact on the other model coefficients and hence was excluded from the main model.

The results from the GLM analysis of $WTA_{Commitment}$ show some consistencies with the above results. Values significantly increased at 3 months and there were trends for increased WTA with increased difficulty and less control. Values also increased with income and education but fell with age and higher perceived risk.

5.3.4.5. Validity of CV survey values

Figure 12 plots the average financial incentive required by the perceived difficulty of change for all behaviours combined. There appears to be a near linear relationship between $WTA_{Certain}$ and difficulty. Figure 13 and Figure 14 show $WTA_{Certain}$ and $WTA_{Uncertain}$ by response to the motivation question (dichotomised) and by strength of unhealthy behaviour, respectively. Equivalent figures for $WTA_{Uncertain}$ and $WTA_{Commitment}$ are presented in Appendix 12.2.6. The results provide some evidence of the internal validity of the CV values. Lower motivation requires greater incentives across the behaviours as does greater levels of unhealthy behaviour (for smoking and drinking). Data on physical inactivity was not available and the relationship between BMI and WTA appeared to be non-linear.

Figure 12: Mean $WTA_{Certain}$ by perceived difficulty

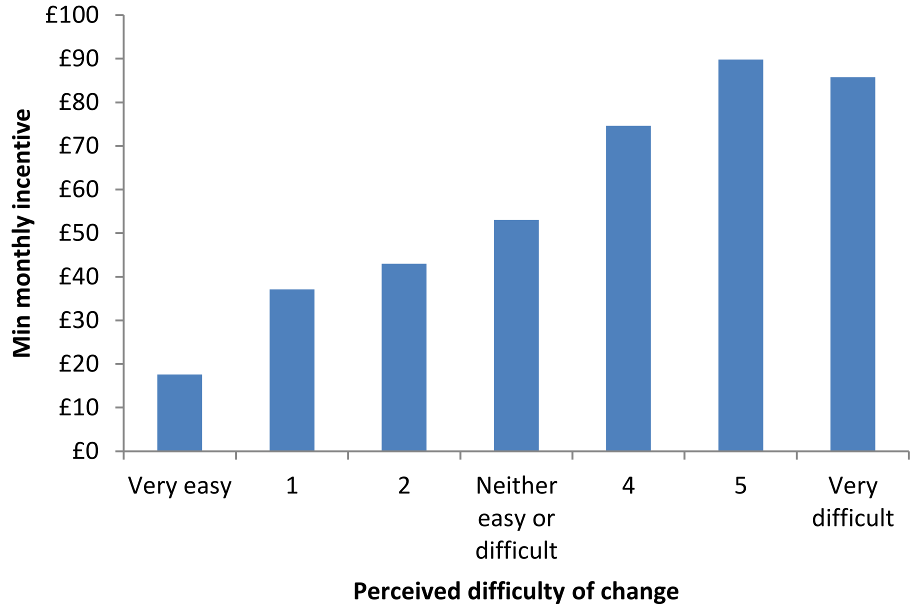


Figure 13: WTA by Motivation

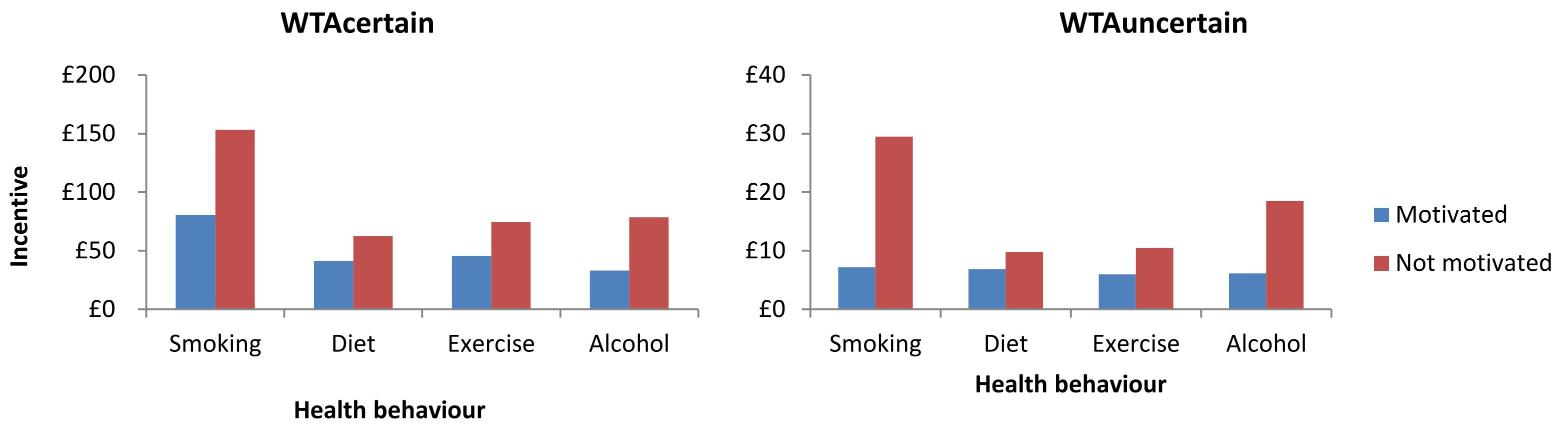
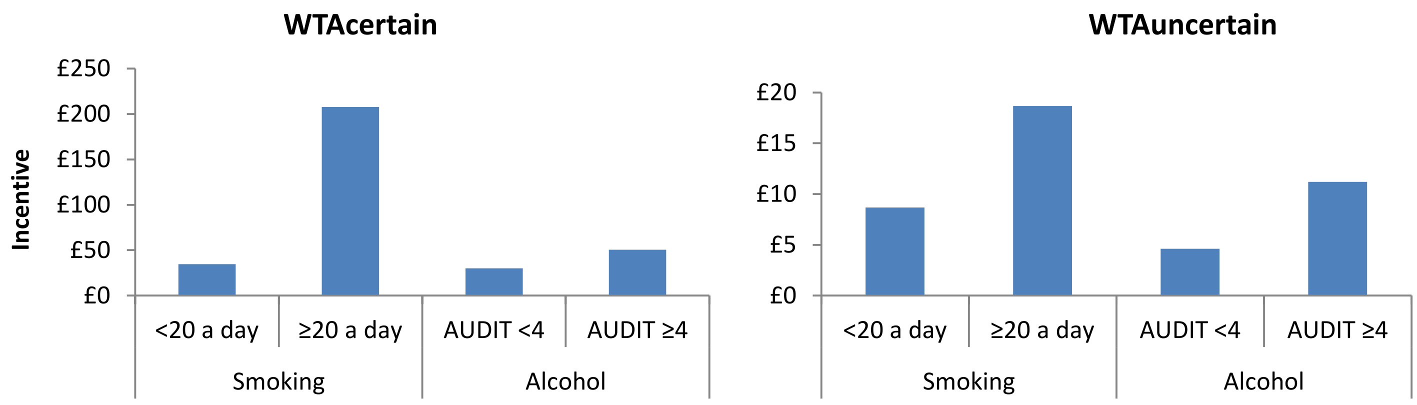


Figure 14: WTA by Unhealthy behaviour strength



5.4. Discussion

This chapter reports on the analysis of a contingent valuation survey which aimed to establish the pricing of incentives and to identify which factors determine acceptable incentive levels. The analysis of required incentive by subgroups and the correlations between guaranteed and lottery incentive, suggest that a certain degree of confidence can be placed in the validity of the survey results. Due to the small sample sizes, the pooled data (by time and by time and health behaviour) was most useful in identifying the minimum incentive pricing and mediators. In the event, there were a high number of zero WTA values and a number of modelling strategies were explored in trying to deal with this. On theoretical and diagnostic performance grounds, the zero-inflated negative binomial model was chosen. However, it is notable that the variables returned as significant were very similar across models. Excluding 'protest' responses from the analysis did not substantively change the results although determining who has protested is to some extent a value judgement. The explanatory power of most of the models was modest despite being generally highly significant. It was also a general finding that the fit of the model was poorer for the higher positive WTA values.

The survey data indicated low support for the NHS providing incentives for behaviour change, even in those who had low motivation and control over health. The average minimum acceptable incentive appeared to depend on the type of behaviour being considered and values varied widely. Smoking cessation was perceived to be the most difficult form of behaviour change and also required the largest incentive to bring about change. Dieting and exercising required about half the incentive amount per month required for smoking cessation. Analysis of the data as continuous suggested that the minimum incentive required fell with age, was lower in males, lower in people with smaller discount rates and higher in low income and less educated individuals. A note of caution must be attached to the discount rates implied by the survey responses which reached as high as 1,900% per annum. It is possible that individuals did not understand the question, were responding strategically rather than responding with the minimum required for them to defer the reward, or were not offering considered responses at all. Regardless, the time preference task used here is one commonly used in economic studies and doubts must be raised about its validity.

The introduction posited the hypothesis that A) there would be a positive relationship between required incentive and the level of unhealthy behaviour (i.e. BMI and alcohol consumption levels) and perceived difficulty of behaviour change. The latter relationship was clearly evident and the item on perceived difficulty of change was one of the strongest predictors of incentive level. The pooled data model suggested that an additional £41.33 would be required to encourage change in an individual who perceived change as difficult (compared to an individual who saw change as easy). This would amount to £495 over the course of 12 months and is therefore a non-trivial figure. The relationship between behaviour strength and incentive was less clear. Given the sample of smokers was small (and data on cigarettes smoked patchy) the analysis concentrated on diet and alcohol consumption. The BMI variable was not found to be a significant predictor of incentives in univariate or multivariate models for $WTA_{Certain}$ but was in some $WTA_{Uncertain}$ and $WTA_{Commitment}$ analyses. The descriptive data reveal a possible non-linear relationship between BMI and incentive required, being positive initially until a certain level of obesity where the required incentives appear to fall. It is unclear why this might be; acknowledgment of a biological process that weight loss would be easier for those very over-weight; over optimism in the heavily overweight; or reflecting an additional premium that people of a certain weight place on weight loss such that they require less external financial incentive. This concept is explored further in the following chapter addressing the cost-effectiveness of incentives for weight loss. BMI was important in the incentives required for exercise however. The AUDIT alcohol score was used to denote the strength of behaviour in alcohol consumption. While not significant in multivariate models $WTA_{Certain}$, AUDIT score was found to be a significant predictor of incentive level in the univariate model and suggested that an additional £6.77 incentive was required for every point increase on the AUDIT tool. It was also a significant predictor in $WTA_{Uncertain}$ and $WTA_{Commitment}$ models.

It was also hypothesised that B) the stated minimum required incentive level would be partly explained by responses to a number of attitudinal items. While this was found to be the case it was the item relating to sense of control and perceived ability to change that had greatest explanatory power; the item relating to motivation had a comparatively weak influence (in $WTA_{Certain}$ at least). The results largely support the inclusion of both of these factors in the proposed framework in Chapter 3. The analyses suggest those who did not agree with the statement that they are in control of their health and are able to change require £49.85 more of an incentive per month than those who did agree with the statement. The item relating to motivation was not a significant predictor in the multivariate analyses for $WTA_{Uncertain}$ but was in the other models. The univariate $WTA_{Certain}$ analysis indicated that an increase in incentive by £36.44 would be needed for an individual who did not feel motivated to change behaviour (compared to an individual who was motivated). The differential explanatory power of these attitudinal items suggests distinct constructs that influence behaviour change; individuals may be motivated to change but may not feel they have sufficient control over their behaviour or requisite skill to do so. It appears that the latter is more important, if not in behaviour change itself, at least in determining the level of financial reward or compensation an individual would need to receive to consider and achieve change.

In support of hypothesis C), there was a trend for the incentives required to be higher at three months. The analyses suggested an increase in $WTA_{Certain}$ on average of £16.59 from baseline to three months although the time-point variable in the selected model achieved only borderline significance. This effect was most marked for those considering smoking cessation or a reduction of alcohol consumption. When the univariate analysis was run considering only these two behaviours the p value decreased and the increase in incentive required over time rose to £40.73. A crude investigation of the change in perceived difficulty over time indicated that the average rated difficulty of dieting and exercising fell slightly by three months whereas the perceived difficulty of smoking cessation and alcohol reduction both rose slightly over the same period. This may offer some reason for the differential change in incentive over time by behaviour although we cannot be certain whether these reflect the behaviours themselves or the differential success or failure that patients may have had in changing those respective behaviours. A clear test of hypothesis C) is an exploration of the change in CV response by the same individuals over time which to some extent mediates the issue of having a different sample at the two time-points. For this, paired t-tests were conducted comparing the baseline and 3 month WTA means by health behaviour. In the event, no significant differences were found. It is unclear whether this is due to some of the small sample sizes available or if there was truly no effect. Despite this finding, means of the individual WTA change over time largely suggested an increase in incentives required; for example, mean increases of £59.12 and £57.10, respectively, were needed for smoking cessation and a reduction in alcohol consumption.

The sample comparison tests suggested there were mainly insignificant differences between those recruited and baseline completers and between baseline and 3 month completers. Education was significant in the latter comparison with those with higher education more likely to complete follow-up; this is a common finding in survey research. In the $WTA_{Certain}$ analysis here, education was associated with lower WTA. Hence the finding that WTA actually appears to increase over time does so in spite of the trend for more educated people to complete the follow-up. In summary though, the sample comparison allows us to be relatively confident that changes in VHCQ responses over time are not the result of changing samples.

Analyses of the lottery and financial commitment survey responses provided results that were largely consistent with those from the guaranteed incentive survey section. For example, that perception of control and difficulty of behaviour change were important determinants of the incentive level chosen. In addition, the suggestion that WTA/WTP values rose from baseline to 3 months was enduring as was the positive relationship between level of unhealthy behaviour (specifically, BMI and AUDIT) and incentive level required. There were some interesting additional findings in the analysis of the commitment responses; for example that those with higher income and education were willing to commit more money to behaviour change disincentive schemes and that willingness to commit was inversely related to discount rate and level of risk perception. However, caution is needed to avoid over-interpreting these findings – partially due to the small sample size but also due to the number of statistical tests performed. There was also qualitative feedback from the interviewer conducting the interviews that the financial commitment section was poorly understood and that respondents may not have provided informed answers. Many of the results from this section of the survey however suggest participants did understand and engage with the questions. For example, as with the guaranteed incentive and lottery questions and as previously mentioned, the WTA for the financial commitment increased in line with factors such as lower motivation and control.

The results presented here may have a number of implications for the design of incentive schemes. Lottery incentives may offer a cheaper alternative to guaranteed incentive as individuals are willing to accept a much lower uncertain incentive value. However, the analyses to determine the mediators of incentive amount were far less informative when a lottery was considered. Results suggest that different incentive amounts may be required for different health behaviours. That said, the health behaviour variable was not found to significantly predict incentive amount in multivariate analysis when perceived difficulty was included. A possible explanation for this is that the pricing of incentives may not necessarily be dependent on the behaviour *per se* but on the underlying difficulty that the individual perceives in achieving that change. Alternatively, the base category in the model (smoking) had a small n which may have reduced power. Optimal incentive levels may vary between individuals for the same behaviour and for the same individual over time. The implication is that incentive pricing may need to be personalised for the individual, accounting for characteristics such as perceived difficulty of change, and be dynamic over time. Information garnered from the study on incentive values and knowledge of what determines them, will be useful for incentive scheme design. It may also be useful in the consideration of cost-effectiveness presented in Chapter 9. There was some support from the survey analysis for the framework proposed in Chapter 3 and the hypothesised relationships therein. For example, self-control was found to be important. However, the survey data should be explored further to help understand inter alia the determinants of reported motivation and time preference.

Analysis of the lottery and financial commitment data provided additional insights. For example, discounting appeared to be significant predictor of WTA but the direction of the relationship varied depending on the incentive scheme. The financial commitment data analysis suggests that level of income or education may affect participation. Those with higher income or education were willing to commit more money to behaviour change and this may reflect an unwillingness to participate in low income individuals. This suggests that financial commitments may not be a suitable design of incentive schemes where the aim is to reduce health inequalities. Risk perception was also important in willingness to commit money to behaviour change with those who perceive themselves as being at low risk willing to commit less. Given the group had all experienced a suspected cardiovascular event and engaged in some form of risky behaviour it is an important finding that some felt they were at relatively low risk and, further, that this may influence their willingness to engage in interventions to reduce this risk. It is possible that increased education is required to counter-act this.

Doubts were raised during the interviews about the comprehensibility of the financial commitment question. Future research in the area whose primary aim is understanding commitment responses should invest time in ensuring the format is clear. It should also minimise respondent burden and consider only enquiring about this form of disincentives since it is possible here that participants were over-burdened and confused by the inclusion of both positive incentives and disincentives in the same survey. Asking the respondents to reframe their thinking from considering what they would need to be paid, to what they would need to commit financially may be too cognitively challenging.

There is reason to treat some of the survey results of the study with caution. A number of explanations have already been offered for the apparent increase in incentive amount over time. An alternative plausible explanation is that those who were more in favour of incentives (and who sought greater incentive levels) were more likely to complete the VHCQ at follow-up, which would have the effect of raising the mean value. This argument is however attenuated by the fact that the trend of an increase only occurs in smoking cessation and alcohol reduction. The sample comparison analyses also indicated that were no significant differences in baseline WTA between those who did and didn't complete the follow-up. The increase may also have resulted from the change in survey administration mode (from face to face to - predominantly - telephone at follow-up)(520) or the change in setting (hospital to home at follow-up).

Some of the results provide evidence of the internal validity of the CV survey. For example, WTA values increased with increased perceived difficulty, lower motivation and with greater strength unhealthy behaviours. A change in WTA values in those who succeeded or failed at behaviour change at 3 months might be additional evidence for the survey validity. There was a trend that those who had begun the behaviour change process required greater incentives at 3 months. We might speculate that this is because people have either a) realised the true disutility of behaviour change; or b) reached a plateau in change and find further efforts more challenging. However, this trend was not consistent across behaviours and the samples were too small to have confidence in the findings.

The values obtained here for smoking, diet and exercise (no incentive studies for alcohol could be identified) are within the range of those offered in trials and studies in these behaviours where some engagement and success with the scheme has been observed. For example the baseline WTA for smoking cessation was £88 per month here while a recent study (105) which found incentives to be effective offered pregnant women up to £752 for smoking cessation up to 6 months post-partum (which equates to ≈£50 per month assuming a 15 month scheme). Furthermore there was evidence that the values elicited here are largely comparable with those elicited in other value elicitation studies. To illustrate, in the You et al (171) discrete choice study, overweight women needed to be paid $53.00 (£35.39) per monthly weigh-in over 3 months to participate in a weight loss programme. This compares to the average value obtained in this study of £47.10 per month.

It was beyond the scope of the current research to attempt to test the external validity of the elicited values. It is known that WTA and WTP values often under and over-estimate values that people would accept and pay in the real world.(521) Many studies apply a calibration rule where the elicited values are divided by a factor to generate a value closer to the actual willingness to pay or accept. While the NOAA panel suggested the "divide by 2" rule (482) a meta-analysis of calibration studies has shown that the ratio of stated and actual preferences is not always above 1 and that the disparity depends on: whether the values elicited are to accept or pay (being larger in the former); the elicitation method; and whether the good considered is a private or public good (with the former being lower).(521)

As stated earlier in the thesis, it is debatable whether the calibration requirements identified in environmental economics (a majority of studies are in this field) are applicable to health and it would be unwise to apply a rule of thumb from that field to this. Additional research is needed on clinical trial data and observational data (for example, from commercial website schemes) where the response to different incentive levels can be observed. Notwithstanding the potential need to adjust for hypothetical bias, the relative values obtained within the survey could still be argued to have inherent value. For example, the knowledge that smokers, those with high levels of unhealthy behaviour, lacking control and perceiving behaviour change as difficult might require higher levels of incentives or that higher incentives might be needed as time progresses is new, important and potentially useful information regardless of the absolute values.

A major criticism of CV in general is that individuals may not have well-formed preferences for the target good or service. For those who do not it may have helped to include a 'Don't know' option, however a review suggests that their omission does not affect the validity of results but does substantially reduce the data available. (522) Regardless, further adjustment of the WTA values may be necessary before applying them in the real world.(523) It is also not clear what proportion of the stated required incentive relates to an extrinsic motivator and to opportunity cost (or financial barriers). For example, respondents may have been factoring into their valuation the costs for gym attendance or nicotine patches or accounted for savings they would may make (e.g. from not smoking). However, this distinction should not be of great significance when designing incentive schemes as the rationale for the incentive level accepted is not required.

Notwithstanding these notes of caution, these analyses represent a valuable addition to existing research. This is the first English study on incentive pricing and the first ever study (and one of very few contingent valuation studies) that reports responses on two occasions over time. A number of issues warrant further research. Analyses could explore whether individuals with multiple (clustered) unhealthy behaviours systematically respond in a different manner to those with only one unhealthy behaviour. Finally, for incentive scheme planning, it would be useful to determine what factors influence people's attitudes towards or acceptance of incentives.

5.4.1. Main findings

The major findings from the analysis are included in Figure 15 with their implications for incentives research and schemes outlined.

Figure 15: Important findings and implications

Finding	Implications for incentive research and schemes
• A high proportion of the sample felt strongly that incentives should not be offered by the NHS	➢ Incentive schemes may not be accepted by many which may limit participation and therefore effectiveness ➢ Careful targeting and framing of incentives may be needed
• There were notable differences in incentive required by health behaviour. Smoking cessation was rated most difficult and required the largest incentive	➢ Schemes and incentive amounts should be tailored to specific behaviours
• The expected cost of uncertain incentives (lottery) was much lower than guaranteed incentives	➢ Lotteries may provide the most cost-effective incentive format
• There was a clear relationship between perceived difficulty of change and minimum required incentive	➢ Incentive pricing should be personalised and take into account the perceived difficulty of behaviour change
• The relationship between self-reported motivation and strength of behaviour and required incentive was sometimes weak or non-linear	➢ Incentive pricing based on these factors alone may not be optimal
• Of the attitudes, sense of control over behaviour had the greatest explanatory power for WTA values	➢ These factors should be accounted for in incentive design, targeting and pricing
• Socioeconomic and demographic factors (education, gender, age and income) were moderately important in explaining WTA values	➢ Special efforts may be required to convince higher income or older individuals of the value of incentive schemes
• There was a suggestion that required incentives changed (increased) over time	➢ Incentive schemes may need to be dynamic over time in response to underlying motivation, change in difficulty and environment

• Willingness to commit money to a disincentive scheme was positively related to income and education	➢ Financial commitment design schemes may not attract/engage lower income groups and fail to address health inequalities
• Willingness to commit money to a disincentive scheme was inversely related to perceived health risk	➢ Interventions may be required to educate individuals regarding health risks (even in those who have had a health scare)
• There was qualitative evidence that respondents struggled with the concept of a disincentive scheme	➢ Future research in this area should devote additional resources to ensure WTP tasks are understood

6. The cost-effectiveness of incentives

6.1. Background

The arena for public health in England has changed significantly recently with a new body – Public Health England – taking charge of national public health and with responsibilities and attendant budgets being devolved to local authorities and Health and Well-Being Boards therein.(524) As local government attempts to manage the health and social care integration and achieve efficiency savings demanded by central government, now, more than ever, it is imperative that they identify which public health interventions represent value for money and best return on investment.

The introduction to this thesis outlined the impact of preventable diseases in terms of financial costs and quality of life and highlighted the link between diseases and health behaviours. It noted the significant contribution that unhealthy behaviours make to increased mortality risks and early, preventable deaths – especially in lower income groups. For example, cardiovascular diseases such as stroke and ischaemic heart disease are the number one cause of death globally and account for 25% of all deaths.(1) Consequently, the mortality associated with preventable diseases explains a large proportion of the life expectancy differential between socioeconomic groups. While there has been an acknowledgement that changing lifestyles is a priority, unhealthy behaviours have proven intractable and a multitude of behavioural schemes and interventions have often delivered only modest and often transient results. Financial incentives are perceived as a more radical and controversial approach to behaviour change than interventions that are based on traditional behavioural models. This may partly explain why, despite some promising results in favour of incentives, their adoption as a public health tool has been limited. Another significant barrier to the wider adoption of financial incentive schemes is the uncertainty as to whether or not they represent value for money and whether they are financially sustainable. If incentives were to deliver higher rates of behaviour change than traditional interventions and therefore prevent a greater number of secondary diseases, they may represent value for money. However, the degree to which such schemes are affordable in the medium and long term and especially on a population basis is questionable. Research establishing the cost-effectiveness of financial incentives is therefore required and frequently cited as a priority for future research.(114, 131, 160) Should such schemes be found cost-effective they may overcome the barrier of negative opinion as studies indicate that the public are more accepting of incentives if they are described as being cost-saving or more cost-effective than alternatives.(153)

To date, there have been very few economic evaluations of financial incentive schemes. Those existing studies were discussed in section 1.1.3.4 of the thesis. Although more robust economic evaluations are planned (e.g.(104)), at the time of writing, no published studies present a full economic evaluation of financial incentives for achieving lifestyle behaviour change that would meet the technology appraisal reference case criteria set out by the National Institute of Health and Care Excellence (NICE).(326)

6.2. Aims and objectives

The following chapters describe research conducted to address this gap in knowledge and reduce the uncertainty surrounding the value for money of financial incentive interventions. The aim was to develop a decision-analytic model and conduct a full economic evaluation of a financial incentive scheme employing the NICE reference case methods and presenting the costs and (dis)benefits of the target scheme over the full period in which they are likely to be experienced (i.e. the participant's lifetime).

For the purpose of the evaluation it was necessary to choose an exemplar health risk to be the focus of the analysis and after careful consideration the application of financial incentives for weight loss was selected. This area was chosen as obesity represents one of the greatest challenges to public health in England (and internationally) and is a growing problem whereas smoking (for example) – although arguably more hazardous – is generally on the decline in England (and high income economies generally). In addition, it was thought that, since much of the work in financial incentives applied to lifestyle changes had occurred in weight loss, the economic evaluation was more likely to be practicable relying as it does on existing evidence. Finally, it was intention that the research, although targeting a specific lifestyle consequence, would provide insights relevant to other behaviour change challenges such as physical inactivity, smoking and excessive alcohol consumption. Thus the evaluation was used to provide information specifically about the cost-effectiveness of incentives for weight loss but also to generate a tool which would allow common methodological issues pertaining to the design and evaluation of incentive schemes to be explored. The following chapters report separately on the i) estimation of the effectiveness of financial incentives for weight loss; ii) the development of the decision-analytic model; and iii) the running of the model and estimation of cost-effectiveness. Specific objectives and research questions are outlined below.

6.2.1. Objectives

i. Determine the effectiveness of incentives for weight loss
ii. Design and develop a decision-analytic model to enable estimation of the cost-effectiveness of weight loss interventions
iii. Adapt the model to account for issues novel to the use and analysis of incentives
iv. Incorporate information relating to pricing derived in Chapter 5 in the model
v. Estimate the cost-effectiveness of incentives for weight loss
vi. Using sensitivity analyses, establish the main drivers of cost-effectiveness

6.2.2. Research questions:

1. What is the effectiveness of financial incentives for weight loss?
2. Is there heterogeneity in this effect by age, gender and starting weight?
3. Is it feasible to conduct a full economic evaluation of a financial incentive scheme that complies with the NICE technology appraisal reference case?
4. What are the challenges in modelling the lifetime costs and (dis)benefits of financial incentives for weight loss?
5. Are financial incentives for weight loss cost-effective?

7. Effectiveness of incentives for weight loss

7.1. Introduction

There are several different types of incentive scheme that could be offered to encourage weight loss. Schemes may differ by *inter alia*: the incentive target (e.g. diet change, physical activity, participation in or completion of a weight loss programme or amount of weight loss); the type of incentive (e.g. vouchers versus cash reward; guaranteed versus uncertain rewards; positive versus negative); the level of the incentive provided (i.e. the value of the incentive); the timing of the incentive (e.g. reward received at the end of the scheme or at various points throughout upon reaching milestones); the duration of the incentive (e.g. 6 versus 12 months); who provides it (e.g. employer versus healthcare provider versus private company); and the unit of the intervention (e.g. individual versus group). In addition, it is possible (and arguably preferable) that the incentive - if not offered merely for programme attendance - would be part of an intervention including other active components such as dietary and physical activity advice, lifestyle coaching and other behavioural programmes.

It was decided that the focus of the economic evaluation would be directly on weight loss (outcome) itself rather than indirectly on specific interventions designed to bring about weight loss such as exercising, diet change and calorie control (behaviours). There are arguments for both approaches; incentivising behaviours is appealing as the targets are more controllable and tangible (i.e. individuals will probably have a good idea as to whether they can attend a gym twice a week or eat five pieces of vegetables and fruit every day and receive immediate feedback as to whether they have been successful) but if the ultimate aim is to achieve weight loss it is reasonable to make that the contingent outcome. By specifying weight loss as the outcome of interest the individuals participating have flexibility to choose the ways in which they attempt this (e.g. a mix of diet change and exercise regime).

A systematic review of the literature was conducted to identify studies of incentives for weight loss that could contribute effectiveness values to help parameterise the model. For reasons of practicality, the full review process including data extraction was not conducted by two independent researchers and no review protocol was generated. However, the methods are considered rigorous and transparent enough to argue that the review is systematic; the review clearly specifies search terms, databases, inclusion and exclusion criteria; was based on two independent researchers selecting studies; and had a formal data extraction process and synthesis. Study effects were synthesised in a meta-regression to provide an aggregate measure of incentive effectiveness and this was the main model effectiveness parameter. It is acceptable for decision-analytic models to be populated using aggregate parameter values taken solely from literature reviews.(525) However, analysis of individual-level data can help provide a more in-depth understanding of effectiveness and heterogeneity in effect. For this reason, in addition to the review and meta-analysis, data were sought from a UK study – the Pounds for Pounds (P4P) study - of incentives for weight loss.(131) This study was chosen as it is recent and had a relatively large sample size.

7.2. Methods

7.2.1. Review and meta-analysis

7.2.1.1. Search strategy

Accepted guidance was referred to in undertaking the review.(526) In order to identify studies that could contribute effectiveness values a search of published literature was conducted. The search terms were informed by those used in previous reviews. Broadly, these covered terms relating to incentives and rewards and to diet and weight loss. The full list of search terms are included in Appendix 12.3. MEDLINE, Embase, PsychINFO and EconLit databases and the internet were searched in August 2014. Initially a search was conducted for reviews and subsequent searches sought only to update the most recent systematic review that was identified. In the event, the update searches were limited to studies published in the period from January 2012 to the date of the search since the review by (527) adequately covered studies prior to this.

7.2.1.2. Inclusion and exclusion criteria

Only studies published in English and of human participants were included. Studies where incentives were solely contingent on behaviours such as exercise or diet (e.g. (222, 407)) were excluded from the review as were studies where the incentive was part of a multi-component intervention. Studies that only incorporated negative incentives (e.g. deposit contracts(231)) were also excluded from the review. The rationale for this criterion is was that making a financial commitment may not be an appealing scheme for many and especially those with lower incomes. While a full assessment of the risk of bias was not conducted for each study, the Cochrane Guidelines were referenced to identify any major bias risks that would give reason to exclude studies from the review.(528) The initial study selection was conducted independently by two researchers who met to discuss their selections and reach agreement on which studies to include. If either researcher shortlisted a study then it would be retained in the review process.

7.2.1.3. Review

Titles and abstracts of potentially relevant studies were read and full versions of the publications (whether they were journal articles, books, book chapters, reports, conference abstracts or PhD theses) were obtained if the study could not be excluded. Those included in the review were read and information extracted. Although it is preferable for two people to extract data independently (526) this was not possible in the current study. Extraction data included country, sample size, incentive format and value, study length and format and outcomes including attrition, weight loss (absolute), proportion achieving 5% weight loss and incentives awarded.

7.2.1.4. Meta-analysis

In order to synthesise study data and derive an aggregate measure of effectiveness from the studies a meta-regression was conducted.(529, 530) Meta-regression (sometime referred to as meta-analysis regression), is an extension of meta-analysis allowing the exploration of statistical heterogeneity between study results.(529) Meta-regression was conducted on study-level summary data extracted from the systematic review. In this case, study characteristics were used to predict the effect of interest (weight loss in kgs). To retain a conservative stance, baseline observation carried forward (BOCF) data was input into the model. Hence, studies that did not report this or where it was not calculable, were excluded from the analysis. The variables included as predictors were sample size, mean sample age, proportion of sample being female, mean sample starting weight, duration of study and total possible reward. These were included along with a measure of the effect variance (standard error). Due to either an absence or inconsistency in reporting across studies, it was not possible to create a usable variable to denote socioeconomic status.

As targeting of weight loss was considered to be an important determinant of actual weight loss, another variable was generated from study information. A variable denoting the amount of incentive/reward paid for 5% loss of baseline bodyweight; this provides an equalised incentive benchmark across studies. All rewards were translated into current (2014) UK pound sterling to allow comparison using a purchasing power parity converter.(531) Despite this, it is likely that the studies differed in some aspects, for example in the payment schedule or advice given to participants at study inception. For this reason, a random effects meta-regression was imposed as this allows for residual heterogeneity in the true effect.

The significance of meta-regression models and covariates were reported. The relationship between weight loss and significant covariates were presented individually on bubble plots. The bubble plot is a graph showing the fitted regression line between dependent and (one) covariate variable. Studies are represented as ‘bubbles’, the size of which indicates the precision of effect – the larger bubbles indicate greater precision or smaller within-study variance.

7.2.2. Data analysis

7.2.2.1. Data

For the economic evaluation, data were available from the Pounds for Pounds (P4P) before and after study which involved a financial incentive scheme from a commercial provider (WeightWins).(532) The P4P study took place in England and was a collaboration between the local Primary Care Trusts in the area of NHS Eastern and Coastal Kent and the scheme provider. WeightWins is an online company that offers incentive schemes to individuals who wish to lose weight. A number of schemes are available to choose from where the incentive amount is linked to the targeted weight loss over different time periods.

The P4P scheme was offered from January 2009 to March 2010 on a local NHS website to staff and the general public who applied online if they were interested in participating. The P4P scheme plans ranged from 15 lb (6.8 kg) weight loss over 3 months to 50 lb (22.7 kg) weight loss over 7 months and included an optional maintenance period extending the plan length to a maximum of 13 months. A P4P algorithm was used to calculate the reward based on weight loss and plan length and ranged from £70 to £425 per year. Participants were credited monthly for cumulative weight loss (with a ceiling of 3.2 kg monthly weight loss rewarded) and for maintenance. The accrued rewards were paid to the participants along with a 50% bonus if they had reached their final target weight at the end of the plan. There were no other intervention components other than the provision of written information on weight loss. To confirm outcomes, participants were weighed at baseline and monthly across the local area at a number of GP practices, pharmacies, gyms and weight loss clubs.

While not a randomised or controlled trial, the study was protocol driven and run by an established academic unit. Full details of the study are described in the evaluation paper.(131) Data available from the study were limited with final variables comprising age, gender, initial weight and height, month of last weigh-in, last weigh-in weight and reward received. Unfortunately, data were not available on the socio-economic class of the participant, their income, the payment schedule or target weight loss selected. Data were also not available on the length of scheme chosen although this can be assumed by the last weigh-in month. Despite these limitations the data was still valuable in estimating the association between incentive and effect and between duration, starting weight and weight loss.

7.2.2.2. Analysis

Descriptive analyses were performed followed by correlation analysis. Mean estimates of weight loss and incentive reward achieved were calculated for the whole group and by the following sub-groups: age groups (<65, >65), gender, initial BMI group (<25, ≥25 and <30, ≥30 and <35, ≥35 and <40, ≥40) and follow-up month. Proportions of people losing 5% and 10% of their starting weight were calculated, the former being a threshold of minimum clinically significant change in weight.(533) Linear regression analyses were employed to predict weight loss and reward with predictor variables including age, gender, start BMI and length of scheme. In addition, squared predictors were explored in the models.

7.3. Results

7.3.1. Literature review

7.3.1.1. Search results

The results of the literature searches are included in the PRISMA diagram (534) in Figure 16. The search for reviews identified 10 relevant studies. Recent reviews – only one as yet published - of incentives for behaviour change excluded weight loss studies on the basis that weight loss is a process measure and chose to include only behaviour change (e.g. diet and physical activity).(82, 83) General reviews of incentives for behaviour change have been conducted by Kane (135), Jochelson (118) and Sutherland (119) while Paul-Ebhohihem and Avenell (121), Goodman and Anise (535), Jeffery et al (124), Wall et al (136), Cawley and Price (536), Burns et al (537) and Paloyo et al (527) conducted independent reviews of diet and weight loss. The Wall et al review included four studies but only two of these (one of which included an additional follow-up analysis) included an incentive while the others included food price reductions or food coupons. The paper by Jeffrey et al is a narrative review covering several of the author's earlier studies on incentives for weight loss, some dating back 30 years. Using an inclusion criteria of randomised controlled trials of incentives for obesity treatments with at least a one year follow-up, Paul-Ebhohihem and Avenell reviewed nine studies. Again, many of these studies may be considered dated with all but one of the studies being 20 years old (the most recent being 1998). A discussion paper by Cawley and Price (536) provides a useful summary table of previous incentive studies in weight loss. They present a summary table of 14 incentive studies dating from 1972 to 2008.

The Paloyo et al study was the most recent systematic review of incentives in weight loss. As their searches were conducted in 2012 (month not reported) the update searches were conducted including studies published from January 2012 onwards. The full list of 32 studies appearing in the review papers are included in Table 30. The updated searches identified 114 de-duplicated abstracts for independent screening review. A majority of shortlisted studies were identified by both reviewers but a small number were only identified by one. If either reviewer shortlisted a study the full paper was retrieved for closer scrutiny. In total, the papers of 15 studies from the review update and 32 studies identified by the meta-review were obtained and 9 of these were deemed to meet the inclusion criteria. Those shortlisted from the updated searches are included in Table 31.

Figure 16: Flow diagram showing literature search results

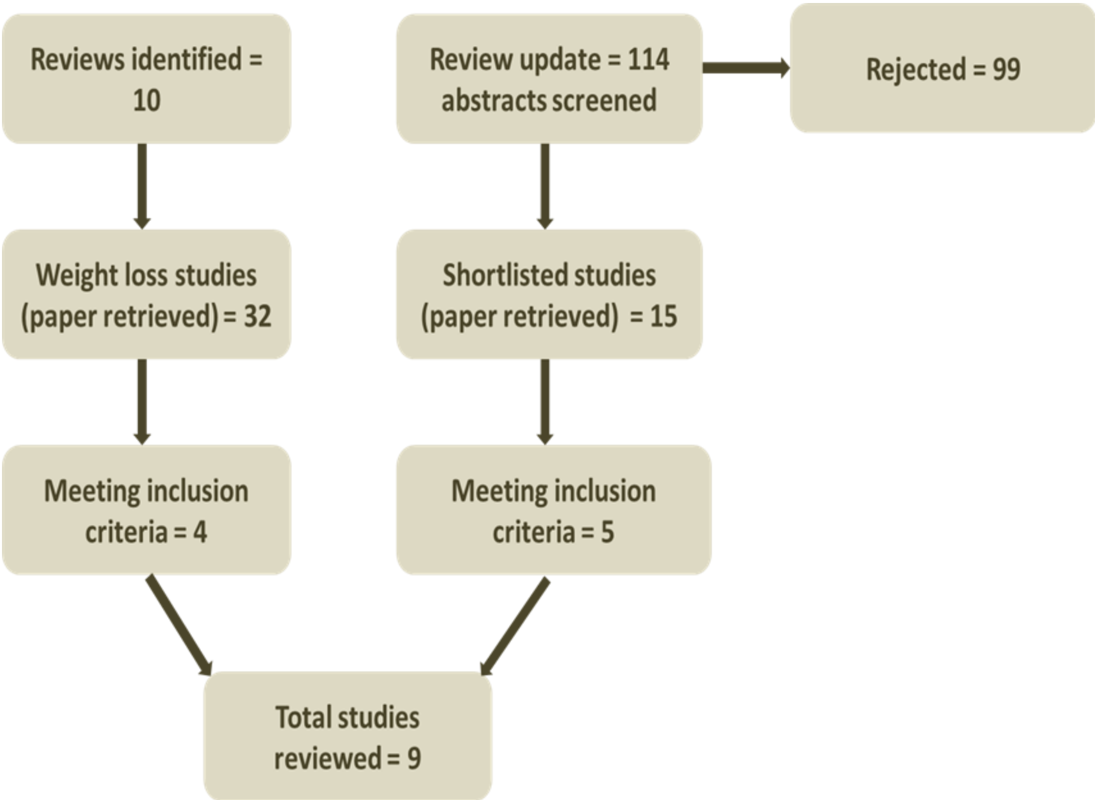


Table 30: Studies identified from the reviews

Study	Country	Include/Exclude	Reason for exclusion
Abrahms and Allen (1974)(538)	US	Exclude	Deposit contract
Anderson et al (2001)(539)	US	Exclude	Incentive contingent on healthier diet
Black and Friesen (1983)(540)	US	Exclude	Deposit contract
Burger and Lynham (2008)(541)	UK	Exclude	Secondary data analysis
Butsch et al (2007)(542)	US	Exclude	Combined intervention (EatRight programme)

Cameron et al (1990)(543)	Canada	Exclude	Deposit contract
Coates et al (1982)(544)	US	Exclude	Adolescents and deposit contract
Englberger (1999)(545)	Tonga	Exclude	Incentive for programme participation
Finkelstein et al (2007)(546)	US	Include	N/A
Follick et al (1984)(547)	US	Exclude	Incentive for programme adherence
Harris and Bruner (1971)(548)	US	Exclude	Deposit contract
Hennrikus and Jeffery (1996)(549)	US	Exclude	Incentive for programme participation
Hubbert et al (2003)(550)	US	Exclude	Combined intervention (EatRight programme)
Jeffery et al (1978)(551)	US	Exclude	Deposit contract
Jeffery et al (1983)(552)	US	Exclude	Deposit contract
Jeffery et al (1984)(553)	US	Exclude	Deposit contract
Jeffrey et al (1990)(554)	US	Exclude	Deposit contract
Jeffrey et al (1993)(555)	US	Exclude	Deposit contract (payroll deduction)
Jeffrey et al (1993)(556)	US	Exclude	Combined intervention (standard behavioural therapy)
Jeffrey and French (1999)(557)	US	Exclude	Incentive contingent on programme participation

John et al (2011) (231)	US	Exclude	Deposit contract
Kramer et al (1986)(558)	US	Exclude	Deposit contract
Lowe et al (2004)(559)	US	Exclude	Target population are children
Luley et al 2010(560)	Germany	Include	N/A
Mahoney (1974)(561)	US	Exclude	Deposit contract
Mann (1972)(562)	US	Exclude	Deposit contract
Mavis and Stoffelmayr (1994)(563)	US	Exclude	Deposit contract
Relton et al (2011) (131)	UK	Include	N/A
Saccone and Israel (1978)(564)	US	Exclude	Combined intervention (programme on behaviour and diet)
Volpp et al (2008)(114)	US	Include	N/A
Wing et al (1981)(565)	US	Exclude	Deposit contract

Table 31: Studies shortlised from the review update

Study	Country	Include/Exclude	Reason for exclusion
Augurzky et al (2012)(566)	Germany	Include	N/A
Bramwell and Cresswell (2013)(567)	UK	Exclude	Vouchers were for weight loss class (not financial incentive)
Burns et al (2012)(537)	US	Exclude	Review only
Cawley and Price (2013)(568)	US	Include	N/A
Crane et al (2012)(407)	US	Exclude	Combined interventions
Driver et al (2013)(569) [Abstract only]	US	Include	N/A
Faghri and Li (2014)(570)	US	Include	N/A
John et al (2012)(571)	US	Exclude	Deposit contract
Kullgren et al (2013)(163)	US	Include	N/A
Kullgren et al (2012)(232)	US	Exclude	Abstract reporting (572)
Kullgren et al (2013)(163)	US	Exclude	Abstract reporting (572)
Mayor (2013)(573)	N/A	Exclude	Editorial referring to Kullgren et al (2013) (163)
Moller et al (2012)(408)	US	Exclude	Combined interventions

Leahey et al (2012)(574)	US	Exclude	Does not include a financial incentive
Spring et al (2012)(222)	US	Exclude	Combined interventions

7.3.1.2. Study review

Nine studies (five identified from previous reviews and four identified in the updated searches) were reviewed (see Table 32). All but three of these were based in the US and five ((114, 163, 566, 569, 570)) could be considered to be randomised controlled trials. Several trials had only modest sample sizes with five having fewer than 150 participants, often split between several trial arms. Follow-up ranged from four to 12 months with a few having explicit weight loss maintenance periods.(131) Most studies insisted on frequent weigh-ins to confirm weight rather than relying on self-reported weight thus reducing the risk of bias.(575) A number of incentive scheme formats were used including threshold weight loss (566), group rewards (163), lotteries (114) and sharing of un-won rewards (569). However, a majority incorporated an incentive reward per unit (or %) of weight loss (up to a maximum level) and money rather than voucher-based rewards.

Although there was a wide range in study attrition rates, in most cases incentive groups were more likely to complete the study. Levels of programme completion were on average 59% in the study control groups and 75% in the incentive groups. Several studies offered incentives for weigh-ins which minimised drop-out. Most studies report intention to treat analysis (as well as complete case) analysis although some define this as ‘last observation’ (LO) rather than ‘baseline observation’ (BO) carried forward (CF) (which may be the same thing depending on the frequency of follow-up). It is the LOCF and BOCF that are of most interest here as they represent a conservative estimate of effect.

Most studies appeared to report a weight loss effect in favour of incentives over control although the Finkelstein et al study is an exception (and Cawley et al for control vs. Continuous payment). Despite the heterogeneity in study designs there broadly appears to be some consistency in effect. At 4 months Augurzky et al report weight loss (greater than control) of -1.88kgs and -2.36kgs for 150 and 300 Euro incentives while Faghri and Li report this figure at the same time-point to be -2.11kgs. At 3 months Finkelstein reports weight loss of -1.36kg and -2.22kgs for different incentive levels. At 12 months, a number of studies suggest weight loss is around 4kgs.(131, 163, 569).

In a few studies, where present, deposit contracts appear to out-perform standard positive incentives (568, 570) although this was not universally the case.(114) In studies with a maintenance or follow-up period, weight appears to be partially regained over time (114, 163, 546) although, again, there were exceptions.(570) Only three of the studies reported analyses by subgroup and two of these found no differences in weight loss according to these. However, Augurzky et al found that those with lower education lost more weight than those with higher education.

Table 32: Studies including financial incentives for weight loss

Study	Country	N	Study design	Duration	Assessment	Incentive payment and schedule	Results
Augurzky et al (2012)(566)	Germany	700	RCT A. Control vs. B. €150 incentive vs. C. €300 incentive	4 months	Weigh-in at pharmacy (€25 received)	Incentive for achieving individual weight loss targets (set by Dr at 6-8% body weight). When 50% target reached rewarded proportionally to the maximum reward and full reward paid if target met.	**Participation** Probability of completion by males/females were: 0.679/0.632, 0.722/0.743, 0.822/0.880 from groups A, B, C, respectively. **Weight loss** Mean absolute unadjusted change in BMI for A, B, C: -0.879, -1.802, -1.957 (All P<001). Significantly more weight loss in B and C vs. A. There was only a small effect between groups B and C (although significant for females). Using ITT (BOCF):- Difference vs. A in % change in body weight (SE) for B and C for all: -1.712 (0.385), -2.096 (0.459); for males: -1.724 (0.445), -1.670 (0.547); for females: -1.744 (0.845), -3.078 (0.872). Difference vs. A in BMI (SE) for B and C for all: -0.628 (0.142), -0.788 (0.170); for males: -0.640 (0.171), -0.655 (0.210); for females: -0.560 (0.290), -1.078 (0.310). Difference vs. A in realising target weight (SE) for B and C for all: 0.117 (0.034), 0.193 (0.038); for males: 0.151 (0.044), 0.186 (0.048); for females: 0.027 (0.061), 0.232 (0.064).

							Compared to high education (university degree) difference in % body weight change was -1.180 (0.674) for very low, -1.388 (0.621) for low, -1.295 (0.640) for medium (all significantly different). Age was not significant and income was not collected. **Rewards** Mean rewards were €62 and €150 for groups B and C hence a 1% reduction of weight costs €26 and €60 for these groups, respectively.
Cawley and Price (2013)(568)	US	2,635	Evaluation of worksite wellness programme with self-selection that included diet/activity information and: A. Control vs. B. Continuous payment vs. C. Deposit Contract + Lump Sum vs.	12 months	Weigh-ins at work at least quarterly	Group A received no incentive except $20 for 12 month participation. For group B quarterly rewards paid according to % weight loss. The reward is $1 per month per % lost but increases after 7% loss. Group C must pay $9.95 per month (except the first) which ($109.45) is refunded if they lose ≥5% of baseline weight at 12 months and $100 bonus if ≥10%. There is also a lottery where weight losers can win gift certificates, and the	**Participation** Attrition at 12 months was significantly higher in Group B than the other groups: 54.9% dropped out by the end of the first quarter and 75.8% compared to approximately 25% by first quarter and 48-58% by the end of the year in the other groups. The working paper reports 12 month attrition to be 76.4% and 48.1% in group B and A. **Weight loss** Both BOCF and LOCF analysis conducted. No significant difference in weight between Control and group B at one year (beta = -0.141). The deposit contract groups did have significantly greater weight loss than control at one year (for BOCF analysis). Weight loss (lbs) coefficients were 2.082 and 1.944 for groups C and D. The working paper reports (BOCF) weight loss in lbs (% body weight loss) to be -1.4 (0.64%) and -1.7 (0.87%) for groups B and A.

			D. Deposit Contract + Continuous Repayment			'biggest loser' receives a $250 gift voucher at 12 months. Group D must pay $9.95 per month (except the first). Rewards paid quarterly from 1% of baseline weight lost and increase to 20% of baseline weight lost. They could join a team competition in which each member of the highest 'losing' team received $50.	Team competition led to greater weight loss. Age and gender were not significant predictors of weight loss but starting weight was. No information on income/education group provided. **Rewards** the average reward paid per pound-year of weight loss amounted to $2.10 in group B and $1.66 in group D.
Driver and Hensrud (2013)(569) [Abstract only]	US	100	RCT A. Education vs. B. Education + incentive vs. C. Education + Behavioural plan D. Education + Behaviour plan + incentive	12 months	Monthly weigh-in	Weight loss goal of 4 lbs per month (adjusted based on their previous month's weight). Successful received $20 per month and unsuccessful paid $20 into bonus pool which was awarded via lottery among participants who completed the study.	**Participation** Difference in completion rates for combined the incentive vs. non-incentive groups was significant (62% vs. 26%, p<0.001) **Weight loss** Assuming BOCF, 12 month weight loss was 9.08 lbs (4.12 kgs) and 2.34 lbs (1.06 kgs) for the combined incentive groups and non-incentive group, respectively. Estimated effect of incentives was 6.5 lbs (2.95 kgs) (ANOVA;SE 1.92, p<0.001). **Rewards** Not reported
Faghri and Li (2014)(570)	US	99	Worksite RCT A. Control	4 month + 3 month follow-up	Weigh-in	Participants were encouraged to lose 1 or 1.5 pounds per week. Group B were paid $10	**Participation**

			B. Incentive C. Incentive + Deposit contract			per 1.0 pound of weight loss for the overweight and $10 per 1.5 pounds for the obese. A possible total of $160 + additional $100 if maintained for further 3 months. Group C could deposit $1 to $5 per pound matched by study. Depositing $5 and losing 16 pounds would return $160 incentive + $80 deposit + matched deposit ($320). Rewards were paid at the end of the program.	Study was completed by 79.2%, 76.2% and 63.3% in groups A, B and C. No differences according to participant characteristics. **Weight loss** LOCF regression difference in weight loss (lbs) at 4 months was –4.65 (-2.11kgs) (-8.35, -0.96) (p=0.028) for B, –7.01 (-10.16, 3.88)(p=0.006) for C and –5.63 (-9.44, -1.81)(p=0.018) for combined incentives. LOCF regression difference in weight loss (lbs) at 7 months was –4.78 (-2.17 kgs) (-9.19, -0.36) (p=0.041) for B, –6.74 (3.06 kgs) (-10.69, -2.79) (p=0.012) for C and –5.58 (2.53 kgs)(-10.48, 1.34) (p=0.032) for combined incentives. Patient characteristics (age, sex, education, race, initial weight) not included in analyses. **Rewards** Not reported
Finkelstein et al (2007)(546)	US	207	Pilot worksite randomised trial. Three reward amounts per % weight loss: A. $7 steady vs.	3 and 6 months	Weigh-ins at 3 and 6 months. Each paying $5	Payment per % weight loss (up to 10%) and a maximum reward of $140 over 6 months. Group A received payment at 3 and 6 months, Group B only at 3 months (front-loaded), Group C only at 6 months (back-loaded)	**Participation** Attrition at 3 months was 24% in A, 13% in B and 36% in C At 6 months these figures were: 31%, 45% and 54%. Group A were 3 and 2 times more likely to attend 6 month weigh in than C and B, respectively. Odds of attending weigh-in for groups A and B were 2.00, 4.30 (p<0.05) more than C. **Weight Loss**

			B. $14 at 3 months vs. C. $14 at 6 months				BOCF assumed for non-attenders**.** Weight loss at 3 months for A and B was -0.87 lbs (-0.395 kgs) and -2.73 lbs (-1.23 kgs) (p<0.05) more than for C who lost 2 lbs (-0.907 kgs) while those in B lost (0.86 kg) more than group A (P=0.05) who lost 3 lbs (1.36 kg). Weight loss at 6 months for A and B was -0.28 lbs (-0.127 kgs) and 0.29 lbs (0.131 kgs). Odds of losing ≥5% of weight for A and B were 2.23, 5.39 (p<0.05) more than C. Age and gender were not significant predictors of weight loss at 3 months and only one age category was significant at 6 months. No information was provided by education or income. There were significant differences by employer (university of community college with the latter losing more weight) but it's not clear this reflects an income or education affect. Non-whites were 3.33 and 4.29 more likely to attend 3 and 6 month weigh-in than whites although this did not translate to significantly greater weight loss. **Rewards** Mean payout of $35 per participant in group B.
Kullgren et al (2013)(163)	US	105	RCT A. Control vs. B. Individual $100 per month vs.	9 months	Monthly weigh-in with $20 paid per month + $50 each for 6 and 9 month.	All participants given goal of losing 0.4kg per week and notified of their earnings (or potential earnings) after weigh-ins. Payment was sent every month if monthly target was met.	**Participation** Weigh-ins were 91% and 88% at 6 and 9 months. Drop-out was minimal due to weigh-in incentives. **Weight loss** Analyses used multiple imputation rather than LOCF or BOCF. Mean weight loss (kgs) at 24 weeks: 0.5, 1.7, 4.8 and at 36

			C. Group $500 incentive per month			Future weight loss goals adjusted if participants failed to achieve them in order that overall target of 10.8 kg loss was achieved. For group C the $500 was split among successful group members. Primary outcome was weight loss at 6 months and secondary outcome weight loss at 9 months (3 month after incentives).	weeks: 0.4, 0.8, 3.4. The group incentive led to weight loss around 3.2 kg more than individual incentives for the same cost. Group C lost significantly more weight than A or B at week 24 and 36. No difference between A and B. Respective % of participants achieving weight loss goals were: 34%, 54%, 76% at week 4; 6%, 20%, 47% at week 12 and 0%, 3%, 9% at week 24. Sub-group analyses not reported. **Rewards** Mean total earnings were $514.70 (SD, $522.60) [£308.27 ± £313.01] and $128.60 (SD, $165.50) [£77.01 ± £99.13] for Group vs. Individual incentive groups.
Luley et al 2010(560)	Germany	142	Randomised study of family intervention + diet (-500 calories/day) + A. Enhanced diet B. Incentive C. Telemonitoring of weight	6 months	Self-weighing and control weigh-in at 6 months	Reward for parents was 5 Euros for every kg of weight loss. Children were also paid an incentive.	**Participation** 66% completed without the incentive, 91% completed with the incentive. **Weight loss** At 6 months mean weight loss for completing parents was −6.9 kgs (± 6.2) and LOCF −6.3kgs ± 6.2 ($p<0.01$ for both) vs. -3.4 and -2.8 without the incentive. Sub-group analyses not reported. **Rewards** Not reported.
Relton et al (2011)(131)	UK	405	Self-selected sample.	13 months	Monthly weigh-in	Incentive plans ranged from 15 lb (6.8 kg) weight loss over	**Participation**

			Before and after evaluation A. Incentive + booklet of weight loss tips			3 months to 50 lb (22.7 kg) weight loss over 7 months and a max. 13 months. Optional weight 'maintenance' periods were also available. Rewards were accrued on a monthly basis and ranged from £70 to £425 per year. Accumulated rewards received at plan end, plus a bonus of 50% of the total maximum reward if final target reached.	Plan lengths ranged from 3 to 13 months (mean: 11.6). At 12 months 101 participants were active on the programme, 53 completed a plan, 248 failed to complete a plan. Mean number of months actively weighing in = 6.4. **Weight loss** Mean (CIs) weight loss (kgs) was: 6.4 (5.7, 7.2). 180/402, 44.8% (40.0%, 49.7%) lost ≥5% of weight; 95/402, 23.6% (20.0%, 28.0%) lost ≥10%. No significant association found between weight loss and age, sex, deprivation, baseline BMI or target weight loss. Mean weight loss at 12 months for active, inactive (plan completed) and inactive (no plan completion) were: 11.5 (9.7, 13.3), 8.7 (5.6, 11.8), 1.6 (21.0, 4.1) and losing ≥5% of weight 78.2%, 75.0%, 31.6%, respectively. Assuming BOCF mean weight loss at 12 months was 4.0 kg (95% CI: 2.4–5.6 kg). 38% completed a plan. **Rewards** Not reported.
Volpp (2008) (114)	US	57	RCT A. Control vs. B. Lottery incentive vs. C. Deposit contract.	4 months and 7 month follow-up	Monthly weigh-ins paying $20	Weight loss goal of 1 lb (0.45 kg) a week Group B eligible for a daily lottery prize with an expected value of $3/d. Lottery included infrequent large (a 1-100 chance of $100) and frequent	**Participation** All but 1 in 2 incentive groups completed the study **Weight loss** Primary analysis ITT (BOCF). Mean (SD) weight loss at 16 weeks: 3.9 lbs (9.1)[1.77 kgs ±4.13], 14.0 lbs (10.2) [6.35 kgs ± 4.63], 13.1 lbs (12.6) [5.94 kgs ±5.72]. Groups B and C lost significantly more than A and significantly higher proportions of

						small (a 1-5 chance of $10) payoffs. Group C contributed $0.01-$3.00/d refunded at month end if target met. Deposit was matched and supplemented by $3/d. Max reward was $252 per month. All participants in B and C who lost more than 20 lb (9.07 kgs) received $50 bonus.	B and C met 16 lb (10.5%, 47.4%, 52.6%) and 20 lb (5.3%, 36.8%, 26.3%) weight loss targets. All groups gained weight between 4 and 7 months. Between group weight loss not significant at 7 months (9.2 lb [4.17 kgs] for B; 6.2 lb [2.81 kgs] for C vs. 4.4 lb [2.0 kgs] for A), but within groups losses were for incentive groups: (lbs)(t= −2.87, P = .01; 95% CI, −15.89 to −2.47 for B; t=−2.41; P=.03; 95% CI, −11.67 to −0.81 for C) but not for Control: (t=−1.97; P=.06, 95% CI, −9.19 to 0.29). No differences were observed by age, income or starting BMI although white participants lost significantly more than black participants. **Rewards** Mean rewards earned were $378.49 (£226.70) and $272.80 (£163.39) for Deposit and Lottery groups, respectively.

7.3.1.3. Meta-analysis

The meta-regression allowed the analysis of 15 estimates of effect with some studies offering more than one estimate, for example, from different trial arms or time-points. Few of the covariates were significant predictors of effect. The exceptions were starting weight and incentive per 5% body weight loss. The results for the univariate analyses and combined model are included in Figure 17 A-C. Results suggest for every kg heavier an individual is at baseline, they will lose 0.071kgs during the incentive scheme. In line with what might have been expected, there was a statistically significant relationship between incentive offered and weight lost. Results suggest that for every £1 higher the incentive is for losing 5% of bodyweight, 0.015kgs of additional weight is lost during the incentive scheme. So incentive amounts of £100, £200 and £300 per 5% body weight lost would lead to an average weight loss of 1.5kgs, 3kgs and 4.5kgs, respectively.

Squared terms were used alongside the incentive variable as we might expect the influence to decrease in relation to incentive size. However, this was not shown to be significant.

Figure 17: Meta-regression results

A

	Number of obs	=	15
REML estimate of between-study variance	**tau2**	=	0.557
% residual variation due to heterogeneity	**I-squared_res**	=	64.83%
Proportion of between-study variance explained	**Adj R-squared**	=	52.22%
With Knapp-Hartung modification			

Weight_loss_kg	**Coefficient**	**SE**	**t**	**P>t**	**L 95% CI**	**U 95% CI**
Start_weight_kg	-0.0710805	0.026494	-2.68	0.019	-0.12832	-0.01384
Constant	5.872195	2.629464	2.23	0.044	0.191585	11.55281

B

	Number of obs	=	15
REML estimate of between-study variance	**tau2**	=	0.3941
% residual variation due to heterogeneity	**I-squared_res**	=	83.16%
Proportion of between-study variance explained	**Adj R-squared**	=	66.20%
With Knapp-Hartung modification			

Weight_loss_kg	**Coefficient**	**SE**	**t**	**P>t**	**L 95% CI**	**U 95% CI**
Incentive_5_loss	-0.0145492	0.004087	-3.56	0.003	-0.02338	-0.00572
Constant	0.1290338	0.40628	0.32	0.756	-0.74868	1.006749

C

	Number of obs	=	15
REML estimate of between-study variance	**tau2**	=	0.3812
% residual variation due to heterogeneity	**I-squared_res**	=	67.31%
Proportion of between-study variance explained	**Adj R-squared**	=	67.30%
Joint test for all covariates	**Model F(2,12)**	=	6.51
With Knapp-Hartung modification	**Prob > F**	=	0.0122

Weight_loss_kg	**Coefficient**	**SE**	**t**	**P>t**	**L 95% CI**	**U 95% CI**
Start_weight_kg	-0.0268692	0.033595	-0.8	0.439	-0.10007	0.046328
Incentive_5_loss	-0.0111557	0.005947	-1.88	0.085	-0.02411	0.001802
Constant	2.49852	2.983556	0.84	0.419	-4.00209	8.99913

Figure 18 shows the plotted meta-regression line between starting weight and weight loss indicating a reasonably strong negative relationship; the more overweight an individual is at baseline, the more weight they will lose in the study. Figure 19 shows the relationship between the level of financial incentive offered for the loss of 5% of baseline weight and actual weight loss. There is a suggestion of a linear trend with higher incentives leading to greater weight loss. The size of the bubbles indicates low precision in the effect estimates however, except for a number of studies where minimal weight loss was witnessed.

Figure 18: Bubble plot for weight loss and starting weight

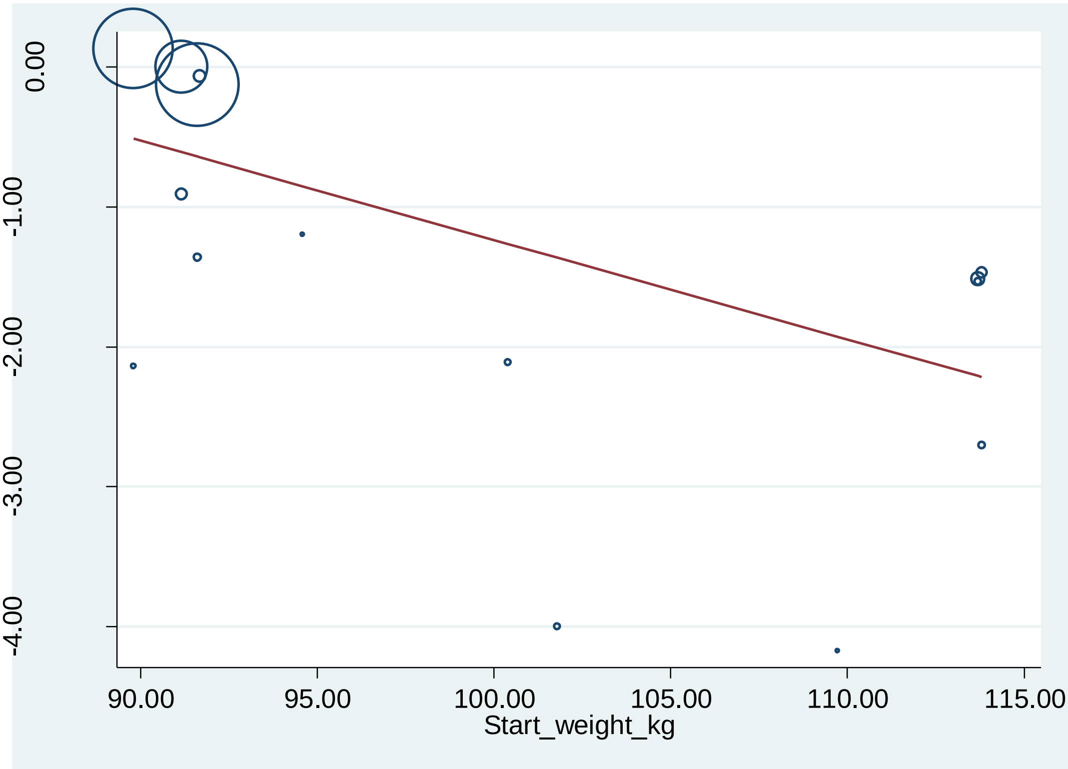
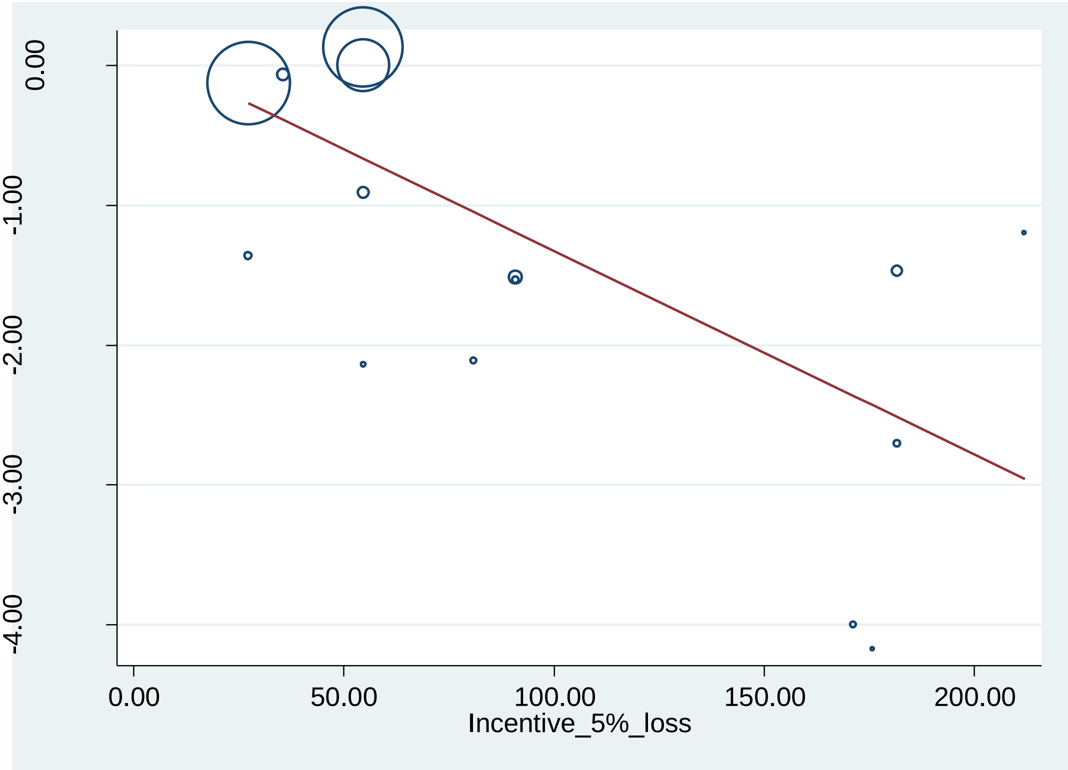


Figure 19: Bubble plot for weight loss and incentive (£) for 5% weight loss



7.3.2. Data analysis

The sample characteristics and outcomes are included in Table 33 while descriptives for weight loss by subgroup are included in Table 34. A majority of the sample were female and the sample age ranged from 17 to 82 years. The descriptives appear to suggest that males lose more weight but less body mass than females (BMI data not shown). Weight loss and reduction in BMI appear to be positively related with starting weight, starting BMI and length of programme. There was a correlation of r=0.70 between both change in weight and change in BMI and reward earned. 72.04% of the sample lost 5% of their weight and 47.63% lost 10% of their weight.

Table 33: Data sample characteristics

Gender	Male (%)	Female (%)				
	360 (27.3%)	960 (72.7%)				
	Mean	**SD**	**Min**	**Max**	**Median**	**IQR**
Age (years)	42.98	11.48	17.00	82.00	43.00	16.00
Weight at start (kgs)	99.45	20.31	63.78	216.82	96.08	27.60
BMI at start	34.80	5.91	23.99	66.98	33.72	8.08
Month last weigh-in	6.11	5.71	0.00	24.00	4.00	10.00
Weight loss by last weigh-in (kgs)	5.68	7.85	-35.74	48.08	3.63	8.62
Change in BMI by last weigh-in	1.98	2.73	-14.50	17.66	1.30	3.07
Reward earned	£64.02	£178.34	£0.00	£2,139.52	£0.00	£32.60

Table 34: Weight loss (kgs) by subgroup

	N	Mean	SD	Min	Max
Gender					
Female	960	5.08	7.39	-35.74	48.08
Male	360	7.28	8.77	-15.20	47.63
Age groups					
<37	404	6.30	8.81	-35.74	48.08
≥37 and <46	373	5.01	7.47	-15.20	47.63
≥46 and <54	283	5.00	7.30	-13.64	45.81
≥54	260	6.42	7.23	-7.91	37.19
BMI group at start					
<25	4	6.24	2.17	3.18	8.16
≥25 and <30	292	4.53	4.85	-4.80	22.41
≥30 and <35	484	4.72	6.31	-35.74	29.03
≥35 and <40	297	6.62	8.45	-10.43	41.00
≥40	243	7.83	11.47	-15.20	48.08
Month last weigh-in					
1-3 months	598	2.91	4.36	-7.91	38.10
4-6 months	224	5.31	6.07	-5.90	34.97
7-11 months	201	6.60	7.51	-13.64	31.30
12 months	119	9.92	9.24	-35.74	38.56
13-24 months	178	11.57	12.40	-15.20	48.08

Table 35 includes univariate regression results predicting weight loss (kgs). Age was not a significant predictor of weight loss however some significant differences were observed when age groups were compared. The higher the start weight and the longer the programme, the higher was weight loss and reward earned. The subsequent table indicates that the relationship between incentive and weight loss may not be linear as the squared-incentive term is significant: higher incentives lead to greater weight loss but at a lower rate with every £ increase. Table 37 shows the results of the multivariate regression predicting weight loss with most predictors being significant although gender is now not. The T values for this analysis are unusually large and this can only partially be explained by the large sample size. When a random sample of 400 is chosen for the analysis the T values corresponding to Table 37, drop to 17.20 for reward, 3.96 for starting weight and 1.02 for last weigh-in. However, the chief reason for the high values is likely to be a degree of collinearity between some of the dependent and independent variables and, particularly, that reward was to some extent dependent on weight loss.

Table 35: Univariate analyses

	Gender	Age	Start weight	Last weigh-in	Reward Earned
Weight loss kg					
N	1320	1304	1320	1318	1320
Coefficient	2.202	-0.004	0.074	0.577	0.026
t value	4.57	-0.21	7.11	16.76	28.21
Probability	0.000	0.836	0.000	0.000	0.000

Table 36: Weight loss with squared reward

			N	1320
			Prob > F	0.000
			Adj R-squared	0.4052
			Root MSE	6.0531
Weight loss kg	**Coef.**	**P>t**	**[95% Conf.**	**Interval]**
Reward Earned	0.0389	0.00	0.035	0.042
Reward Earned^2	-0.000012	0.00	0.000	0.000
Constant	3.5200	0.00	3.159	3.881

Table 37: Multivariate analyses predicting weight loss

N	1318
F	141.49
Prob>F	0.000
Adj R-squared	0.4305

Change in Weight (kgs)	**Coef.**	**Std. Err.**	**t**	**P>t**	**Lower CI**	**Upper CI**
Male	0.191	0.401	0.480	0.635	-0.597	0.978
Age group (vs. <37)						
≥37 and <46	-1.232	0.428	-2.880	0.004	-2.072	-0.392
≥46 and <54	-1.228	0.463	-2.650	0.008	-2.136	-0.319
≥54	-0.414	0.477	-0.870	0.386	-1.349	0.522
Start weight	0.053	0.009	6.020	0.000	0.036	0.071
Last weigh-in	0.251	0.032	7.810	0.000	0.188	0.314
Reward earned	0.023	0.001	22.460	0.000	0.021	0.024
Constant	-2.003	0.905	-2.210	0.027	-3.778	-0.229

7.4. Discussion

The aim of this research was to identify incentive weight loss effectiveness parameters for the decision-model. This was achieved with a review of the literature to identify relevant studies. Additional information was gleaned from analysis of a weight loss study dataset. The trial data analysis was somewhat limited by the small number of variables that were available. Data on incentives (as opposed to rewards – what is offered as opposed to what is received based on weight loss success), plans, plan length, attrition and socio-economic status were unavailable. In addition, there was likely a degree of collinearity between dependent and independent variable from the WeightWins data. However, these data were still useful, particularly as it permitted a closer look at whether this relationship was linear. Due to the nature of the trial data, the meta-analysis is considered the key measure of incentive efficacy.

The review aim was to identify studies that could provide the main effectiveness information for the economic model. The review included only studies incorporating positive incentives targeted at weight loss (rather than behaviours that might bring about weight loss such as diet change and exercise). There is an absence of research to suggest either is better than the other. A majority of studies identified by the review were what might be termed negative incentives (i.e. deposit or commitment contracts). It is unclear why this is the case but may relate to a perception that this approach might be more financially sustainable and fairer. While there is some evidence that – due to loss aversion – deposit contracts may be more effective, there is the counter argument that carrots are preferred to sticks.(172) Studies targeting negative incentives solely were excluded from detailed review and synthesis. While these schemes may be cheaper they may be unacceptable to lower income groups which is the target population and primary rationale for employing incentives. In any case, the decision model will briefly explore their cost-effectiveness in a sensitivity analysis.

Only a handful of studies were found to meet the inclusion criteria. These generally had small sample sizes and heterogeneous incentive schemes. Most studies included a control arm however several incentivised the weigh-in required which may have changed the participant’s behaviour and leads the author to question whether these are actually ‘control’ arms. Since the effects of interest were usually reported as weight loss compared to control, reported effects may be an underestimate. Confidence in the results of the review and meta-analysis is slightly attenuated by the fact that non-randomised studies were included. The self-selection of participants for a particular trial arm may mean the effectiveness estimates for the arms are biased. For example, those who are particularly likely to be motivated by a certain incentive scheme and self-select into that arm may produce higher levels of effect than may have been witnessed had randomisation occurred. While non-randomised studies can provide useful, pragmatic effectiveness data – especially if schemes are to be offered to participants in a similar manner in the real world – they may have introduced additional bias here when pooled with data from randomised studies. That said, only two of the nine studies did not conduct randomisation so the overall effect is likely to be minimal. Most studies also presented a last-observation or baseline-observation carried forward approach to deal with drop-outs. This is a conservative stance but it is unclear whether the assumption that drop-out = return to baseline weight is valid.

Perhaps the most impressive study was from Augurzky and colleagues. It was a randomised trial with control arm and two levels of incentives, had a large sample and monitored weigh-ins. It is also the only study in the review that had more than one trial arm using the same incentive format (but different incentive levels). The other studies used the study arms to test the effect of different incentive and payment methods. Thus the Augurzky et al study provided information on the effect of incentive pricing (which was positive but not linear). The study authors were approached for their data but were unable to share this due to a data embargo. In the reviewed studies there appeared to be an element of consistency of effect with 3 month weight loss being around 2kgs and 12 month weight loss around 4kgs.

One of the justifications for incentive use is that they may help tackle health inequalities by convincing hard to reach populations with low incomes to participate and attempt lifestyle change. The assumption is that the marginal utility of incentives will be higher for low income groups and thus be more motivating. However, the review found few studies had explicitly evaluated effectiveness by income or socio-economic group and education. Only the study from Augursky and colleagues found an effect that corroborates this hypothesis. The remaining studies either did not consider such sub-group analyses or found no effect.

The meta-regression indicated that there was a positive relationship between incentive offered and weight lost. The squared term was not significant suggesting the relationship may be linear (although the opposite was found in the trial analysis). Results suggested that a £200 incentive for the loss of 5% of bodyweight is required to bring about an average weight loss of 3kgs. The analysis also suggests that, while other covariates were not important, it is necessary to control for starting weight in incentive schemes. This information will be valuable in modelling the cost-effectiveness of incentives.

8. Developing a decision-analytic model to evaluate incentives

Chapter 6 outlined the rationale for conducting an economic evaluation of financial incentives in weight loss, presented the aims, objectives and research questions. Chapter 7 examined the effectiveness of incentives for weight loss with a focus on positive incentives for weight reduction. This chapter reports the viewpoint adopted and methods employed in the economic evaluation. It reports the development of the decision-analytic model - which is to be the evaluation tool - including the rationale for the model structure, the identification of parameter values and the proposed sensitivity analyses. A form of model was developed by the author in previous research and is adapted for use here.(576)

Decision analysis is an explicit, quantitative, and systematic approach to decision making under conditions of uncertainty (577) and is used to aid decision making in a number of fields including health, business, law and engineering.(578) It is a framework that allows the identification, representation and disaggregation of important components of a decision. Decision analysis models in health are an analytical approach allowing an economic evaluation of (at least two) alternative courses of action (i.e. treatments or services) in the face of uncertainty. The decision model is created to reflect the healthcare process, capturing the events that occur to the patient or health system during care and estimating the expected costs and (dis)benefits of the treatment options. They are powerful tools as they can combine information from many sources (e.g. several clinical trials) and quantify uncertainty which may emanate from the variance in observed estimates of effect or from simulated or extrapolated aspects of the modelling process. The decision model presented here sought to be structured and explained in such a way to achieve transparency and, should it be required, reproducibility. Published best practice was followed in the development of the decision model (579, 580) and more generally in terms of the economic evaluation conduct (581, 582) and reporting.(583)

8.1. Methods

8.1.1. Target interventions

The target interventions for the economic evaluation are described below.

8.1.1.1. Financial incentives

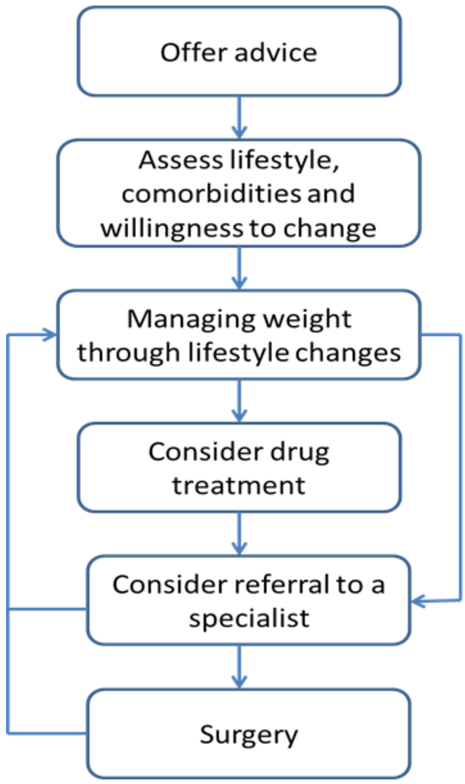
As stated in the Introduction to the economic evaluation chapters, the focus was placed on establishing the cost-effectiveness of *positive* financial incentives for achieving weight loss. Positive incentives include guaranteed or lottery incentives whereas negative incentives, such as commitment or deposit contracts, involve the threat of financial ‘punishment’ or loss of money should failure occur. While the former is the focus for the main analyses, subsequent analyses compare these results with those obtained from negative incentives in sensitivity analyses using effectiveness values from selected studies. Although the meta-analysis, and therefore, the synthesised measure of effectiveness, includes one study reporting lottery incentives, a sensitivity analyses will separately consider the cost-effectiveness of schemes with uncertain rewards.

The payment schedule for the incentives was that every month participants would receive the incentive amount (£10, £20 and £30 were tested) for every 1% of their baseline weight they lost in that month. This is typical of the studies in the meta-analysis. There were no rewards offered for a proportion of baseline weight percentage lost and this was assumed not to affect performance in subsequent months. The incentive scheme considered here is assumed to have a duration of six months since the average duration of studies included in the meta-regression was 5.4 months. It is also assumed to reward weight loss (rather than maintenance). Subsequent analyses explored the cost-effectiveness of a reward per kg lost approach.

8.1.1.2. Usual care

For the purpose of the analysis it is necessary to specify an intervention representing the service that overweight or obese patients presenting at primary care might reasonably (or typically) expect to receive; defined as ‘usual’ or ‘standard’ care. There is great variation in weight management service provision in England and many different services are currently available. In the NHS, obese and overweight patients are initially managed in primary care with NICE guidance encouraging a focus on long term lifestyle changes in physical activity and diet.(584) The clinical recommendations available to GPs for managing this group is set out in the NICE pathway illustrated below.

Figure 20: NICE Pathway for managing obese adults



(http://pathways.nice.org.uk/pathways/obesity/obesity-overview)

Currently, drug treatments and surgery are only considered after lifestyle and behavioural interventions have been tried, evaluated and proved unsuccessful. In attempting to manage weight through lifestyle changes the clinician may at first provide information but also may refer the patient on to self-help, commercial or community weight loss programmes if the programmes meet certain criteria. However, in a majority of cases, the service offered by GPs amounts to printed information about dietary and activity lifestyle changes. This being the case, usual care was defined here as information provision (i.e. verbally or using printed material such as a leaflet) and an absence of an ‘active’ component. This definition of usual care is commonly used in weight loss intervention trials (585, 586) and economic evaluations.(587, 588)

8.1.2. Population, perspective and time horizon

The population of interest were people in England who were either overweight or obese - hence individuals with a body mass index (BMI) of 25 or greater. The individuals may have comorbidities (e.g. type II diabetes mellitus) and have received weight loss services in the past. The P4P study data was used to generate the proportions of male, females, age-groups and starting BMI groups of the cohort at the start of the model. Although it may have been possible to base these proportions on a national database or large observational study, it was assumed that, as participants in the P4P study had signed up to be involved, then they might more closely reflect the typical group of people who might agree to be involved in future incentive schemes. The P4P sample size was relatively large so the sample characteristics should be a reasonably robust representation of the population of interest. However, it is acknowledged that, since starting weight (and BMI) will influence the effectiveness of incentives, the particular measure of cost-effectiveness derived in this study may be specific to this population. While beyond the scope of the research conducted here, future efforts should run the analyses using alternative base samples. The age of the cohort at model start is 47 (as this was the average in meta-analysed studies). The analysis assumes that all individuals are healthy at model entry.

The primary analysis adopted the perspective of the NHS and Personal Social Services (PSS) as recommended by the NICE technology appraisal guidance.(326) As such only costs incurred by the health and social care sector are considered. A secondary analysis was conducted from an employer's perspective since they may be the other likely provider of such schemes and new Public Health England emphasises the role of employers in encouraging healthier lifestyles in staff. As successful weight loss may impact on the ability of the participant to undertake paid employment there may be productivity benefits of incentive schemes for employers. This analysis was effectively a cost-benefit analysis where employers weigh up the costs of the scheme vs. cost(productivity) savings. A third analysis adopted the wider, combined perspective which included the costs to the health and social care provider and employers.

The primary analysis considered costs and effects of the interventions over a lifetime horizon but cost-effectiveness at 12 months is also reported.

8.1.3. Analysis

A decision model was developed to facilitate the economic evaluation. A cohort Markov modelling approach was chosen since the health process being modelled must incorporate recursive events (ruling out a decision tree) and because the costs and benefits of weight loss occur over a long period of time.(589) A recent review of decision models employed in evaluations of weight loss interventions revealed that the Markov model is the most commonly applied type of model.(590) While patient or micro simulation approaches offer certain benefits over Markov models, they are often more computationally intensive and less easily interpreted.

The Markov process (named after Andrey Markov) is a mathematical system where entities exist in mutually exclusive 'states' and move between these states according to prescribed 'transition probabilities'.(591) The Markov process is 'memoryless' and therefore the transitions are independent of the previous location of the modelled entities in the 'state space'. In the current application the modelled process is that of weight loss (or gain) and the associated impact on obesity-related illnesses while the health 'states' (described below) are degrees of obesity and the related diseases (e.g. stroke). Entities (in this case, members of a cohort of overweight or obese individuals) transit between the health states at the end of fixed temporal 'cycles'. In the current model, costs and effects were estimated for participants in annual cycles from 12 months over a lifetime horizon. The analysis adopted NICE reference case methods presenting a cost-utility analysis with the main outcome being incremental cost per quality-adjusted life year (QALY).(326) In addition to the main cost-utility analyses, cost-effectiveness analyses are also presented where the effect of interest is cost-per kg of weight lost and cost per 5% of body weight lost. The latter is generally considered to be the minimum weight loss at an individual level to be clinically meaningful.(533) Scenario analyses also explored the optimal pricing of incentives in terms of cost-effectiveness.

Where one intervention is more effective and more costly or less effective and cheaper incremental cost-effectiveness ratios (ICERs) are calculated and presented (581):

$$ICER = \frac{Mean\ Cost_{fi} - Mean\ Cost_{uc}}{Mean\ QALY_{fi} - Mean\ QALY_{uc}}$$

Where *fi* is financial incentive and *uc* is usual care. Interventions with an ICER <£20,000 per QALY gain will generally be considered cost-effective while interventions with ICERs in the range £20,000-£30,000 may be considered cost-effective depending on, among other things, the level of uncertainty surrounding the plausible ICER.(326) Where the ICER is above £30,000 the intervention in question will not normally be considered cost-effective and be deemed an inefficient use of resources unless it fulfils one of a number of other special criteria such as representing an innovative approach, being an ‘end-of-life’ treatment or improves distributive justice (reduces health inequalities).(326)

In line with best practice, extensive one-way, scenario and threshold deterministic sensitivity analyses (DSA) were conducted using alternative parameter values and plausible ranges.(592) Ten thousand (10,000) Monte Carlo simulations parameterising the model from pre-specified parameter distributions enabled a probabilistic sensitivity analysis (PSA). There is a close relationship between incentive amount, effectiveness and costs in incentive studies; however, Cholesky decomposition for joint distributions was not required as the incentive costs were tied to actual weight loss and was perfectly dependent upon it. The simulated ICERs are presented in a cost-effectiveness plane and simulated net monetary benefit (NMB) in a cost effectiveness acceptability curve (CEAC) showing probability of cost-effectiveness.(593, 594)

Incremental NMB was calculated:

$$INMB = (\lambda * \Delta QALYS) - \Delta Costs$$

In line with the NICE reference case, future (beyond 12 months) costs and effects were discounted at 3.5% per annum with alternative rates (1% and 6% for costs and effects) being tested in sensitivity analyses. A half-cycle correction was applied to reflect the fact that, on average, health state transitions will occur at the mid-point of the cycle.(591) All analyses were conducted in Microsoft Excel© (Microsoft Corporation, Redmond, WA, USA).

8.1.3.1. Employer and societal perspectives

There is a precedent for using an employer perspective in analyses of incentives.(127) It is now possible to predict productivity losses based on health-related quality of life but as this requires patient-level EQ-5D responses an alternative method was used here.(595) For each year up to the age of 65 (assumed the average age of retirement), the number of short and long absences from work were predicted based on a published relationship between BMI and absences.(596) As BMI increases, the number of absences increases per year. Short absences were defined as an absence between 1-7 days and long absences defined as 10 or more days off sick. Here these were assumed to be 4 and 10, respectively but were allowed to vary in the PSA. This was assumed to capture the loss of productivity relating to obesity only, thus a further analysis estimated the number of days lost to myocardial infarction (MI) and stroke for those who did and did not return to work. Loss of productivity due to death was assumed to be captured in the rates of those experiencing and MI or stroke but not returning to work. The overall total productivity loss was the sum of these two products. The human capital approach was taken to cost sickness absence where the number of days absent is multiplied by the average daily wage (in this case £121.77).(581) The total days available for work took into account annual leave (assumed 25 days) and bank holidays (assumed 8 days); however compassionate leave was not accounted for and all sick days were assumed not to occur on annual leave days.

The human capital approach has been criticised for generating unrealistically high valuations of productivity loss.(597) For this reason, a sensitivity analysis was conducted that applied the 'friction' costing method as an alternative.(598) This approach to costing productivity loss assumes that loss only occurs during a 'friction period' which is the time needed for a company to replace the employee who is absent from work due to sickness. Beyond this time period, the employee is presumed to have been replaced and productivity returned to normal. Given this, the friction method tends to yield smaller estimates of productivity loss than the human capital approach.(599, 600) The method also requires information on when the friction period occurs and assumes a production 'elasticity'. The latter denotes the hypothesised phenomenon that the loss of productivity is not proportionate to the reduction in human capital input. For example, when an employee is absent, productivity is not reduced fully as colleagues cover the work or the employee catches up with work on return. Although there appears little technical justification for this, an elasticity figure of 0.8 is often employed.(598) In addition to this, the cost of hiring and training the replacement employee should be incorporated. The productivity losses calculated using the friction method use the same data as that used in the human capital approach except absence is limited to the friction period (68.6 days) after which the staff member is replaced and a recruitment and training cost incurred (£6,125) and losses limited by the elasticity factor (0.8). Macroeconomic effects are not considered here given this is not a population-level analysis.

These costs were added to those of the health and social care system costs to generate the total costs from a wider perspective in a supplementary analysis. Participant costs were assumed to be none or minimal since these would amount to the 10 minutes required for weigh-in. Since this could be done at local pharmacies or place of work it was assumed there was no travel required. The parameter values for these analyses are listed separately in Table 39.

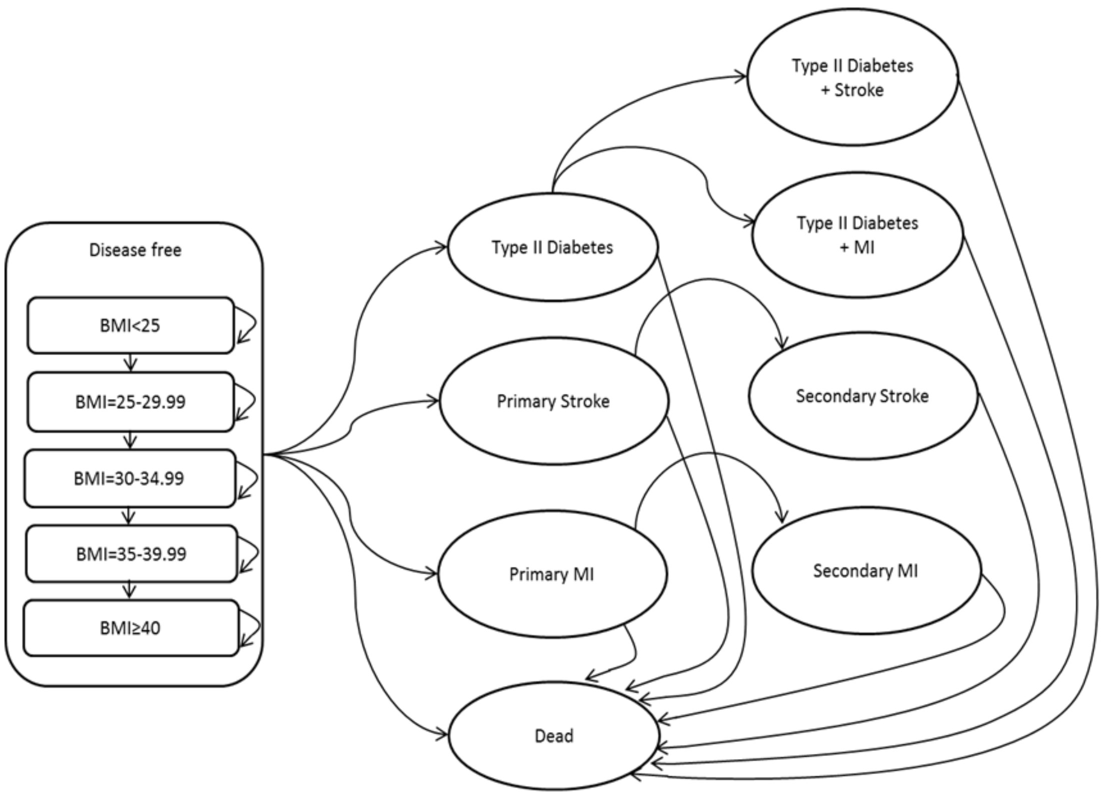
8.1.4. Model structure

In developing a decision model it is important to strike a balance between having sufficient complexity such that real-world processes and behaviours are accurately reflected and achieving simplicity such that errors and computational and data requirements are minimised and the model is transparent and readily interpretable. These considerations were borne in mind in deciding which and how many health states to include.

The health risks of obesity are well established with studies showing associated heightened risks of type II diabetes (601), myocardial infarction (602), stroke (603), and a number of cancers (604). Accompanying the significant human cost in terms of obesity-related morbidity and mortality is the financial burden borne by the NHS. The direct NHS costs for type II diabetes alone for 2010/11 was estimated to be £8.8bn.(14) A recent analysis predicted that the annual costs of treating obesity-related diseases would increase by £648 million per year by 2020 and £2 billion by 2030.(13) Thus a decision model capturing the full costs and benefits of financial incentives for weight loss necessarily incorporated not only the costs of the intervention but also the potential cost savings and quality of life benefits associated with averting obesity-related diseases.

The model design and structure was informed by consulting experts in the field of weight loss, by published studies and a published systematic review of economic evaluations of weight loss interventions.(590) The health states chosen for the model were accepted categories of BMI and the three most commonly employed obesity-related diseases employed in previous modelling studies.(590) Model health states and the possible transitions are shown in Figure 21. A cohort of modelled overweight and obese individuals move between BMI groups (‘normal’ - <25; ‘Overweight’ - 25-29.9; ‘Moderately obese’ - 30-34.9; ‘Severely obese’ - 35-39.9; ‘Very severely obese’ - ≥40) based on intervention efficacy (and as a result of kgs lost). Up to 6 months, weight loss is based on the synthesised results of trials and beyond this time-point, assumptions are made about maintenance and weight loss/gain trajectories for the rest of the cohort's life. Members of the cohort transit to diseased states of type II diabetes, stroke, MI and death (the latter either directly or via a diseased health state). The probability of transiting increases with higher category BMI group membership reflecting the higher risks associated with increased levels of obesity. Transition probabilities were introduced to reflect the fact that those with type II diabetes have an increased likelihood of experiencing a stroke and MI and that those who have experienced a stroke or MI are more likely to experience a secondary event. The Markovian assumption of memory-free transitions was relaxed to accommodate the fact that the QoL and cost impact of stroke and MI differ over time. A year 1 'tunnel' state (not included in the figure) was added for these diseases which cohort members occupy for the first year subsequent to the negative health event, after which they transit automatically to 'year 2+' health states. The diseased health states are absorbing in the sense that cohort members cannot move from these back to the healthy states and only exit if they die.

Figure 21: Model structure



8.1.5. Model parameter values

The model parameter values were identified using targeted searches of the relevant published literature. The search strategies employed are included in Appendix 12.4. Priority was given to the most recent data and data from UK studies. Large epidemiological studies were targeted to provide relevant risk values. The final parameter values are included in Table 38.

Acknowledging the fact that the financial and health impact of a stroke and MI are more severe immediately after the event, costs and utility decrements associated with these are higher in year one (the tunnel health state) post event than subsequent years. The risk of secondary events is also higher in year one than subsequent years.

8.1.5.1. Weight change and intervention effectiveness

The main efficacy parameter value (and variance) for the study is weight loss in kilograms. This value for the incentive arm was derived from the meta-regression coefficients for starting weight and incentive amount as follows (although here the beta for weight loss has been multiplied by 5 to give the incentive offered per 1% loss – rather than 5%):

$$\widehat{WL} = 2.5 - 0.056I - 0.027W$$

Where $\widehat{WL}$ is weight loss, 2.5 is the constant, I is monthly incentive level per % loss and W is the starting weight. Thus, *ceteris paribus*, 0.056kgs of weight is lost for every £1 of incentive offered. This being the case we assume here that the usual care cohort do not experience weight loss over the study period. This assumption of zero weight loss is considered conservative as it is likely that those not receiving an active intervention will gain weight over time. An alternative model predicting usual care weight loss was also tested.

In the period beyond 6 months a number of assumptions were made as very little long term outcome data is available for incentive schemes. The primary assumption is that after 6 months, both incentive and usual care cohorts gain weight at the same rate. Alternative assumptions are tested in the sensitivity analyses such as the incentive group regaining all weight lost by 24 months.

8.1.5.2. Transition probabilities

Annual risks of health events were based on recent epidemiological studies. The stroke risk for example was taken from a study reporting on the Norfolk cohort of European Prospective Investigation of Cancer (EPIC Norfolk) which included 20,040 men and women and a follow-up of 11 years. Risks ranged from 0.0022 to 0.0283 for type II diabetes for those with a BMI of 25-29.9 and >40, respectively. The equivalent risk ranges for stroke and MI were: 0.0027 to 0.0029 and 0.010 to 0.016, respectively.

The transition probabilities for obesity-related diseases were fixed over time and did not increase with age. However, this was mediated by the fact that a natural weight gain was assumed and this would have indirectly increased the risk of obesity-related diseases. They were also assumed to be the same for males and females. The annual mortality transition rates were taken from the English Office for National Statistics data on annual death rates. The mortality rates relating to type II diabetes were also based on these data but with a published multiplier applied to reflect the greater risk of death for those with type II diabetes.

Additional probabilities were specified for the employer analyses where one of the effects of interest was absences from work.

8.1.5.3. Costs

Costs for the financial incentive intervention were taken from the literature and with additional estimates made by the author.(605) These included a fixed set up cost per participant and then incentive cost which was solely dependent on weight loss. For the latter, a range of incentive amounts that had been employed in previous studies were explored in the model. The magnitude of the costs depended on the proportion of individuals achieving the weight loss goals and receiving the financial payment. There are no studies that report set-up, administration and running costs for a weight loss incentive scheme. However a cost (£22 per participant in 2011) has been reported for administrating a commercial weight loss programme (605) and this was included in the model with a supplement assumed to be £10 per participant. The £10 supplement, which equates to approximately 20 minutes of a grade 5 (without qualification) general practice nurse time, was estimated by the author to cover the additional time required to arrange the financial aspects of the incentive scheme including the transfer of rewards to a bank account or purchasing and distribution of vouchers. In addition it was assumed that a cost would be incurred in the assessment of effect (weigh-ins) which is proposed to be done in community pharmacies. This approach avoids the potential of bias if participants self-report. The cost is assumed to be 10 minutes of a qualified community pharmacist's time to weigh the participant and record the weight. No equipment costs were included (it was assumed, for example, that weighing scales were already present).

The diseased-state costs were garnered from the literature and updated to current prices (year 2013) where necessary using a healthcare specific online inflation index.(531) It was assumed that both incentive and usual care interventions were associated with an initial visit to the GP where referral (or information provision) would occur. However, as this was present in both arms and not considered part of the intervention per se, it was not costed in the analyses. It was assumed that usual care incurred no cost as only leaflet printing was required and excluding this (albeit minimal cost) maintains a conservative analysis stance. It was also assumed that there was no cost associated with individuals who were overweight or obese but who had not experienced a secondary illness.

8.1.5.4. Utility values

Utility is the metric employed to quality-adjust survival in economic evaluations. Typically, utility values range from 1 which denotes 'full health' through zero which denotes dead to negative infinity where negative values represent health states considered worse than death.(606, 607) Utility values were based on UK studies presenting recent, relevant data based on the EQ-5D (three-level) measure (608) and scored using the UK time-trade-off tariff.(609) Separate analyses of Health Survey for England data provided utility values both for the BMI groups (610) and for the diseased states.(611)

It was assumed that as individuals transit to a diseased state the utility decrements associated with their BMI category are lost and the disutility of their health state was assumed to be captured by the disease utility decrement. In addition, it was assumed that utility decrements were additive (612) (i.e. they were incurred independently); thus the health state representing those who experienced type II diabetes and a stroke would have the full utility decrements for diabetes and stroke.

Table 38: Model parameter values

Parameter	**Mean point estimate**	**PSA Distribution**	**Source**
Efficacy for 5% weight loss target			
	-0.056kg per £1	Normal	Meta-regression
Annual change >6 months	+0.429 (Kgs)	Normal	(587)
Usual Care			
6 Months	0	Normal	Conservative assumption
Annual change >6 months	+0.429 (Kgs)	Normal	(587)
Annual transition probabilities			
Age-related mortality	N/A	Normal	ONS Life Table
Type II Diabetes			
<25	0.0006	Beta	(613)
25-29.9	0.0022	Beta	(613)
30-34.9	0.0041	Beta	(613)
35-39.9	0.0158	Beta	(613)
≥40	0.0283	Beta	(613)
Mortality	Age-specific mortality *1.36	Normal	(15)
Stroke			
<25	0.0024	Beta	(614)
25-29.9	0.0027	Beta	(614)
30-34.9	0.0029	Beta	(614)
35-39.9	0.0029	Beta	(614)
≥40	0.0029	Beta	(614)
Secondary stroke Year 1	0.1110	Beta	(615)
Secondary stroke ≥Year 2	0.0360	Beta	(615)

Mortality Year 1	0.28	Beta	(614)
Mortality ≥Year 2	0.14	Beta	(614)/2
Myocardial Infarction			
<25	0.007	Beta	(616)
25-29.9	0.010	Beta	(616)
30-34.9	0.011	Beta	(616)
35-39.9	0.016	Beta	(616)
≥40	0.016	Beta	(616)
Secondary MI Year 1	0.0406	Beta	(617)
Secondary MI ≥Year 2	0.0203	Beta	(617)/2
Mortality Year 1	0.392	Beta	(618)
Mortality ≥Year 2	0.196	Beta	(618)/2
Type II Diabetes + stroke	0.009	Beta	(15)
Type II Diabetes + MI	0.0155	Beta	(619)
Costs			
Incentive scheme set-up and running	£33.28	N/A	(605)+£10
Cost of weighing-in	£71.64	N/A	Assume 10 minutes x 6 of qualified community pharmacy time
Total cost	£107.03	Fixed	
Cost of incentives	Dependent on weight loss	N/A	
Usual Care	£0	Gamma	Conservative assumption
Type II Diabetes	£2,765.17	Gamma	(14)
Stroke Year 1	£11,968.89	Gamma	(620)
Stroke ≥Year 2	£1,643	Gamma	(620)
MI Year 1	£5,895.42	Gamma	(621)
MI ≥Year 2	£260.82	Gamma	(621)

Utility			
Age-related norms	Not presented	Beta	(610)
BMI-related decrements			
<25	0	Beta	(610)
25-29.9	-0.006	Beta	(610)
30-34.9	-0.033	Beta	(610)
35-39.9	-0.033	Beta	(610)
≥40	-0.117	Beta	(610)
Type II Diabetes	-0.096	Beta	(611)
Stroke Year 1	-0.16	Beta	(611)
Stroke ≥Year 2	-.080	Beta	(611)/2
MI Year 1	-0.139	Beta	(611)
MI ≥Year 2	-.070	Beta	(611)/2

Table 39: Additional parameters for the employer perspective analysis

Parameter	Mean point estimate	PSA Distribution	Source
Short absences per year by BMI			
<25	0	Fixed	(596)
25-29.9	1	Gamma	(596)
30-34.9	1.18	Gamma	(596)
35-39.9	1.30	Gamma	(596)
≥40	1.30	Gamma	(596)
Long absences per year by BMI			
<25	0	Fixed	(596)
25-29.9	1	Gamma	(596)
30-34.9	1.34	Gamma	(596)
35-39.9	1.71	Gamma	(596)
≥40	1.71	Gamma	(596)
Absence length (days)			
Short	4	Gamma	(596)
Long	10	Gamma	(596)
Daily wage	£121.77	Fixed	(622)
Probability return to work post MI	0.83	Beta	(623)
Time to return to work post MI (days)	103.6	Gamma	(623)
Probability return to work post Stroke	0.44	Beta	(624)
Time to return to work post Stroke (days)	75.5	Gamma	(625)
Friction cost of employee replacement	£6,125	Fixed	(626)
Friction period (days)	68.6	Fixed	(626)
Production elasticity	0.80	Fixed	(598)

8.1.6. Uncertainty

Variability in the model was accounted for by conducting the PSA and taking the central estimate of the Monte Carlo simulations as the main estimate of cost-effectiveness.(580) As recommended in best practice guides, parameter uncertainty was assessed using the PSA where all parameters are varied simultaneously.(592) Structural uncertainty is that which relates to the structure of the model and the assumptions upon which it is built. One method to combat this it to derive alternative models based on different structural assumptions and average the outputs of these.(627) However, this was not practicable in the current research. These assumptions were tested in deterministic one-way and multi-way (scenario) sensitivity analyses (Table 40).

Table 40: Values for deterministic sensitivity analyses

Parameter	**Alternative values**	**Source**
Efficacy	£10 incentive = -3.91kgs £20 incentive = -4.29kgs	P4P analyses with squared incentive term
FI	All weight lost regained by year 2	
	All weight lost regained by year 3	
UC		
3 Months	-2 (kgs)	Conservative assumption
6 Months	-2 (kgs)	Conservative assumption
Weight change >12 months (both groups)		
Age 45-54	0.245	Health Survey for England data
Age 55-64	-0.135	
Age 65-74	-0.160	
Age 75+	-0.459	

Probability of Type II Diabetes		All(628)
<25	0.004	
25-29.9	0.008	
30-34.9	0.016	
35-39.9	0.024	
≥40	0.024	
Probability of Stroke		
<25	0.0010	(629)
25-29.9	0.0011	(603)
30-34.9	0.0013	(603)
35-39.9	0.0013	(603)
≥40	0.0013	(603)
Stroke mortality		
Year 1	0.2090	(630)
Year 2+	0.10	(630)/2
Probability of MI		
<25	0.007	(616)
25-29.9	0.0084	(602)
30-34.9	0.0098	(602)
35-39.9	0.0098	(602)
≥40	0.0098	(602)
MI Mortality		
Year 1	0.16	Base case analysis/2
Year 2+	0.08	
2nd Stroke		
Year 1	0.0555	Base case analysis/2
Year 2+	0.0180	

2nd MI		
Year 1	0.0656	Base case analysis/2
Year 2+	0.0102	
Type II Diabetes + stroke	0.00	(631)
Type II Diabetes + MI	0.01	(632)
25% reduction in cost of diseases		
Type II Diabetes	£2,073.88	Conservative assumption
Stroke Year 1	£8,976.67	
Stroke Year 2+	£1,232.08	
MI Year 1	£4,421.57	
MI Year 2+	£195.62	
25% Reduction in disease-related utility decrements		Conservative assumption
Type II Diabetes	0.072	
Stroke Year 1	0.120	
MI	0.104	

8.1.7. Model evaluation

The face and content validity of the model was checked by holding a number of discussions with experts in the field of weight loss and found to be acceptable. The internal validity of the model was tested by varying model inputs, by inputting extreme values and observing whether or not these produced intuitive and sensible changes in the model outputs.(633) We might expect, for example, that increasing the weight loss (effectiveness) of an intervention to result in lower aggregate expected levels of secondary illnesses (such as type II diabetes) or that increasing the probability of secondary illnesses would reduce the ICER for whichever intervention yielded the greatest weight loss. Internal validation also involved checking that increases in weight produced increases in lifetime risks of type II diabetes, stroke and MI that were in line with published risk estimates.

8.2. Conclusion

A decision model was developed to enable an economic evaluation of financial incentives for weight loss. The model was developed and validated according to best practice and allows estimates of cost-effectiveness, disease-impact and financial burden on the NHS and employers. It will allow the testing of several different incentive formats and pricing levels and capture the levels of uncertainty associated with each analysis. The following chapter reports the results of the model application and cost-effectiveness of incentives for weight loss.

9. Cost-effectiveness of incentives for weight loss

This chapter reports the results from the modelled economic evaluation of financial incentives for weight loss. The model development, parameter values and sensitivity analysis strategy are described in the preceding chapter.

9.1. Weight and secondary disease outcomes

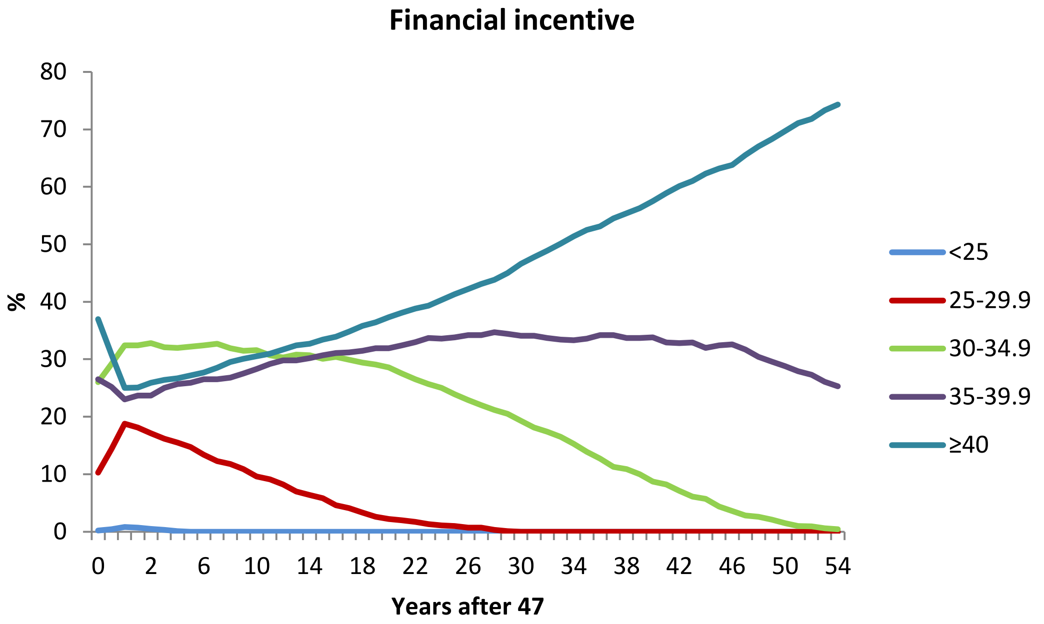
The level of weight loss achieved at six months for different levels of incentive is shown in Table 41. These figures were predicted using the meta-regression model which adjusts for starting weight. Since each month's weight loss was predicted separately with the starting weight updated, the effect is lower proportional predicted weight loss as time passes; this reflects clinical reality where weight loss success tends to taper off over time. The weight loss figures appear sensible and mirror those found in some studies (for example, both Relton et al and Volpp et al reported weight loss of in the order of 4kgs). The base case cost-effectiveness analysis adopted the £10 per month incentive level. At this level, over a quarter of participants lose at least 5% of their initial body weight. According to the model, even offering a small incentive of £5 per percentage point lost leads to nearly two thirds of individuals achieving that milestone (1% loss) at six months. A scenario analysis indicates that only offering above £14.07 per month will ensure that at least 50% of the participants achieve, what is commonly considered to be, a clinically significant cumulative weight loss of 5% of starting weight at six months.

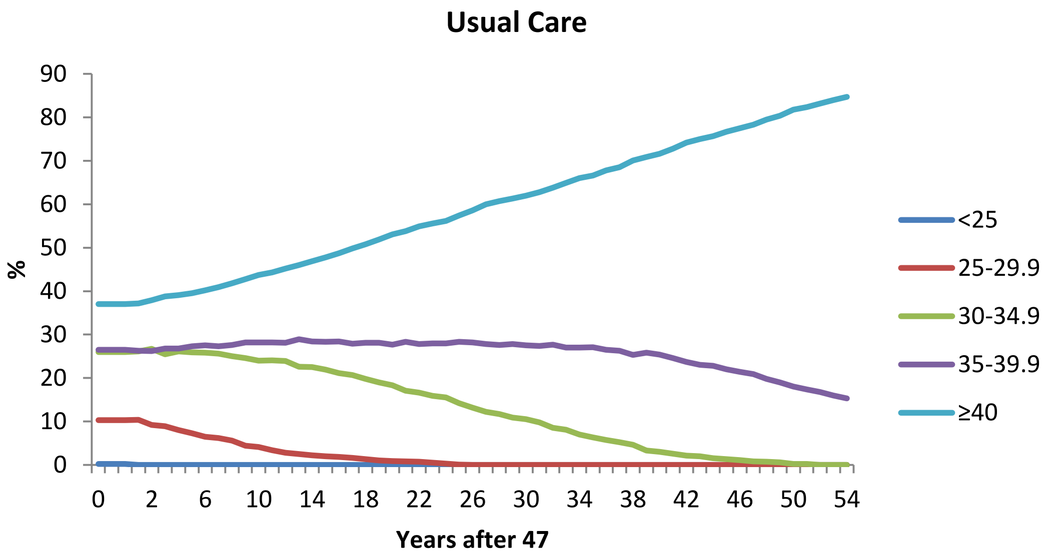
Table 41: Weight loss outcomes at 6 months

Financial Incentive per % weight loss	**Mean weight (kg) loss (SD)**	**Achieving 1% loss at 6 months**	**Achieving 5% loss at 6 months**
£5	-2.49 (3.06)	65.7%	11.9%
£10	-4.06 (3.06)	88.4%	28.7%
£15	-5.62 (3.06)	99.2%	56.3%
£20	-7.19 (3.06)	100%	89.5%
£25	-8.75 (3.06)	100%	100%
£30	-10.32 (3.06)	100%	100%

Figure 22 shows the predicted transitions in body mass index (BMI) over a lifetime (without mortality or transition to diseased health states) following the 6 month intervention offering £10 for every percent of body weight lost. The effect of the financial incentive is evident at the start of the BMI trajectories with a sharp decline in the BMI>40 group numbers and increases in the 25-30 and 30-35 BMI group numbers. After a few years all group proportions start to fall as the assumed natural weight gain pushes people into the BMI>40 group.

Figure 22: BMI Proportions over lifetime





The impact of these BMI shifts in terms of predicted secondary diseases is shown in Table 42 which shows incidence of type II diabetes, stroke and myocardial infarction (MI) over a lifetime for two levels of incentive (£10 and £20 per percent weight lost) and usual care. Both incentive groups lead to lower predicted incidence of disease, longer life expectancy and disease-free life years. The higher incentive level does confer incremental benefits over the lower level however differences between all three groups are small. The £10 and £20 incentives lead to a 1.9% and 4.2% lower risk of type II diabetes respectively than usual care. Reductions in stroke and MI from incentives compared to usual care appear negligible. The model predicted that the £10 and £20 incentives led to around 51 and 128 days of increased life expectancy over usual care.

Table 42: Secondary diseases and life year outcomes

	£10 per % Financial Incentive	**£20 per % Financial Incentive**	**Usual Care**
Lifetime probability of secondary diseases			
Type 2 diabetes	0.345	0.322	0.364
Stroke	0.103	0.101	0.104
MI	0.367	0.361	0.369
Life expectancy	72.90	73.11	72.76
Life years	25.90	26.11	25.76
Disease-free years	20.00	20.63	19.51

9.2. Cost-effectiveness

The estimated cost of obesity-related diseases is included in Table 43. The largest cost savings predicted from incentive use appear to be in type II diabetes which reflects the higher differential in incidence rates highlighted earlier. Table 44 includes the cost-per weight loss outcome. As usual care is assumed to be no cost and lead to no weight change these figures can be considered incremental cost-effectiveness outcomes. If the usual care group were to gain weight these figures would be an underestimation of incentive effect. While the reward earned increases in line with incentive level increase, the cost-effectiveness does not. There appears to be a curvilinear relationship between incentive level and outcome. This is illustrated in Figure 23 which shows cost-per effect falling rapidly with an increase in incentive up to about £10-£20 after which it begins to increase. The almost U-shaped form suggests the optimal incentive level in the current intervention format might be between £10 and £20 per month per percent point of weight reduction. Given this, cost-utility results are presented for both below.

The nature and cause of the U-shaped curve was investigated in further detail. This pattern appeared to be present in both the cost per Kg loss and cost per 5% weight loss analyses. Model diagnostics were conducted to determine what was driving this apparent relationship which involved systematically adjusting effectiveness and risk parameter values of the model and observing the outcome. However, none of these adjustments explained the relationship, which is likely due to the fact that these analyses have a time horizon of 6 months (the end of the incentivised weight loss programme period) and the impact of obesity-related diseases at that juncture would be minimal. The original weight loss model employed was applied every month in the incentive programme for 6 months to estimate monthly weight loss. The start weight in this model was updated every month reflecting the individual's new (lower weight). The effect of this is that the model predicted slightly lower weight loss at each successive month. To investigate whether this had an impact on results, the analyses were run again but with only baseline weight applied to the model. However, the results shown in Figure 23 persist regardless of which start weight is used in the model.

Examination of the Markov trace was more informative in establishing the cause of the cost-effectiveness results and this is clearly shown in Figure 24. This figure plots cost per 5% weight loss along with total costs and proportion of the cohort achieving this milestone. As the incentive per month increases, weight loss increases and a greater proportion of the cohort achieve 5% weight loss at 6 months. At an incentive level of £25 per month 100% the cohort achieve the weight loss milestone and a ceiling in effectiveness is reached. Thus increases in incentive level beyond £25 only increase costs and do not influence the measure of effectiveness and it is this which drives the U-shape curve. Hence beyond £25 incentive, cost-effectiveness drops (cost per 5% loss increases). Thus the phenomenon relates to the ceiling in the measure of effectiveness chosen. A similar analysis is conducted in the cost-utility section to explore whether this relationship exists when the QALY (and net monetary benefit) metrics are employed.

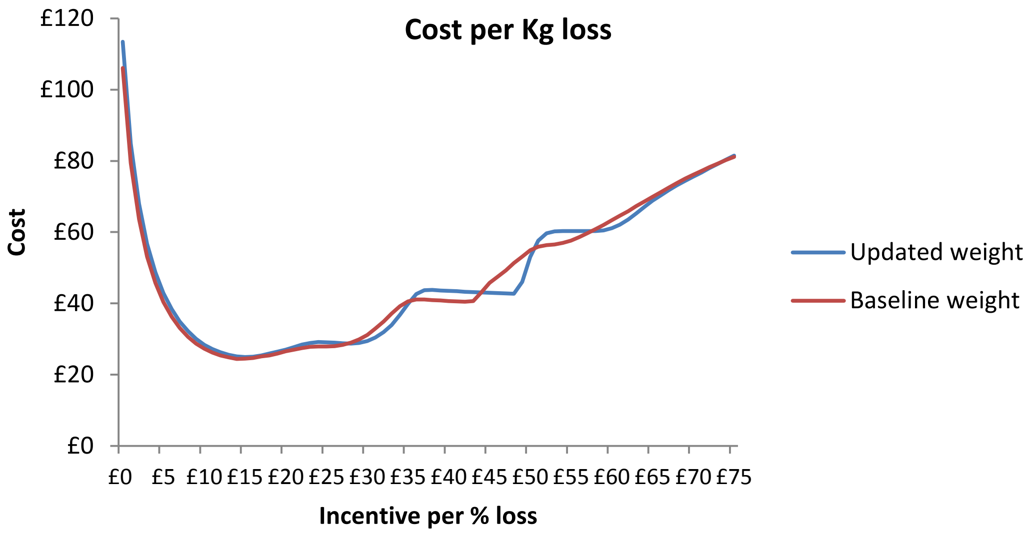
Table 43: Lifetime cost of obesity-related diseases

	£10 per % Financial Incentive	**£20 per % Financial Incentive**	**Usual Care**
Type 2 diabetes	£1,627	£1,497	£1,740
Stroke	£294	£287	£300
MI	£349	£340	£355

Table 44: Cost per weight loss outcome

	£10 per % Financial Incentive	**£20 per % Financial Incentive**	**£30 per % Financial Incentive**
Average reward earned	£10.03	£89.30	£198.12
Cost per kg weight loss	£28.40	£27.07	£29.41
Cost per 5% weight loss	£401.47	£217.34	£303.37

Figure 23: Cost-effectiveness by incentive level



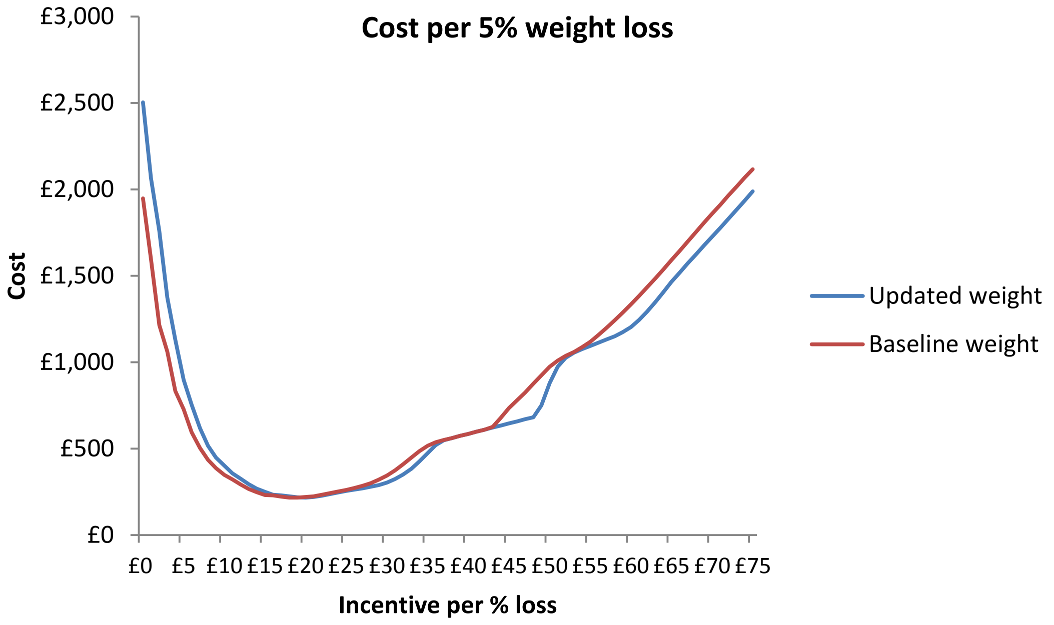
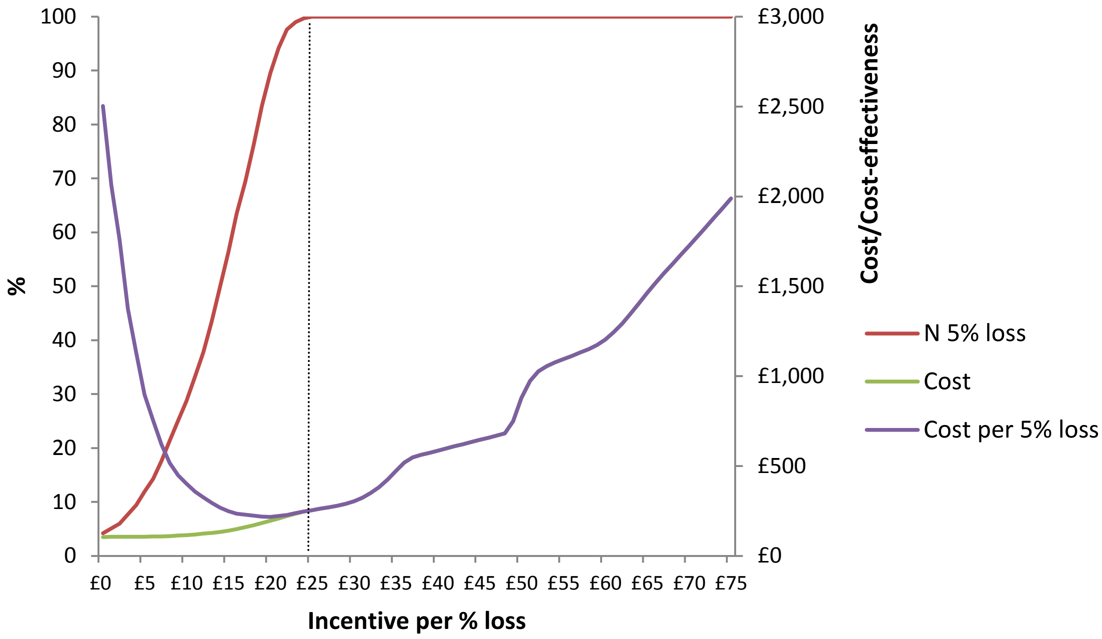


Figure 24: Ceiling in effect



9.3. Cost-utility

The results for the base case cost-utility analyses for a 12 month and lifetime horizon are presented in Table 45. At 12 months, six month incentive interventions offering £10 or £20 per percent weight loss have incremental cost-effectiveness thresholds (ICER) just exceeding the NICE threshold of £20,000 thus would not be considered cost-effective compared to usual care. However, both incentive levels confer incremental QALY benefits over usual care. Over a lifetime horizon, the incentive arms dominate usual care yielding additional health gain and lower costs. Over this period, net present cost savings versus usual care are £467 and £1,057 for the £10 and £20 incentives, respectively. The results for the probabilistic sensitivity analyses (PSA) are included in Table 46. Only results from the PSA of the £10 incentive level are presented. The mean simulated costs and QALYs suggest a 12 month ICER of £23,956, dominance of the (£10) incentive and a net monetary benefit of £3,038 over a lifetime horizon.

Table 45: Cost-utility results – base case scenarios

	Costs	QALYs	ICER
Base case deterministic analysis – 12 months			
Financial incentive – £10 per %	£188.11	0.795	£23,635
Financial incentive – £20 per %	£264.90	0.800	£20,420
Usual Care	£75.15	0.790	
Base case deterministic analysis – Lifetime			
Financial incentive – £10 per %	£10,378	12.30	FI Dominates
Financial incentive – £20 per %	£9,788	12.45	FI Dominates
Usual Care	£10,845	12.17	

FI = Financial Incentive

The deterministic sensitivity and scenario analyses for the £10 incentive over a lifetime horizon are included in Table 47. In all but one of the analyses conducted the incentive still conferred incremental QALYs and cost savings over usual care. The costs appeared most sensitive to the type II diabetes risks used. Alternative cost, utility and risk model inputs did not change the results materially. However, results were sensitive to assumptions regarding weight regain. When the incentive group are assumed to regain any weight lost from the incentive intervention by the end of the first year the intervention is no longer cost saving and QALY benefits are negligible although the lifetime ICER remains below £20,000.

The results from an additional comparative analysis are included in Table 48. Here the results (average rewards and weight loss values) from two deposit contract studies (114, 231) and one lottery incentive study (114) were input into the model assuming the same set-up cost as the current incentive scheme. Like the exemplar incentive scheme evaluated here, at 12 months the ICERs were above the £20,000 threshold but over a lifetime the incentive schemes dominated usual care. However, the ICERs at 12 months were noticeably higher than the ones derived for the incentive scheme under consideration. The lottery incentive from the Volpp et al study appeared to offer the greatest value for money over a lifetime with an average cost saving of £927.41 and incremental QALY gain of 0.28.

Table 46: Probabilistic sensitivity analysis results

	Costs		QALYs		Mean ICER	Incremental NMB*	
	Mean	95% CIs	Mean	95% CIs		Mean	95% CIs
12 Months							
Financial incentive – £10	£191.67	£191.17-£192.18	0.7953	0.7951-0.7955			
Usual Care	£75.06	£74.59-£75.54	0.7904	0.7903-0.7906	£23,956		
Lifetime							
Financial incentive – £10	£10,353	£10,276-£10,431	12.318	12.311-12.325			
Usual Care	£10,811	£10,728-£10,894	12.189	12.181-12.196	**FI Dominates**	£3,038	£2,997-£3,079

NMB = Net Monetary Benefit (Calculated assuming lambda = £20,000)

Table 47: Deterministic sensitivity and scenario analysis

Analysis – assuming £10 per % incentive	**Incremental cost**	**Incremental QALY**	**Lifetime ICER**
Efficacy			
P4P analyses with squared incentive term	-£609.27	0.16	FI Dominates
Weight loss and gain			
UC assuming weight loss	-£108.06	0.05	FI Dominates
Alternative weight change >6 months	-£568.69	0.15	FI Dominates
All weight loss regained by year 3	-£173.00	0.06	FI Dominates
All weight loss regained by year 2	-£71.35	0.04	FI Dominates
All weight loss regained by year 1	£48.92	0.01	£3,521
Assume habit formation and weight loss continues	-£702.98	0.19	FI Dominates
Assume crowding-out after removal of incentive – higher weight gain	-£449.32	0.12	FI Dominates
Risks			
Alternative type 2 diabetes risk	-£30.73	0.11	FI Dominates
Alternative stroke risk	-£482.53	0.13	FI Dominates
Alternative stroke mortality risk	-£471.89	0.13	FI Dominates
Alternative MI risk	-£495.39	0.12	FI Dominates
Halved MI mortality	-£493.13	0.12	FI Dominates
Halved risk of second stroke and MI	-£468.92	0.13	FI Dominates
Alternative type 2 diabetes+ stroke and MI risk	-£44.61	0.09	FI Dominates
Costs			

FI set-up cost x 2	-£361.92	0.13	FI Dominates
Cost of secondary diseases (combined) - 25%	-£321.53	0.13	FI Dominates
Utility			
Utility decrement of diseases (combined) - 25%	-£467.11	0.12	FI Dominates
Discounting costs and utility			
1% Discount rate	-£771.52	0.19	FI Dominates
6% Discount rate	-£290.01	0.09	FI Dominates

Table 48: Deterministic sensitivity analyses - alternative incentive studies

Analysis	**Incremental cost**	**Incremental QALY**	**ICER**
Commitment contract - 12 months			
Volpp et al*	£323	0.009	£35,066
John et al**	£165	0.004	£37,789
Commitment contract - Lifetime			
Volpp et al	-£787	0.26	FI Dominates
John et al	-£558	0.17	FI Dominates
Lottery incentive – 12 months			
Volpp et al*	£260.51	0.010	£27,383
Lottery incentive – Lifetime			
Volpp et al*	-£927.41	0.28	FI Dominates

*Effect assumed to last to 6 months; ** Effect assumed to last to 12 months

The simulated ICERs and expected net benefits from the PSA are illustrated in Figure 25 (cost-effectiveness plane) and Figure 26 (CEAC). The cost-effectiveness plane shows a majority of the simulated ICERs are in the south-east quadrant of the plane indicating dominance of the incentive over usual care. The CEAC shows that, at all willingness to pay values for health gain, the incentive scheme has over a 90% chance of being the cost-effective option compared to usual care. Where λ = £20,000 the incentive has a 94.4% chance of being cost-effective.

Figure 25: Cost-effectiveness plane

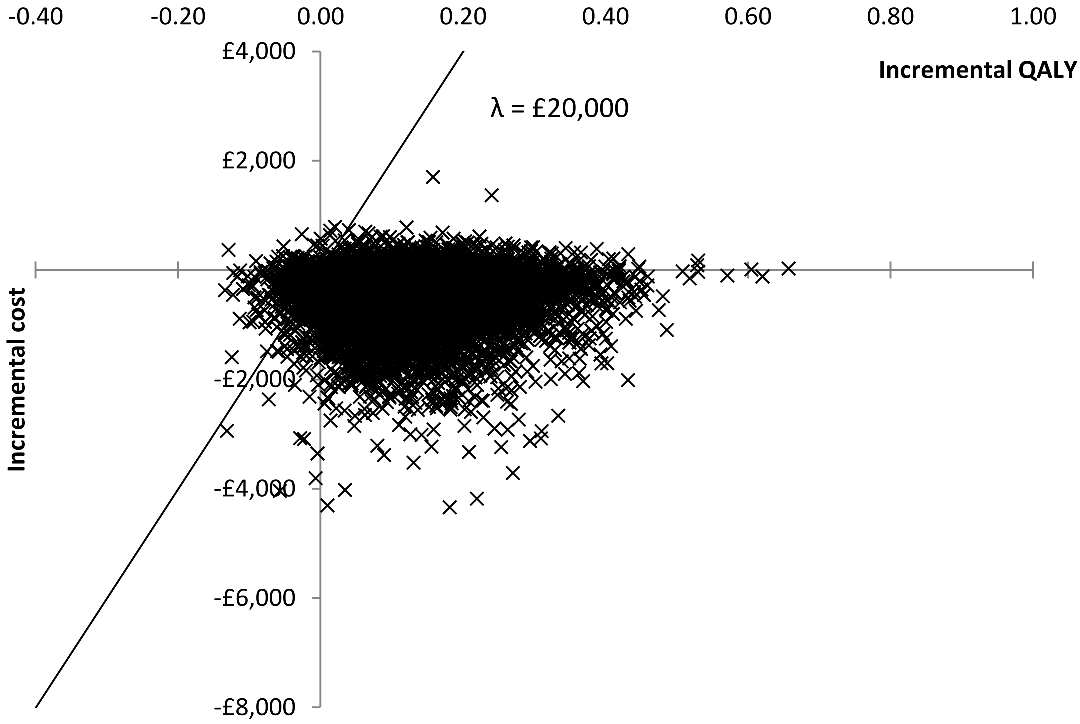
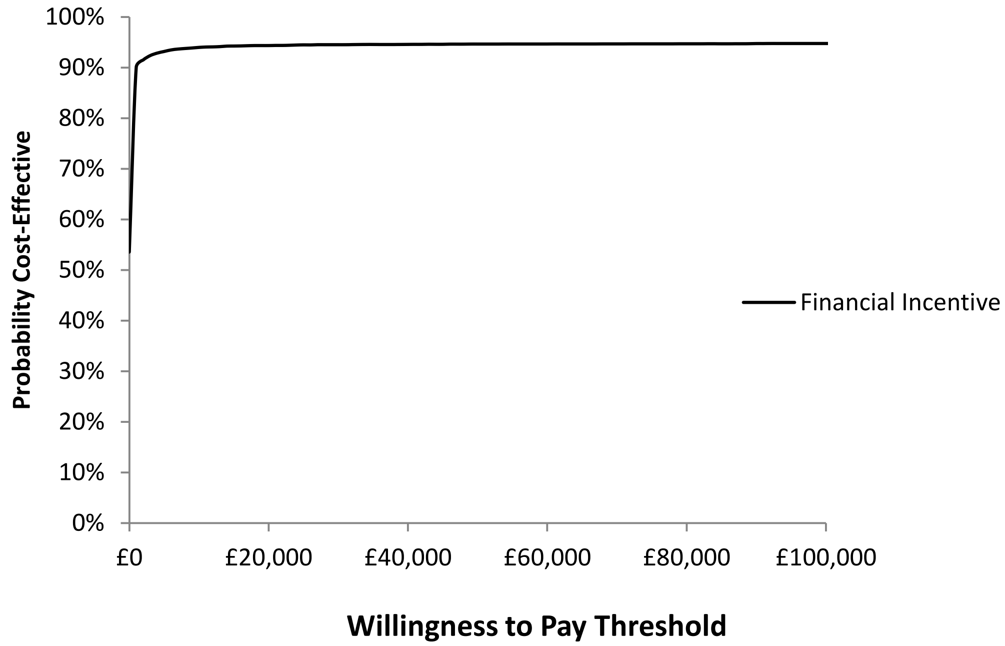
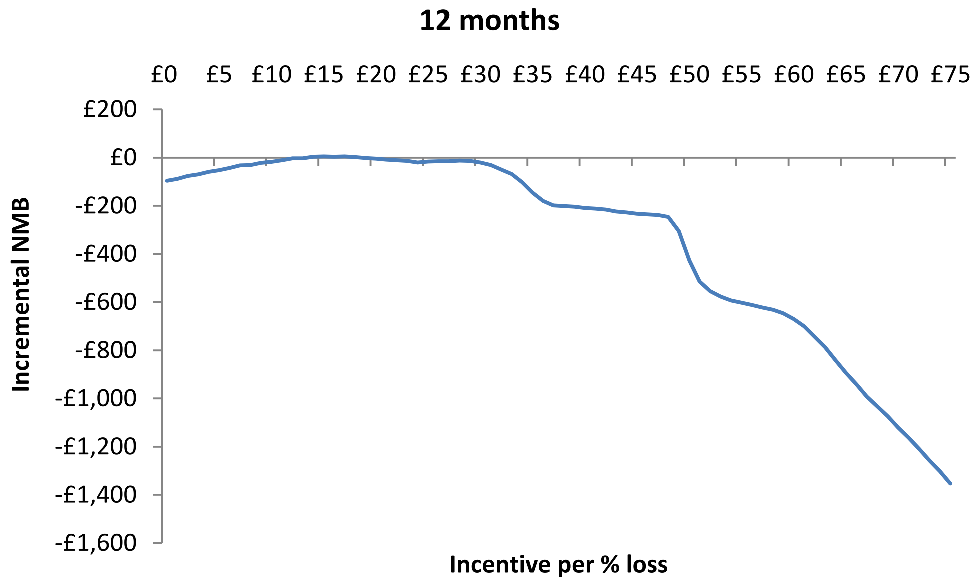


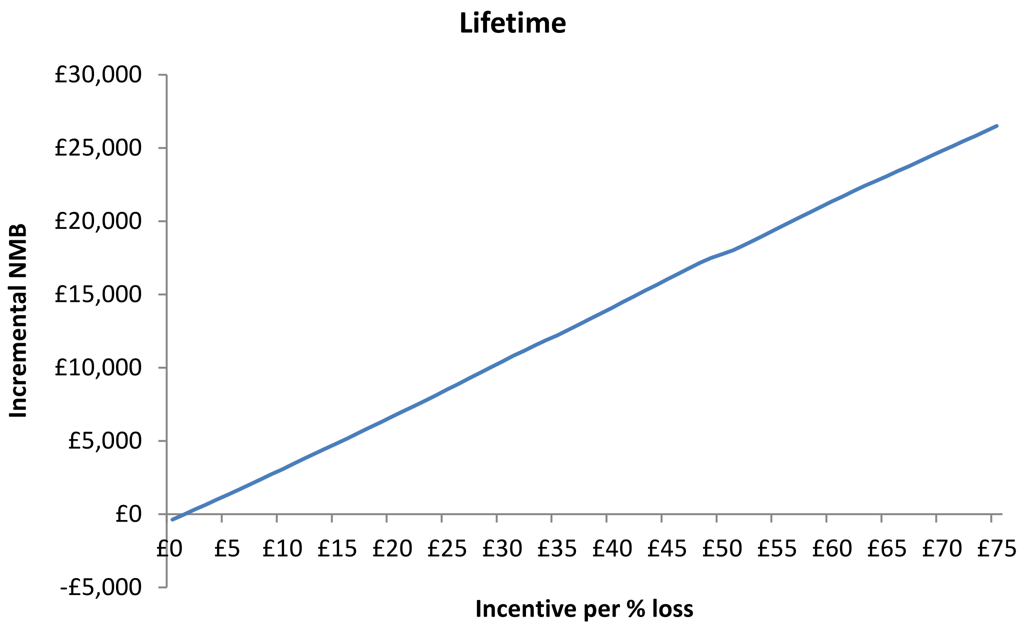
Figure 26: Cost effectiveness acceptability curve



Analyses were conducted to determine whether the U-shaped relationship between incentive level and cost-effectiveness observed in the previous section existed in the cost-per-QALY analysis. Figure 27 shows the incremental net monetary benefit (INMB) by different incentive levels at the 12 month and lifetime horizons. Over 12 months there does appear to be a curvilinear relationship between incentive and cost-effectiveness. Only when the incentive level is in the range £14 to £18 does INMB become positive, indicating incentives are cost-effective compared to usual care. After this point the value falls rapidly. However, when the lifetime horizon is adopted and downstream impact of weight loss factored in, the relationship between incentive level and INMB appears positive and linear.

Figure 27: Incremental NMB by incentive level





9.4. Alternative perspectives

9.4.1. The employer perspective – productivity loss

Results of the cost-benefit analysis from the perspective of the employer are included in Table 49. As with the cost-utility analyses, the between-arm differential in the effect of interest was very small. Use of an incentive scheme would, for example, lead to an average 0.13 (£10 incentive) or 0.61 (£20 incentive) fewer short sickness absences (from the age of 47 to 65) than if no intervention was initiated (usual care). Along with a - similarly small - reduction in longer absences, this resulted in 1.2 (£10 incentive) or 4.87 (£20 incentive) fewer sick days in a working lifetime. The differences in productivity loss according to costing method are marked with those calculated using the friction method being roughly half (over a lifetime) those calculated using the human capital method. Assuming a set-up cost of £107 (as in the cost-utility analysis) and previously stated rewards, total per employee scheme costs would be £117.03 and £196.30 for the £10 and £20 incentive schemes, respectively. The net benefit of the schemes are included in Table 50. At 12 months, both £10 and £20 incentive schemes lead to a net loss (vs. usual care), regardless of the approach used to cost productivity. Results are more favourable for incentives over a lifetime when greater productivity loss savings are created. When the reward is £20 per % lost, incentives are cost-effective regardless of the productivity loss calculation method used. However, the probabilistic simulations indicate that there is a high level of uncertainty around these estimates.

Table 49: Sickness absence and productivity loss

	Financial Incentive		Usual care
	£10 per % lost	**£20 per % lost**	
Absences predicted by BMI			
Mean no. short absences (1-7 days)	33.99	33.51	34.12
Mean no. longer absences (≥10 days)	6.13	5.95	6.19
Mean no. days off in lifetime	197.22	193.55	198.42
Total productivity loss (costs £)			
12 months			
Human capital approach	£2,229	£2,177	£2,253
Friction cost approach	£1,221	£1,189	£1,233
Lifetime			
Human capital approach	£31,836	£31,298	£32,009
Friction cost approach	£16,083	£15,767	£16,189

Table 50: Cost-effectiveness from employer perspective

	Deterministic total Cost*	Deterministic Net Benefit vs Usual Care**	Probabilistic Net Benefit vs Usual Care**	Probability cost-effective
12 months				
Human Capital approach				
Usual Care	£2,253			
£10 per % lost	£2,346	-£93.49	-£92.95	0.092
£20 per % lost	£2,373	-£120.06	-£122.29	0.12
Friction costing approach				
Usual Care	£1,233			
£10 per % lost	£1,338	-£104.87	-£105.14	0.063
£20 per % lost	£1,385	-£151.91	-£154.23	0.07
Lifetime				
Human Capital approach				

Usual Care	£32,009			
£10 per % lost	£31,953	£56.23	£106.85	0.47
£20 per % lost	£31,495	£514.76	£549.81	0.57
Friction costing approach				
Usual Care	£16,189			
£10 per % lost	£16,200	-£11.01	£22.79	0.42
£20 per % lost	£15,963	£225.97	£239.21	0.46

*Total cost is equal to the set-up cost, plus the cost of running the incentive scheme plus productivity loss; **This is the difference between the total cost and productivity loss in the usual care arm

9.4.2. Combined healthcare provider and employer perspective

The results below (Table 51) include the cost-effectiveness and cost-utility analyses when both the health provider and employer costs are taken into account for usual care vs. £10 incentive per % weight loss. Two sets of results are provided – one where productivity loss is calculated using the human capital approach and one where it is calculated using the friction method. Over a lifetime, the incentive intervention still dominates usual care. The effect of combining the healthcare provider and employer costs at 12 months is to reduce costs on average and the ICER to acceptable levels.

Table 51: Cost-effectiveness – societal perspective

Analysis	**Incremental cost**	**Incremental benefit**	**ICER**
Cost-effectiveness (per 5% loss)*			
Human capital approach	£91.66	0.287	£319.36
Friction cost approach	£103.03	0.287	£359.00
Cost-utility			
12 months			
Human capital approach	£89.39	0.005	£17,879
Friction cost approach	£100.77	0.005	£20,154
Lifetime			
Human capital approach	-£640.40	0.13	Incentive dominates
Friction cost approach	-£573.16	0.13	Incentive dominates

9.5. Discussion

This is the first study to explore the cost-effectiveness of financial incentives for weight loss. The model predictions and outputs are logical, consistent with prior expectations and produce disease incidence estimations in line with those generated from a well-known risk calculator.(634) The analysis presents cost-effectiveness (cost per unit of weight loss), cost-benefit (for the employer perspective) and cost-utility metrics for two levels of incentive pricing across two time horizons (12 months and lifetime). In all analyses, the cost and effect differential between incentive and usual care (defined as no active intervention) was small. The cost-utility analyses from the healthcare provider perspective suggested incentives may not be cost-effective at 12 months but might confer health gains and cost savings over a lifetime. This finding was generally robust to a suite of sensitivity analyses (both deterministic and probabilistic). However, these analyses imply that assumptions relating to what happens after the incentivised period in terms of weight change are important.

One of the most likely adopters of incentives as a tool to bring about health change are employers. The analysis of incentives from the employer perspective indicated that although they provided only modest benefits over a ‘do nothing’ approach they may save the employer money in the long term. This was the case when both human capital and friction methods were applied to estimate productivity loss. The programme costs were assumed to be the same for the NHS and employer perspective but the latter may be somewhat cheaper (and thus the results an underestimate of cost-effectiveness) since weighing-in may be completed at work with supervision rather than in a pharmacy (for example). In fact these costs may be removed from both sets of analyses if self-reported weight could be relied upon. Furthermore, productivity loss is based on absenteeism only and presenteeism is not included.

The analysis of cost-per weight loss outcome suggested that there was a curvilinear relationship between incentive level and cost-effectiveness, that cost-per weight loss milestone fell as incentives increased up to a point after which it began to rise again. A number of diagnostic tests were conducted and revealed that this phenomenon was due to a ceiling in effectiveness being reached, beyond which increasing the incentive level resulted only in higher costs. The incentive level offered should be sufficient to motivate individuals to lose enough weight but not be above that required. In the current analysis, an incentive of between £10 and £20 per month per percent of weight lost appeared to be optimal. However, cost-effectiveness is not necessarily a good indicator of value for money in the cost-utility framework. To illustrate, while John et al (231) concluded that their intervention was more cost-effective than Volpp et al's (114) (cost per kg weigh loss of £16.02 vs. £38.16), when applied to the decision model and the cost-utility framework, both the ICER at 12 months and the cost savings and QALYs gained over a lifetime were in favour of the Volpp et al study. Thus the relationship between incentive level, cost-effectiveness and health outcomes is complex, delicate and no doubt sensitive to changes in any of the contributing factors. Additional analyses indicated that the curvilinear relationship between incentive and effect was not present when INMB was the metric employed. In this case, there was a linear relationship between incentive level and NMB; the higher the incentive, the greater the NMB. This was due to the relationships between weight and risk of secondary illnesses specified in the model. However at 12 months, in line with the cost-effectiveness analysis, there was a non-linear relationship between incentive level and NMB and INMB was only positive between £14-£18 monthly incentive levels. As different decision makers may make decisions over different time horizons, it is possible that the results of different analyses may be of value depending on the perspective. Employers for example, may be less interested in the long term secondary illnesses avoided than the NHS and therefore the 6 and 12 month analyses may be more relevant to them.

There is a debate as to whether making behaviours such as diet and physical activity (process) the incentive target would be more effective than targeting the outcome (weight loss).(635-637) The cost-effectiveness analysis presented here considered the incentivisation of weight loss however this was in part due to the fact that there are more studies reporting data of this nature. Financial incentives are clearly a highly complex intervention and it is likely the effect is sensitive to nuances in the format, delivery and assessment. Many of the studies in weight loss included study arms with multi-component aspects. For example, Faghri and Li (2014)(570) included an arm with deposit contracts and matched funding, Driver and Hensrud (2013)(569) incorporated a deposit contract and bonus pool and elsewhere group interventions were employed. There was heterogeneity also in the targets set and payment scheme with some study rewards increasing after a certain level of weight loss, some paying rewards monthly and some at study end (with and without a bonus). Clearly, synthesising outcomes from these studies was a challenge and consequently the uncertainty surrounding the predicted weight loss is increased.

Crowding-out of intrinsic motivation is a general concern with extrinsic reward schemes. However, those with the lowest incomes are the most appropriate target group for incentives and will be most responsive. Given discussions in the framework section (Chapter 3), this group will have the least intrinsic drive for behaviour change and thus have little motivation to be crowded out. It is plausible though that while baseline motivation is low, the introduction and subsequent removal of incentives may reduce motivation even further. A sensitivity analysis was conducted to model the potential impact of crowding-out by using a higher weight regain value in the incentive arm after the removal of the incentive. Although a simple modification, it was thought that this approach would capture the effect of a motivation level that was lower post-incentive than pre-incentive. In the event, however, it did not change the decision regarding incentive cost-effectiveness.

The results of the meta-regression suggested that the effects of incentives were not heterogeneous according to gender, age and socio-economic class. Given this, sub-group analyses were not deemed necessary. A major argument for incentives is that those earning less will respond more and hence they represent a way to reduce health inequalities. Unfortunately, this was not empirically testable due to the dearth of effectiveness data by income group. There was no information either in the trial data or from the meta-analysis relating weight loss to difficulty of behaviour change or motivation. Thus it was not possible to further test some of the theories developed in the survey chapter. The results from the CV survey analysis suggested that people consider smaller expected values of lotteries as equivalent to much larger certain rewards (for the pooled time data for changing diet and losing weight these were £47.10 vs. £7.67 for certain and uncertain rewards, respectively). This suggests that reward schemes may be more cost-effective if they take advantage of this.

Future research should explore the cost-effectiveness of alternative incentive scheme formats such as ‘foot in the door’ approaches, where participation in a programme is incentivised rather than process or outcomes. Work should also establish the extent to which those in lower income groups would be attracted to such schemes and whether offering incentives in this manner would encourage a ‘different’ type of individual to participate. Future incentive schemes should seek to measure participant’s motivation during studies and explore the value and practicability of modifying incentive levels in line with required self-control or motivation deficits.

10. Discussion

The research conducted as part of this PhD programme focussed on user financial incentives - a relatively new field of enquiry in health. The work has made a number of potentially valuable and novel additions to the research and evidence base. It is the first to propose a framework to explain the impact of incentives in a health setting related to behaviour change. It is the first incentive pricing study conducted in England and represents the first longitudinal contingent valuation survey (and one of the few follow-up valuation surveys in any field of enquiry). Since the contingent valuation survey was conducted a number of other stated preference studies have explored pricing from a more limited perspective; there was limited additional information collected in these studies that would help interpret the elicited values (for example, perceived difficulty of change and sense of control). The design of the survey, including the contingent valuation and additional items, was facilitated by the literature reviews and subsequent development of the theoretical framework. This research also presents the first meta-analysis of incentives for weight-loss (as opposed to behaviour change). Finally the research represents one of the most comprehensive assessments of the cost-effectiveness of incentives and the only one conducted in weight loss. In doing this the research has addressed a number of research gaps and provides a basis for extending knowledge in the field. However, there were a number of limitations to the research; these are discussed below along with the extent to which they could have been avoided and how future research can address these limitations.

While the theory review, framework and contingent valuation survey had a broad perspective, for reasons of practicality, it was necessary for the effectiveness and cost-effectiveness sections to narrow the focus to one area. Weight loss was chosen as the focus as obesity is a growing public health concern. However, it is hoped that the research has provided some learning that could be generalisable to other behaviours such as smoking and alcohol consumption.

10.1. Framework for incentives

The literature reviews carried out here concluded that little work had been conducted in this area and that there had been no substantive attempts to formally characterise the impact of user financial incentives within behaviour change. In contrast much effort has been expended in testing and refining generalised economic frameworks of health behaviour such as the Grossman and rational addiction models. However, the review concluded that these general frameworks would not be useful in the area of financial incentives for behaviour change. The formal process of framework development requires the generation of a hypothesis about the impact of incentives, formal econometric representation of the hypothesised relationships and testing of this (often) in large, panel datasets.(638) It is possible that research in the area has been stymied by a lack such datasets that included relevant variables.

A framework was suggested based on the hypothesised process of behaviour change, key aspects of incentives and theories garnered form the literature reviews. The framework incorporated the idea that decision making processes are based on a dual-system as espoused by Kahneman (208, 357) and embedded in the Behaviour Change Wheel developed by Michie and colleagues following their meta-theory of behaviour change.(33) In the framework proposed here, intention and motivation (and therefore incentives) only come into play when System 2 holds sway over a decision. Empirical testing of this dual-system would be a worthy pursuit as it may help define *inter alia*, the conditions necessary (e.g. timing, behaviour 'load' or repetition) for the shift from System 2 to System 1 and the 'resistance' of these systems (e.g. how robust is it to shocks such as environmental cues and stresses?). Knowing this may help determine how long people with a motivation deficit should be incentivised for.

Time preference is consistently found to have a significant association with unhealthy behaviours. It was included in the contingent valuation survey as it was thought *a priori* to be an important component of continuation of unhealthy behaviours. The results of the survey called this into question as it was seldom shown to be a significant predictor of required incentive. However the survey highlighted the difficulty in measuring this concept and the author questions the direction of the relationship. It is plausible that an individual's circumstances and mood determine the extent to which they discount future benefits and costs and thus their risky health behaviour and not – as commonly assumed – that time preferences are endogenous. If discounting were shown to reduce with improved circumstances or health this would have significant implications for addiction models. It might also bring discounting itself into the picture as a target for interventions. Regrettably, it was not possible to explicitly test such theories within this research programme due to time constraints and lack of available data.

One of the key aspects of the framework is that it assumes, while System 2 is in play, the costs and benefits of behaviour change will fluctuate and as such motivation will not be constant over time. The natural corollary is that incentives should not be constant either. Incentives may have to be of a certain magnitude to raise motivation above a minimum required (remembering initial costs will be high) for behaviour change. They may also need to be increased commensurate with the difficulty of change and depleted self-control over time or individuals may relapse. Although the sample was small, this was to some extent indicated by the contingent valuation survey results as there was a suggestion that the minimum incentive required rose over time.

Unless the relationships specified in the framework can be empirically tested however, it remains speculative. Unfortunately this is an unavoidable limitation of the research. Further research using large databases is required to empirically test the framework. It may have been possible to acquire large datasets reporting incentive data such as conditional cash transfer programme evaluations from low and middle income countries. However, it is unlikely that these would have the data necessary to test the theories presented here (for example on time preference or feelings of control). The nature of such data may mean it is not applicable here as they do not often relate to behaviours such as weight loss or smoking but more on combinations of behaviours covering diverse factors such as vaccination, nutrition and school attendance. However, it is hoped that large databases will soon become available as workplace wellness programmes take off (especially in the US) and these may permit the required endeavours. Additional econometric work is also required to develop testable theories regarding issues such as the optimal pricing of lottery incentives and commitment contracts taking into account factors such as prospect theory, loss aversion and regret theory.

10.2. Pricing and acceptability of incentives

The contingent survey conducted here may provide valuable information about the acceptability and pricing of incentives. Possibly because of the framing of the question, the environment, or situation of the respondents (or combination of these factors), incentives provided by the NHS were not found to be acceptable by many (over 57% of people strongly disagreed with them). It is not uncommon for high proportions of people surveyed to disagree with incentives.(639) However, it is also a common finding that they are acceptable in certain circumstances, for example if privately funded, if they are in the form of vouchers (for healthy products and services) and described as ‘effective’.(153, 639, 640) Unfortunately such follow-up questions or testing of the question framing that may have shed light on why incentives were generally considered unacceptable were not possible here. As the survey was quite long it was not possible to add in additional questions and since the sample was relatively small it was not possible to split it and give differently framed attitude or valuation survey questions to each. It is quite possible that the valuations are a product of the particular formulation of the survey and that – for instance – one where the NHS was not mentioned (and say, the employer was the payer) may have produced quite different values. In that sense, the values may be context dependent and not applicable to incentive settings where the healthcare provider is not the incentive payer.

Some manipulation of the data and application of non-standard regression models were necessary to make the most of the contingent valuation survey given its categorical nature and skewed responses. One of the notable findings was that there were clear differences in the perceived difficulty of changing behaviour depending on the behaviour with smoking appearing to be the most challenging. There was a clear trend between perceived difficulty of changing and self control and the incentive required. As a result, smokers required the greatest incentive to change. The hypothesis that the incentive would be correlated with the strength of the behaviour (e.g. number of cigarettes smoked and weight) was not consistently observed across behaviours. In weight loss there appeared to be a curvilinear relationship, with those over-weight requiring a larger incentive than the obese. However, this was also reflected in the weight loss incentive trial analysis which showed starting weight a significant positive predictor of weight loss; that is – the heavier people are the easier they find weight loss initially.

As discussed above and contrary to the hypothesis, time preference was not found to be a strong predictor of required incentive, although this may be a function of the question asked. It is conceivable that responses to monetary time preference questions do not reflect discounting but the level of uncertainty people feel regarding the receipt of rewards in the future.

Crude means suggested that an incentive of £55 per month was required across behaviours for individuals to adopt a healthier lifestyle. The equivalent expected value in terms of the lottery reward was close to £17 and these represented around 8.56% and 1.37% of monthly income, respectively. The analyses suggested those with low health control required £49.85 more than those in control of health to change behaviour and those perceiving change as ‘difficult’ required £41.33 more than those who felt it was ‘easy’. The motivation item was less powerful in predicting incentive although univariate analyses suggested £36.44 would be needed for an individual who did not feel motivated to change behaviour (compared to an individual who was motivated). Comparisons with other pricing studies are difficult because responses are likely sensitive to the population surveyed, mode of survey and question format. You et al's discrete choice experiment (DCE) revealed that an overweight male would need to be paid $59.46 (£42.64) per weigh-in (month) in cash (received at 3 months) to motivate them to join the a wellness programme (171) which is close to figures observed in this study. The per month weigh-in amount falls to $10.23 (£7.34) if the payment was made at each weigh-in. This may reflect high discount rates of individuals or their aversion to uncertainty about reward receipt. In contrast, a DCE by Wanders and colleagues found that willingness to participate in a lifestyle programme actually decreased as incentive level increased. The authors postulate that the higher amounts of incentive deter respondents who may believe that more effort is required.(641)

While these studies have explored preference heterogeneity in terms of socio-demographics, few have included attitudinal items as were here which support the hypothesis laid out the in the framework: that the incentive level required is a function of the difficulty the individual perceives in changing. Once this idea is considered and you acknowledge that this may fluctuate over time it is a natural conclusion that incentives should also be allowed to fluctuate in line with this. There was some suggestion from the data corroborating this as the incentives required rose over time and a further £16.59 per month needed at three months versus baseline. It is unclear why this might have been – whether due to a change in WTA, change in setting or mode of delivery. The sample comparison suggests it was not due to a systematic difference in the sample make-up at different time points. Regardless of the reason for it, the fact that WTA appears to change is a finding in itself and is worth knowing even if it is useful for this context (incentivising those who are initially hospitalised) or highlighting potential future research direction.

Although there was evidence of the internal validity of the survey there are reasons to treat the elicited values with caution. The sample was small and a large proportion stated a £0 willingness to accept. It was also a specific population – namely a relatively older group of people who had experienced a health shock and were in hospital. Whether the values presented here are generalisable outside of this context is unknown. The conditions of completion also changed over time (from hospital to community) which limit the extent to which claims can be made about WTA longitudinally. Many of these limitations were unavoidable as survey was completed alongside an on-going study. With hindsight an additional general population survey which may have offered a larger sample and an opportunity to test framing effects may have been a worthwhile pursuit.

An additional cautionary caveat is required here as in any stated preference experiment. While these studies are useful for planning future incentive schemes they represent stated preferences only and the derived WTA values may be quite different to what people would actually be willing to accept in reality. Thus analysis of revealed preferences is required when data permits the endeavour. Others have advocated a pricing strategy where individuals are paid according to the costs that would be saved by the healthcare system if they were to change behaviour.(636) However, the practicability and desirability of such a scheme is unclear.

10.3. Cost-effectiveness of incentives for weight loss

The review and meta-analysis of incentives for weight loss concluded that incentives led to significantly greater weight loss than control or no active intervention. However the results continue to be mixed (83, 642) and the jury is out until larger scale studies have reported. The wide range of effects observed may partly be explained by the heterogeneity in the incentive designs, pricing and targeting of weight loss. Due to this heterogeneity it is questionable whether meta-analyses were appropriate. However, the uncertainty captured in this process could be incorporated in the decision-analytic model. It is worth noting that weight loss is one of the most common goals of incentives. Possibly only smoking cessation has been the focus of as many studies and these also exhibit heterogeneity of design and effect. Hence, choosing a different behaviour as the focus for the review and analyses would not necessarily have improved the synthesis. Although the aggregate weight loss from the meta-analysis was modest (around 4 kgs) and in line with other interventions such as commercial weight loss programmes,(576) there were some exceptional results. For example the Volpp study found that weight loss was 6.35 kgs at 16 weeks in a lottery incentive arm. The review and analysis of the P4P (WeightWins) trial data suggested that higher incentives are better but not proportionately so, which is in line with others study findings.(566)

The results of the economic evaluation suggested that financial incentives for weight loss – or at least the particular configuration examined here - do represent value for money over a lifetime, both for the NHS and employers. However, for the latter perspective, how productivity losses were calculated made a difference to this finding. Even small levels of weight loss could be cost-effective although these results were obviously sensitive to assumptions made about long term weight trajectory after the incentive period for the incentive group and for the usual care group. Usual care for the decision model was only the provision of information about diet and other comparators were not included which could be considered a limitation of the evaluation. Future analyses might consider head to head comparisons with other weight loss programmes and alternative incentive schemes (such as incentives for behaviour change or scheme participation alone). As outlined in the framework, motivation is necessary but not sufficient for behaviour change as change may be reliant on skills and education which would also need to be present in future incentive programmes.(124)

A reduction in weight of 4kg over 6 months of an individual who is motivated to change, who has a supportive social network, who see the benefits of a healthier lifestyle and who may have (eventually) found an alternative route to weight loss in the absence of incentivisation, does not necessarily have the same ‘value’ as same level of weight reduction in an individual who had no intention of changing. The analyses did not specifically explore the impact of incentives on who is encouraged to participate, nor the impact of incentives on inequalities which is a limitation of the evaluation. This was due to the lack of evidence for this in the review which stems from a lack of testing rather than lack of effect. It is possible the modelling could have explored differential effects on participation and weight loss across different socio-economic groups but this would largely have been speculative in the absence of such evidence.

Standard cost-effectiveness analyses do not accommodate considerations of equity, concerned as they are with efficiency and the maximisation of health benefit.(643) However, it has been argued that equity could and should be considered in resource allocation decisions (644) although this is not straight forward.(645) A number of alternative methods have been proposed to incorporate health distributional effects in cost-effectiveness analyses and technology appraisals (646) including the application of equity weights (645) and multi-criteria decision analysis.(647) A number of frameworks have recently been proposed (648) but have yet to come into common use. Formal incorporation of these methods was beyond the current piece of research but should be considered in future when data on effectiveness by income (or socio-economic) group is available as it may identify any added value of incentive use.

The cost-effectiveness analysis was useful in highlighting some of the complexities in conducting an economic evaluation in this area. A key issue to note is the challenge in modelling the complexity of the intervention. Incentive schemes are themselves complex interventions but may also be bundled together with other interventions such as education or skills-based programmes which adds further complexity. This is confounded by the fact that, at least in behaviours which are not ‘all or nothing’, both the behaviour change target that is set and the incentive amount are likely to be crucial. If we consider that there is a ‘dose-response’ relationship between the incentive and its effectiveness, the net ‘dose’ is dependent on incentive pricing and ‘amount’ of behaviour change required as well as individual characteristics. Added to this is fact that the dose of incentives is directly linked to cost since raising incentive levels increases both costs but also increases effectiveness and likelihood of payouts (which again increases costs). Given these complex inter-relationships, establishing a trade-off point between incentive level and effects which optimises value for money will be very challenging.

There is likely to be significant heterogeneity in responses to incentives and modelling this in the absence of detailed data (for example on income and motivation levels) will be difficult. Since the power of incentives is linked to the marginal utility of income and behavioural factors such as motivation, the differential in effect across individuals may be marked. Factoring in the possibility that this will change over time adds another layer of complexity. Furthermore, the impact of behavioural phenomena such as crowding out and habit formation is still to be determined and these will likely substantively affect estimates of cost-effectiveness and may determine whether incentives are sustainable in the long term. Longer term and more detailed follow-up data on the effectiveness of incentives and on the personal characteristics of scheme participants is required to improve modelled estimates of cost-effectiveness.

Thus identifying optimal pricing for incentives based on modelled cost-effectiveness estimates will be difficult and fraught with uncertainly. However this is an important endeavour since paying too much in certain scheme designs (e.g. where the effect is per 5% weight loss) may mean that a ceiling in effect is reached and excess ‘consumer surplus’ generated. This was observed in the current evaluation where, beyond a critical incentive level, only costs rose and increases in incentive beyond this ceiling decreased cost-effectiveness.

10.4. Prospects for user financial incentives

Interest in the use of incentives appears to be steadily increasing and new studies emerge all the time.(642, 649, 650) There have been some very positive results for incentives for one-off (e.g. vaccination) and time limited (e.g. smoking during pregnancy) behaviours and it is likely, in the UK at least, these will have an opportunity to be explored. Indeed a majority of the research thus far has been conducted in these categories. While these are obvious avenues to pursue, tackling obesity remains one of the key public health challenges and where incentives may play a part.

Ethical questions will continue to be raised in protest to incentives. The research described here did not directly address the ethics of incentives although some of the findings may have implications for the moral debate. If incentives help people to make choices that are more in line with their future preferences (e.g. not having cardiovascular disease) it is difficult to argue that they are coercive. Since the downstream social costs of healthcare resource use expended in dealing with cardiovascular diseases (for example) are higher than the private costs of (unhealthy levels of) consumption, they represent a negative externality. As these costs are imposed on others - indirectly in the form of tax payers bearing healthcare costs; or directly, for example, in the form of secondary smoke (361) - there is a moral argument to intervene and offering incentives in this context may be justifiable. Further, if health behaviour can even in part be explained by factors beyond an individual’s control such as social environment (651, 652) accusations of unfairness may be rebutted.

The results here suggest that not only do incentives have the potential to be cost-effective (at least in the weight loss example), they have the potential to be cost saving. The efficiency argument these results generate translate into moral arguments for incentive use: doing nothing or using interventions that are cost-ineffective will not optimise societal health. The contingent valuation survey indicated that the most important factor in determining the acceptability and pricing of incentives was the level of control that individuals felt in their ability to change behaviour. We can conclude that those who do not feel able to control their behaviour need help to do so. Adopting a consequentialist approach one could argue that incentives are permissible if they achieve the ends of reducing inequalities regardless of whether or not they are perceived as unfair or coercive. Due to short-comings in the data this was not empirically testable here but the idea that incentives may encourage low income individuals to change behaviour is enduring. NICE acknowledge that reducing health inequalities is a priority and their Citizens Council stated that NICE should support strategies that offer benefit to the most disadvantaged so as to reduce health inequalities, especially in the context of public health.(653) In fact, the reduction of health inequalities is one of the criteria which the Department of Health uses to decide referrals of technologies for NICE appraisal.(653)

The debate surrounding the morality and fairness of incentives are inextricably tied in with both their (cost-)effectiveness and who funds the schemes. Surveys of the acceptability of incentives are highly sensitive to framing.(153) Here it's possible the high levels of disagreement with incentives may have been due to the framing of the question which specified the NHS would pay. This may have been mediated by statements about the effectiveness of incentives. However, this question may be moot depending on who funds incentive schemes. A consideration of the agents involved provides insight into who could pay: the target individuals (e.g. via deposit contracts); employers seeking to reduce productivity losses; the NHS (thus society indirectly as tax payers) seeking to avoid cost of future illnesses; society directly through donations; charities and the voluntary sector; the Department of Work and Pensions seeking to maximise income tax revenues and avoid disability benefit costs; local authorities; commercial incentive and wellness scheme companies; and commercial companies who would benefit from individuals switching expenditure from unhealthy to healthy goods and services (e.g. gyms, health and sports goods producers and service providers).

Although widespread provision directly by the NHS may be contested, more NHS work is being tendered out to the private sector who may be more willing to entertain such ideas and have more freedom to ‘get results’ by whatever means. Currently the trend appears to be for employers to take the lead on incentive scheme provision. Several authors have highlighted the reforms of the US Patient Protection and Affordable Care Act (ACA) of 2010 as having the potential to herald greater prospects for incentives.(654, 655) The ACA continues and expands the 2006 Health Insurance Portability and Accountability Act (HIPAA) of 1996 which supported the use of outcome-based health targets within private insurance incentives in both public and private insurance. The HIPAA regulation allowed the use of incentives to encourage weight loss and smoking cessation as long as the incentive was part of a wellness programme and did not exceed 20% of insurance coverage costs. The ACA has now increased the amount of incentive that can be offered and this has seen a growth in incentive scheme use. In companies with 200 or more workers in 2013, 99% offered at least one wellness programme and 36% a financial incentive of some description for participation.((656) cited in (655))

In 2014 NHS England published their five year plan for the NHS which is facing a challenging financial situation.(657) In their Five Year Forward View NHS England state that: "*the future health of millions of children, the sustainability of the NHS, and the economic prosperity of Britain all now depend on a* ***radical upgrade in prevention and public health***" and point four in the executive summary (as a marker of its importance): "*The NHS will.... help develop and support new workplace incentives to promote employee health and cut sickness-related unemployment*". Thus it seems the workplace might be fertile ground for incentive schemes in England. The use of incentives in the workplace introduces another set of ethical questions however since in this case people may have no chance to opt out and may be discriminated against if they are unfit.(658) Those who are unemployed would also miss out and may be a more valuable target for intervention. Regardless, if the role of incentives in companies and health services does not gather momentum, people will continue to use their own commitment devices and incentives to try to stick to behaviours.(659) In all cases additional research is needed to further finesse the design of incentive schemes and to understand their impact.

10.5. Recommendations

10.5.1. Incentive scheme design and analysis

The reviews, theoretical work and analysis presented here afford the opportunity to describe what effective incentive schemes should look like. Some of the recommendations are derived from previous studies and others are derived directly from primary research conducted in this PhD research.

- Although there is limited evidence to confirm or refute this point, the theoretical framework developed in the PhD suggests that incentive-generated motivation alone would not be sufficient and that incentives should be part of a wider scheme offering education and skills (e.g. in nutrition and exercise) to convert motivation into efficient and effective action.
- There was evidence from the literature review of incentives in weight loss that group incentives are better than individual ones and, in the review of

frameworks (e.g. MINDSPACE), it is suggested that this is especially so when commitments are made publicly.

- Previous stated preference studies identified in the reviews suggest that we should offer cash where possible although people are also willing to accept vouchers (which, according to studies exploring the public view of incentives are more acceptable).
- The literature review conducted here in weight loss incentives did not identify any robust attempts to estimate optimal weight loss targets for individuals. Certainly in behaviours where the outcome is on a continuum (e.g. weight loss and physical activity) rather than binary (continue vs. stop smoking), the setting of behaviour change targets is possibly at least as important as the incentive amount offered. Further research is required to establish this but it is reasonable to say that the target outcome should be measurable in the first instance. The target should also be achievable; however, as the economic evaluation showed, setting the target too low in relation to the incentive may not optimise cost-effectiveness.
- The reviews of incentives and stated preference studies suggest that people prefer certain payments. However, the review in weight loss indicated that lotteries are also effective and the decision modelling conducted here suggested they may be a more cost-effective option.
- Studies identified in the reviews of the literature appear to suggest that more frequent payments are better than less frequent ones and people may be willing to accept smaller incentives as a trade-off.
- The results of the contingent valuation survey conducted here indicate that incentive levels should take account of how difficult the person feels change is – that is, one size does not fit all.
- As some behaviours may be more difficult than others to change, incentive levels may need to be specific to behaviour and even strength of health behaviour (e.g. amount of alcohol consumed)
- The survey results also suggest that incentive pricing may need to adapt to how difficult people find change during the process.
- The level of control of the individual may also be critical in behaviour change and level of incentive required thus incentives offered should reflect this but control or willpower could also be a target for interventions.

- Some attempts to measure health behaviour, self-control, perceived difficulty and motivation should be undertaken in incentive schemes to facilitate pricing and future research.
- Acceptability of incentives may be low if described as being funded by the NHS so alternative funders may need to be sought along with ways of carefully framing schemes to maximise participation.
- The economic evaluation conducted here suggests that incentives can be cost-effective from an employer and health service perspective
- While higher incentives appear (in weight loss at least and over a lifetime horizon) to lead to better value for money in cost-utility terms, when cost-effectiveness is considered there may be a level of incentive where a ceiling in effect occurs, beyond which increases in incentive serve only to increase costs and reduce cost-effectiveness.

10.5.2. Further research

Much of the incentive research continues to be conducted in the US which may limit generalisability to the UK. In addition, many of the methodological studies are unfortunately underpowered. An investment from the present research infrastructure is required to allow the conduct of UK studies of sufficient power to answer some of the key questions with confidence. Further studies of 30-40 participants per arm will not convince anybody of the potential of incentives nor dissuade them that they are a worthwhile pursuit.

Longer term studies are required too. There is already significant uncertainty regarding the long term impact of traditional health behaviour change interventions and the use of incentives adds another layer of complexity. The conclusions of the economic evaluation conducted here were sensitive to the assumptions made about what happens after the incentivised period. If is it shown that crowding-out (or some other negative effect) occurs then, at best, incentives would be the same as the panoply of traditional behaviour change interventions and at worst could deliver poorer outcomes than no intervention at all. Conversely, if it becomes apparent that the desired and incentivised behaviours become for the participants something that is either: a) enjoyable (the behaviour itself or the process such as the social aspects); or b) something that is automatic (and thus shifted to System 1 and evading our conscious cost-benefit evaluation), then the power of incentives may be underestimated.

There is mixed evidence as to whether crowding-out occurs in the health context.(409, 410, 660) Beyond this there is scope for other negative consequences which are less measurable such as strategic behaviour and the change in the principal-agent relationship and these should be monitored in future studies. Regardless, it is recommended that some measure of motivation, self-control and perceived difficulty of change is included in future studies. This is to understand who is attracted to studies, to understand the level of incentive that is required and to understand what happens to motivation during and after incentivisation.

An increased understanding of sub-group effects, especially relating to social class is required. The key question is: do incentives help reduce inequalities and do they encourage those who would not have otherwise considered change to attempt change? The hypothesis is that incentives should attract lower income individuals who are traditionally the hardest to reach in behaviour change interventions but this remains untested. Research is required to establish the role of incentives in this respect. Is there a case for incentivising participation in programmes or should the reward be contingent on process or outcome? For each of these points it would be useful to understand the impact of incentives on different income or social groups – if incentives do attract the hardest to reach, are they also the first to fail after incentive removal? If we are interested in answering this question then randomised controlled trials are possibly not a suitable mode of research. It may be that we need people who are motivated by finance to self-select for incentive study arms.

Despite growing research on the matter, the key question of incentive pricing also demands further attention. Future research could explore the value and practicability of creating a personalised and dynamic pricing system, where rewards are based on how difficult change is and allowing this to change over time should it need to. A related and equally important point relevant for some behaviours is target setting. The incentive level is only one aspect of the mechanism and only makes sense when it relates to a target; £50 for losing 1kg of weight is a good deal but perhaps not for losing 5kgs. In smoking you could argue that incentivising cessation is the only goal (rather than reduction in cigarettes smoked). However, in diet, weight loss, physical activity and alcohol consumption, the desired level of consumption is on a sliding scale and the optimal may differ for different individuals based on their current consumption levels, and what they feel is achievable. Little or no research has been conducted in how these targets are set but it is important as targets that are too easy may not optimise cost-effectiveness and targets that are difficult to achieve may de-motivate and lead to failure.

The sustainability of incentives remains in doubt and depends on how they are financed. Research is needed to explore alternative financing models that might involve charities and the commercial sector. The cost structure may also play a part in ensuring that they do not increase inequalities. For example, introducing means-tested enrolment fees would ensure that higher income individuals could still participate in schemes but would help fund the incentive payments to those on lower income (whose fees are waived). Introducing an enrolment fee (of $50) has been shown not to significantly reduce participation in schemes although the potential incentive would have to make the investment worth it.(661)

Additional research is also required on the cost-effectiveness of incentives. Future economic evaluations would be aided by micro-costing of incentive schemes, including incentive costs but also less tangible costs such as cost of marketing and running the schemes. This element was estimated in the current analysis which is a shortcoming. Finally, future decision-modelling work should explore the extent to which success in attracting low income individuals into programmes and achieving behaviour change may reduce inequalities and therefore have distributional effects. This requires some trial estimates relating to any such distributional effects to parameterise the decision model.

10.6. Conclusion

In the face of increasing evidence from experimental psychology and other areas it is increasingly untenable to see economics as anything other than behavioural. Decisions, including those relating to health, are refracted through a lens of perceptions and attitudes, and subject to a number biases and errors. The NHS is under increasing financial pressure and a substantive proportion of its available resources are expended in dealing with the consequences of preventable diseases which result from health behaviour decisions.

Financial incentives are increasingly being explored as a way to bring about health behaviour change. However, we are still some way away from a sufficient understanding of incentives and there are few examples of well designed schemes. As Loewenstein and colleagues point out, poor design may lead to the widening of health inequalities because they reward healthy behaviours which are disproportionately higher in higher income individuals.(361) The research conducted here sought to apply behavioural economic concepts to standard economic approaches and to apply technology assessment methods to improve the understanding of financial incentives for preventive health. The research provides some evidence that may be useful for future scheme design, may remove some of the barriers to further use and exploration and highlights key areas for future investigation. Further research is encouraged to build on what is presented here.

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12. Appendix

12.1. Pilot VHCQ

I.D ___________

Valuing Health Questionnaire

The purpose of this questionnaire is to collect information about how you think about your health, your lifestyle and what you think about certain health problems

The information you provide will help us understand people's attitudes to health and what helps people to take up healthier lifestyles.

Please answer all of the questions you feel able to. There are no right or wrong answers. All of your responses are anonymous and confidential and **will not** affect any treatment you might receive in the future.

Thank you for your help

If you have any questions about the research please contact

David Meads, telephone: 0113 343 0860

Please enter today's date:

d	d	m	m	y	y	y	y

First, a few questions about you

1. What is your date of birth?

d	d	m	m	y	y	y	y	

2. Are you? (*please tick one*): ❑ Male ❑ Female

3. How many children do you have (under 18)?

4. Which ethnic group do you belong to? *(please tick only one)*

- ❑ White
- ❑ Asian or Asian British
- ❑ Black or Black British
- ❑ Chinese
- ❑ Mixed ethnicity
- ❑ Gypsy / traveller
- ❑ Other ethnic group

Your education

5. What is the highest level of education you have completed? *(please tick only one)*

- University or college or equivalent ❑
- Intermediate between secondary level and university (e.g. technical training) ❑
- Secondary school ❑
- Primary school (or less) ❑

Your employment and income

6. What is your current employment status? *(please tick only one)*

- ❑ Employed (full or part time)
- ❑ On long term sick leave
- ❑ Housewife
- ❑ Retired
- ❑ Full time student
- ❑ Unemployed

7. Please estimate the **<u>monthly</u>** income of your household (before deducting tax and national insurance)? If you receive any benefits or pensions please include them as income. *(please tick only one)*

- ❑ Less than £500
- ❑ £2501 - £3500
- ❑ £501 - £1500
- ❑ £3501 - £4500
- ❑ £1501 - £2500
- ❑ More than £4500

Your attitudes

8. Compared to most people, how willing are you to take risks? *For example, do you like to gamble or do you often drive faster than the speed limit?* *(Please tick only one)*

Not at all 0	1	2	3	4	5	Very 6
❑	❑	❑	❑	❑	❑	❑

Your health

1. Do you have any medical conditions, illnesses or disabilities?
❑ Yes ❑ No

If you ticked 'Yes', please list your main illnesses or disabilities:

…….
….

…….
….

2. Thinking about your life in general and your current circumstances, how happy are you at the moment? *(Please tick one)*

Extremely happy	Very happy	Happy	Neither happy or unhappy	Unhappy	Very unhappy	Extremely unhappy
❑	❑	❑	❑	❑	❑	❑

3. Thinking only about your health, how would you rate your overall health at the moment? *(Please tick one)*

Extremely good	Very good	Good	Fair	Poor	Very poor	Extremely poor
❑	❑	❑	❑	❑	❑	❑

Your Health-Related Quality of Life

By placing a tick in **one** box in each group below, please indicate which statement best describes your own health state **today**.

Mobility

I have no problems in walking about ❑

I have some problems walking about ❑

I am confined to bed ❑

Self Care

I have no problems with self care ❑

I have some problems washing or dressing myself ❑

I am unable to wash or dress myself ❑

Usual Activities

(e.g. work, study, housework, family or leisure activities)

I have no problems with performing my usual activities ❑

I have some problems with performing my usual activities ❑

I am unable to perform my usual activities ❑

Pain/Discomfort

I have no pain or discomfort ❑

I have moderate pain or discomfort ❑

I have extreme pain or discomfort ❑

Anxiety/Depression

I am not anxious or depressed ❑

I am moderately anxious or depressed ❑

I am extremely anxious or depressed ❑

To help people say how good or bad their health state is, we have drawn a scale (rather like a thermometer) on which the best health you can imagine is marked 100 and the worst health you can imagine is marked 0.

Box 1.

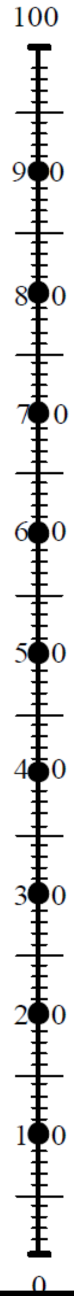
We would like you to indicate on this scale how good or bad you own health is today, in your opinion. Please do this by drawing a line from the **Box 1** to whichever point on the scale indicates how good or bad you health is **today**.

Box 2.

Next, we would like you to imagine what your health state will be in 10 year's time, assuming you continue will your current lifestyle (e.g. you have the same diet, same levels of alcohol and cigarette use and same physical activity levels).

Please indicate on this scale how good or bad you expect your own health to be in **10 years time** by drawing a line to the scale from **Box 2**.

Best imaginable health



Box 1:

Your own health today

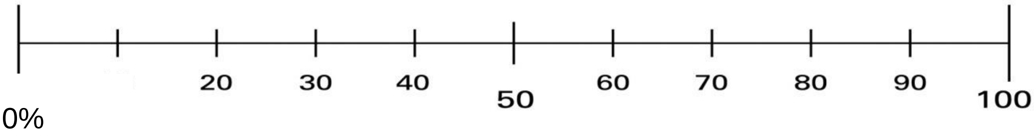
Box 2:

Your health in 10 year's time

Worst imaginable health

1. Taking into account your current lifestyle (your weight, diet, whether you smoke, drink alcohol and how much you exercise), what do you think is the chance (0-100%) that you will suffer from an illness such as heart disease or stroke in the next 10 years?

Please mark on the line with a cross what you think your chances are



0%

(It definitely

100%

(It definitely

2. How likely do you think it is that you will suffer from an illness such as heart disease or stroke in the next 10 years? (*please tick one*)

Very unlikely 0	1	2	3	4	5	Very likely 6
❑	❑	❑	❑	❑	❑	❑

3. Many factors can affect the length of a person's life (for example, smoking and diet). Assuming you continue with your current lifestyle, how old do you think you will live to be?

I think I will live to be............years old

Imaginary health exercise

For this question please **IMAGINE** you have recently had a stroke. Please read the description of what it is like to have had a stroke (Box 1) and then answer the question below.

Box 1: Description of a major stroke

The right side of your body is totally limp (paralysed)

You can think clearly

Your speech is slow and unclear but understandable

You have full control of bladder and bowel

You must use a wheelchair, because you cannot walk at all

You need some help for feeding, dressing and transferring

You are totally dependent on help for bathing

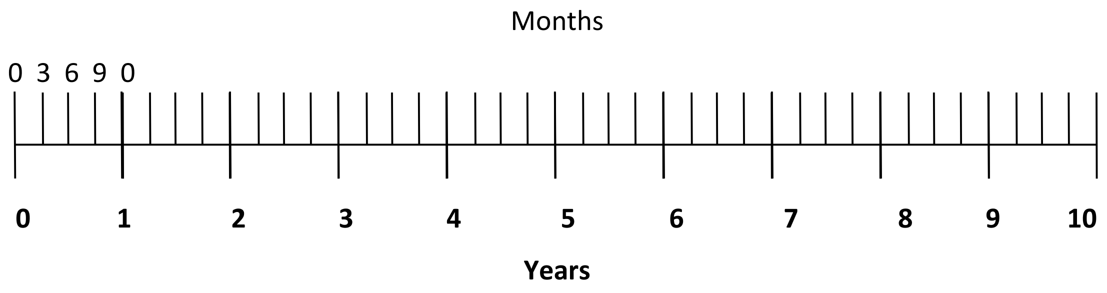
Imagine that you have had a stroke and your health is as described above in Box 1. Also imagine that you will live in this situation for 10 years, after which you die. Now imagine that there is a cure for the stroke symptoms that would return you to full health. The only problem with the cure is that it shortens life expectancy. This means that you would live for less than 10 years but in full health.

So please imagine that you were in the situation described in **Box 1** and would be for 10 years.

1. Would you accept the cure, if it meant living a shorter life but in full health?

❑ Yes ❑ No

2. If you ticked 'Yes', what is the minimum number of months/years in full health you would want after the cure? (*Please mark your answer on the scale below*).



3. For each question below **imagine** that you have the choice between living for the next 10 years with the stroke symptoms described in Box. 1 (after which you would die) or living fewer years but in full health (after which you would die).

For each pair of options please tick **one** box. Please tick one answer in <u>each</u> pair

Live 10 years with stroke symptoms ❑ Live 6 months in full health ❑	Live 10 years with stroke symptoms ❑ Live 6 years in full health ❑
Live 10 years with stroke symptoms ❑ Live 1 year in full health ❑	Live 10 years with stroke symptoms ❑ Live 7 years in full health ❑
Live 10 years with stroke symptoms ❑ Live 2 years in full health ❑	Live 10 years with stroke symptoms ❑ Live 8 years in full health ❑
Live 10 years with stroke symptoms ❑ Live 3 years in full health ❑	Live 10 years with stroke symptoms ❑ Live 9 years in full health ❑
Live 10 years with stroke symptoms ❑ Live 4 years in full health ❑	Live 10 years with stroke symptoms ❑ Live 9 years and 6 months in full health ❑
Live 10 years with stroke symptoms ❑ Live 5 years in full health ❑	Live 10 years with stroke symptoms ❑ Live 9 years and 9 months in full health ❑

Imagine again that you have a stroke and will live in the situation described in **Box 1** for the rest of your life. Now Imagine a new (make believe) pill is available to cure stroke symptoms. Your doctor advises you that if you take the pill today and it works you will not have any stroke symptoms and will live the rest of your life in full health. However, if you take the pill today and it *does not* work it causes sudden and painless death in your sleep tonight. Your doctor has no way of predicting which patients will be cured by this new (make believe) pill, and will support whatever decision you make. We want to know what you think about this pill.

4. **Would you take this (make believe) pill right now if you knew . . .** (please circle yes or no for every question).	**Please circle yes or no**
. . . it had a **100%** chance of cure and **0%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **99.9999%** chance of cure and a **1 in 1 million** risk of causing death in your sleep tonight?	Yes No
. . . it had a **99.999%** chance of cure and a **1 in 100,000 (**risk of causing death in your sleep tonight?	Yes No
. . . it had a **99.99%** chance of cure and a **1 in 10,000** risk of causing death in your sleep tonight?	Yes No
. . . it had a **99.9%** chance of cure and a **1 in 1000** risk of causing death in your sleep tonight?	Yes No
. . . it had a **99%** chance of cure and **1%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **97%** chance of cure and **3%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **95%** chance of cure and **5%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **90%** chance of cure and **10%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **80%** chance of cure and **20%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **75%** chance of cure and **25%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **65%** chance of cure and **35%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **60%** chance of cure and **40%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **50%** chance of cure and **50%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **40%** chance of cure and **60%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **30%** chance of cure and **70%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **20%** chance of cure and **80%** risk of causing death in your sleep tonight?	Yes No
. . . it had a **10%** chance of cure and **90%** risk of causing death in your sleep tonight?	Yes No

We now like you to do the same exercises but this time **IMAGINING** you have heart disease and are in the situation described in **Box 2**.

Box 2: Description of heart disease symptoms

You have noticeable limits to how much physical activity you can do

You are comfortable only when resting

Physical activity makes you tired, have palpitations or short of breath

It is difficult to sleep well at night

Walking is difficult

It's difficult to participate in sports, hobbies or recreational pastimes

Imagine now that you have heart disease and your health is as described above in Box 2. Also imagine that you will live in this situation for 10 years, after which you die. Now imagine that there is a cure for heart disease that would return you to full health. The only problem with the cure is that it shortens life expectancy. This means that you would live for less than 10 years but in full health.

So please imagine that you were in the situation described in **Box 2** and would be for 10 years.

5. Would you accept the cure, if it meant living a shorter life but in full health? ❑ Yes ❑ No

6. If you ticked 'Yes', what is the minimum number of months/years in full health you would want after the cure? (*Please mark your answer on the scale below*).

Months

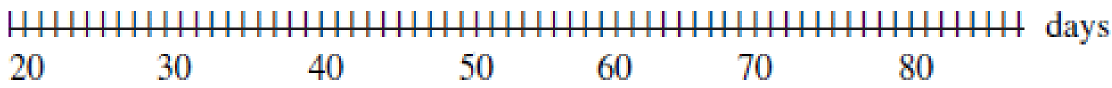
0 3 6 9 0

0 1 2 3 4 5 6 7 8 9
10

Years

Imagine that you will be ill starting 2 years from now for 20 days (after which you return to normal health). Now imagine that there is a treatment that will postpone the illness so it will not start in 2 years but in 6 years time. Although the treatment delays the illness, it means you will be ill for longer than 20 days. How many extra days would be prepared to be ill for, if it meant you could put off being ill until 6 years from now?

7. Please mark on the scale below the maximum number of days of illness you would be willing to accept to delay the illness.



8. Imagine you won a prize draw competition and the prize was either £50 now **OR** instead you could receive £100 in 12 months' time. Which would you choose? (*Please tick only one*)

£50 now	❑
£100 in 12 months' time	❑

9. If you would choose £50 now, how much would you have to receive in 12 months' time instead to choose the second option? £..............

Changing your health behaviour

For this section of the questionnaire we would like you to think about your current lifestyle and health (your weight, your diet, your level of physical activity, whether you smoke or not or drink alcohol). We would then like you to think about what it would take to get you to change your behaviour.

1. How difficult do you think it would be for you to do the following:

Health change	**Very easy 0**	**1**	**2**	**3**	**4**	**5**	**Very difficult 6**
Stop smoking (Tick here if you do not smoke ❑)	❑	❑	❑	❑	❑	❑	❑
Lose weight	❑	❑	❑	❑	❑	❑	❑
Eat less fat, salt and sugary foods	❑	❑	❑	❑	❑	❑	❑
Exercise for 30 minutes, 3 times a week	❑	❑	❑	❑	❑	❑	❑
Drink alcohol in moderation	❑	❑	❑	❑	❑	❑	❑

2. How likely do you think it is that you could significantly affect how long you will live by the lifestyle choices (for example, smoking, not exercising) you make? (*please tick one*)

Very unlikely 0	1	2	3	4	5	Very likely 6
❑	❑	❑	❑	❑	❑	❑

Please **IMAGINE** that the NHS would be willing to pay people to change their lifestyles. The NHS would pay you an amount every month for <u>one year</u> and you would be tested or weighed every month to make sure you maintained a healthier lifestyle.

(*Please keep in mind this is an **imaginary exercise** – the NHS are not proposing to pay people to change their health behaviours.*)

3. What is the minimum amount of money per month that you would want to persuade you to change your behaviour? Please consider each separately. For each health change please write an amount.

Behaviour change	**I would have to be paid**
To stop smoking (Tick here if you do not smoke ❑)	£……….. per month
To go on a calorie controlled diet and weight loss programme	£………. per month
To exercise for 30 minutes at least 3 times a week	£………. per month
To reduce the amount of alcohol you drink to a moderate amount	£………. per month

4. People who live unhealthy lifestyles have a high risk of dying from diseases such as stroke or heart disease or of being left disabled by them. Given that eating too much fat, salt and sugar; smoking; drinking alcohol; and not getting enough exercise can increase the risks of stroke or heart disease, how likely are you to try and change your behaviour to become healthier? (*please tick one*)

Very unlikely 0	1	2	3	4	5	Very likely 6
❑	❑	❑	❑	❑	❑	❑

5. Imagine your doctor told you that you have a 1 in 5 risk of a heart attack or stroke in the next 10 years, how likely would you be to try and change your behaviour to become healthier? (*please tick one*)

Very unlikely 0	1	2	3	4	5	Very likely 6
❑	❑	❑	❑	❑	❑	❑

Thank you for completing the questionnaire. Please take a moment to check that you have responded to all of the questions.

12.1.1. *Pilot survey questions*

Health Valuation Survey – pilot test schedule

Time started questionnaire:............... Time finished:.....................

Does the respondent read the instructions to the questions? Yes ❑ No ❑

Were any questions difficult to answer or understand? Yes ❑ No ❑

If Yes:

Question No.	Why difficult?

Which question did you find easiest to answer?

Your Health Question 6	❑
Your Health Question 7	❑
Imaginary health Question 2	❑
Imaginary health Question 3	❑
Imaginary health Question 2	❑
Imaginary health Question 4	❑
Imaginary health Question 5	❑
Imaginary health Question 6	❑

Did the respondent take a long time over any questions or appear to struggle? Yes ❑ No ❑

Did the respondent check their to make sure they answered all questions Yes ❑ No ❑

Which questions?

Did the respondent check their to make sure they answered all questions Yes ❑ No ❑

Did the respondent miss any questions? Yes ❑ No ❑

If yes, which?...

Do you have any comments on the questionnaire?

12.2. Contingent valuation analysis

12.2.1. Comparison of samples

Table 52: Comparing recruited vs. VHCQ completers

	n	Odds Ratio	SE	z	P>z	LCI	UCI
Male	130	0.85	0.35	-0.39	0.696	0.38	1.92
Education to college or higher	130	1.42	0.61	0.81	0.419	0.61	3.31
EQ-5D	128	0.53	0.36	-0.94	0.347	0.14	2.00
EQ-5D VAS	130	1.01	0.01	1.02	0.306	0.99	1.03
Not in control arm	132	0.93	0.36	-0.2	0.844	0.43	2.00
Age	132	0.97	0.02	-1.23	0.217	0.93	1.02
Smoker	130	0.90	0.38	-0.26	0.797	0.39	2.08
Drinks alcohol	129	1.23	0.53	0.47	0.635	0.53	2.87
Exercises	128	1.72	0.79	1.18	0.238	0.70	4.24
BMI group (vs. <25)	122						
25-30		1.85	1.01	1.13	0.259	0.64	5.41
>30		1.93	1.03	1.23	0.221	0.68	5.49

Table 53: Comparing baseline vs. 3 month VHCQ completers

	n	Odds Ratio	SE	z	P>z	LCI	UCI
Male	112	1.08	0.42	0.19	0.847	0.51	2.29
Education to college or higher	112	2.33	0.93	2.12	**0.034**	1.07	5.09
Income ≥£2000 pm	91	0.84	0.36	-0.42	0.678	0.36	1.93
EQ-5D	111	2.73	1.66	1.65	0.099	0.83	8.98
EQ-5D VAS	112	1.01	0.01	0.98	0.325	0.99	1.03
Not in control arm	112	1.91	0.73	1.69	0.09	0.90	4.05
Age	112	1.02	0.02	1.05	0.292	0.98	1.07
Mean Difficulty*	97	1.02	0.14	0.14	0.891	0.78	1.34
Mean WTA*	94	0.99	0.00	-1.97	**0.049**	0.99	1.00
Smoker	112	0.71	0.29	-0.82	0.412	0.32	1.60
Drinks alcohol	112	0.78	0.32	-0.61	0.541	0.35	1.74
Exercises	111	0.69	0.28	-0.92	0.356	0.32	1.51
BMI group (vs. <25)							
25-30	107	1.05	0.56	0.1	0.923	0.37	2.99
>30		1.00	0.52	0	1	0.36	2.76

*Averages were taken of the responses to the difficulty questions and WTA the guaranteed incentive at baseline

12.2.2. *Logistic regression results*

Table 54: Logistic regression for £0 vs >£0 $WTA_{Certain}$ responses

	Wald chi^2 =	10.640			n =	43
	Log likelihood =	-16.184			Prob > chi^2 =	**0.031**
Smoking	**Beta**	**SE**	**z**	**P>z**	**Lower CI**	**Upper CI**
Not in Control	3.316	1.243	2.670	**0.008**	0.879	5.754
EQ-5D VAS	-0.045	0.026	-1.730	0.083	-0.095	0.006
age >=59	-0.120	0.063	-1.900	0.058	-0.244	0.004
VisitCycle = 3 months	3.257	1.355	2.400	**0.016**	0.602	5.912
Constant	4.840	3.576	1.350	0.176	-2.169	11.849

	Wald chi^2 =	7.25			n =	117
	Log likelihood =	-66.476			Prob > chi^2 =	0.0645
Weight	**Beta**	**SE**	**z**	**P>z**	**Lower CI**	**Upper CI**
Perceive weight loss as difficult	0.844	0.730	1.160	0.248	-0.587	2.275
Not in Control	2.248	0.954	2.360	**0.018**	0.378	4.119

Disagree with incentives	-1.568	0.811	-1.930	0.053	-3.159	0.022
Constant	0.486	0.728	0.670	0.505	-0.941	1.914

Wald chi^2 =	20.9	n =	136
Log likelihood =	-77.920	Prob > chi^2 =	**0.002**

Exercise	Beta	SE	z	P>z	Lower CI	Upper CI
Not in Control	1.159	0.466	2.490	**0.013**	0.245	2.072
Disagree with incentives	-1.615	0.465	-3.480	**0.001**	-2.526	-0.705
EQ-5D	1.229	0.678	1.810	0.070	-0.101	2.559
Discount rate groups						
20-100%	0.534	0.475	1.120	0.261	-0.397	1.466
>100%	0.844	0.522	1.620	0.106	-0.180	1.868
age >=59	-0.492	0.393	-1.250	0.210	-1.262	0.278
Constant	0.165	0.704	0.230	0.815	-1.216	1.546

Wald chi^2 =	20.91	n =	96
Log likelihood =	-48.648	Prob > chi^2 =	**0.004**

Alcohol	Beta	SE	z	P>z	Lower CI	Upper CI
Perceive alcohol reduction as difficult	2.158	0.671	3.220	**0.001**	0.843	3.472
Believe at high risk of health event	-1.038	0.573	-1.810	0.070	-2.162	0.085
Disagree with incentives	-1.293	0.583	-2.220	**0.027**	-2.436	-0.150
EQ-5D	0.722	0.831	0.870	0.385	-0.907	2.350
age >=59	-1.234	0.541	-2.280	**0.022**	-2.294	-0.175
VisitCycle = 3 months	1.349	0.588	2.300	**0.022**	0.197	2.501
Education to college or higher	1.467	0.576	2.550	**0.011**	0.338	2.596
Constant	-1.595	0.995	-1.600	0.109	-3.545	0.355

12.2.3. Multinomial regression results

WTA$_{Certain}$ reward responses were collapsed due to low samples in some categories.

Table 55: Multinomial regression for WTA$_{Certain}$ (all vs. £0)

N =	44
Wald chi2(12) =	760.91
Prob > chi2 =	0.0000
Pseudo R2 =	0.27
Log pseudo likelihood	-42.56

Smoking	**Beta**	**SE**	**Z**	**P>Z**	**Lower CI**	**Upper CI**
£1-£30						
Perceived smoking cessation as difficult	14.77	0.86	17.20	**0.000**	13.08	16.45
Not in Control	2.97	1.41	2.11	**0.035**	0.21	5.74
Not motivated	1.15	1.09	1.06	0.290	-0.98	3.29
VisitCycle = 3 months	1.05	1.52	0.69	0.489	-1.92	4.02
Constant	-17.91	1.80	-9.97	**0.000**	-21.43	-14.39
£31-£100						
Perceived smoking cessation as difficult	1.20	1.01	1.19	0.234	-0.78	3.18
Control	2.55	1.28	1.99	**0.046**	0.04	5.06
Not motivated	0.10	1.06	0.10	0.924	-1.99	2.19
VisitCycle = 3 months	1.58	0.90	1.75	0.080	-0.19	3.35
Constant	-3.72	1.41	-2.63	**0.008**	-6.49	-0.95
Over £100						
Perceived smoking cessation as difficult	-0.01	1.48	-0.01	0.996	-2.90	2.89
Control	4.25	1.39	3.06	**0.002**	1.53	6.97
Not motivated	2.39	1.01	2.36	**0.018**	0.41	4.36
VisitCycle = 3 months	3.00	1.26	2.38	**0.017**	0.53	5.47
Constant	-6.56	1.78	-3.69	**0.000**	-10.05	-3.08

N =	110
Wald chi2(12) =	34.24
Prob > chi2 =	0.0032
Pseudo R2 =	0.14
Log pseudo likelihood	-123.90

Weight loss	**Beta**	**SE**	**Z**	**P>Z**	**Lower CI**	**Upper CI**
£1-£30						

age >=59	-0.09	0.58	-0.15	0.880	-1.22	1.05
BMI Group	0.16	0.48	0.33	0.741	-0.78	1.09
Not in Control	1.13	0.58	1.93	0.053	-0.02	2.27
Disagree with incentives	-0.51	0.63	-0.81	0.417	-1.74	0.72
VisitCycle = 3 months	-0.26	0.53	-0.49	0.623	-1.30	0.78
Constant	-0.34	0.97	-0.35	0.724	-2.23	1.55
£31-£100						
age >=59	-1.35	0.59	-2.30	**0.021**	-2.50	-0.20
BMI Group	0.85	0.46	1.84	0.065	-0.05	1.75
Not in Control	1.82	0.65	2.79	**0.005**	0.54	3.11
Disagree with incentives	-0.91	0.62	-1.48	0.139	-2.12	0.30
VisitCycle = 3 months	0.35	0.56	0.63	0.531	-0.75	1.45
Constant	-1.64	1.11	-1.48	0.138	-3.81	0.53
Over £100						
age >=59	-0.07	0.76	-0.09	0.926	-1.56	1.42
BMI Group	-0.04	0.46	-0.09	0.929	-0.95	0.87
Not in Control	2.26	0.74	3.06	**0.002**	0.81	3.71
Disagree with incentives	-1.78	0.72	-2.47	**0.013**	-3.20	-0.37
VisitCycle = 3 months	1.43	0.70	2.04	**0.041**	0.06	2.80
Constant	-2.82	1.35	-2.09	**0.036**	-5.46	-0.18

N =	137
Wald chi2(12) =	35.17
Prob > chi2 =	0.0023
Pseudo R2 =	0.13
Log pseudo likelihood	-156.08

Exercise	**Beta**	**SE**	**Z**	**P>Z**	**Lower CI**	**Upper CI**
£1-£30						
age >=59	-0.24	0.54	-0.44	0.662	-1.29	0.82
EQ-5D VAS	0.03	0.01	2.49	**0.013**	0.01	0.05
Perceived exercise as difficult	-0.40	0.55	-0.73	0.466	-1.49	0.68
Not in Control	0.95	0.58	1.62	0.106	-0.20	2.09
Disagree with incentives	-1.53	0.60	-2.55	**0.011**	-2.71	-0.35
Constant	-1.32	0.92	-1.44	0.150	-3.12	0.48
£31-£100						
age >=59	-1.26	0.51	-2.46	**0.014**	-2.26	-0.26
EQ-5D VAS	0.00	0.01	0.15	0.879	-0.02	0.03
Perceived exercise as difficult	0.26	0.56	0.46	0.643	-0.84	1.35

Not in Control	0.96	0.54	1.79	0.073	-0.09	2.01
Disagree with incentives	-1.36	0.56	-2.43	**0.015**	-2.46	-0.26
Constant	0.36	1.02	0.35	0.723	-1.64	2.37
Over £100						
age >=59	0.34	0.64	0.53	0.598	-0.92	1.60
EQ-5D VAS	0.00	0.01	-0.08	0.940	-0.03	0.03
Perceived exercise as difficult	0.65	0.69	0.95	0.342	-0.69	2.00
Not in Control	1.59	0.64	2.48	**0.013**	0.34	2.84
Disagree with incentives	-1.70	0.64	-2.66	**0.008**	-2.94	-0.45
Constant	-1.05	1.24	-0.85	0.396	-3.47	1.37

N =	98
Wald chi2(12) =	28.69
Prob > chi2 =	0.0044
Pseudo R2 =	0.18
Log pseudo likelihood	-98.49

Alcohol	**Beta**	**SE**	**Z**	**P>Z**	**Lower CI**	**Upper CI**
£1-£30						
age >=59	-0.91	0.64	-1.43	0.154	-2.16	0.34
Perceive alcohol reduction as difficult	0.55	0.84	0.65	0.515	-1.10	2.20
Not in Control	0.77	0.63	1.23	0.219	-0.46	2.00
VisitCycle = 3 months	0.59	0.65	0.91	0.364	-0.69	1.88
Constant	-1.72	0.93	-1.84	0.066	-3.55	0.11
£31-£100						
age >=59	-0.85	0.62	-1.38	0.169	-2.07	0.36
Perceive alcohol reduction as difficult	2.14	0.65	3.30	**0.001**	0.87	3.42
Not in Control	-0.03	0.71	-0.04	0.964	-1.42	1.36
VisitCycle = 3 months	1.12	0.54	2.07	**0.038**	0.06	2.17
Constant	-2.56	0.86	-2.96	**0.003**	-4.25	-0.87
Over £100						
age >=59	-2.48	0.89	-2.79	**0.005**	-4.23	-0.74
Perceive alcohol reduction as difficult	2.96	1.04	2.84	**0.005**	0.92	5.00
Not in Control	1.94	0.94	2.06	**0.039**	0.09	3.78
VisitCycle = 3 months	2.32	0.94	2.47	**0.014**	0.48	4.17
Constant	-5.93	1.89	-3.14	**0.002**	-9.63	-2.23

12.2.4. Baseline – 3 month change in WTA

Table 56: Baseline - 3 month change in WTA*

	$WTA_{Certain}$			$WTA_{Uncertain}$			$WTA_{Commitment}$		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
Smoking	9	£59.17	£113.66	8	£0.55	£29.64	8	£55.44	£109.75
Diet	30	£14.08	£83.72	29	-£0.73	£17.62	28	£17.71	£70.35
Exercise	36	£8.82	£82.16	34	-£1.59	£16.10	34	£6.53	£66.38
Alcohol	25	£57.10	£148.83	21	£11.87	£30.22	23	£29.83	£120.65

*Positive values represent an increase in WTA from baseline to 3 months

12.2.5. Pooled time-point descriptives – $WTA_{Uncertain}$ and $WTA_{Commitment}$

12.2.5.1. $WTA_{Uncertain}$

Table 57: Pooled time-point descriptives – $WTA_{Uncertain}$ by demographics and attitudes

	Smoking	Diet	Exercise	Alcohol
Socio-demographics				
Age group				
<=59	£14.49	£7.90	£6.16	£10.72
>59	£14.95	£7.45	£8.40	£8.18
P value	0.769	0.324	0.099	0.121
Sex				
Female	£13.36	£7.20	£8.24	£6.24
Male	£15.23	£8.01	£6.49	£11.19
P value	0.340	0.988	0.524	0.924
Income group				
<£2000 pm	£12.25	£7.12	£9.13	£12.01
>=£2000 pm	£12.14	£7.40	£4.61	£6.54
P value	0.443	0.481	0.021	0.257
Attitude questions				
I am in control				
Agree	£10.85	£6.79	£5.93	£6.90
Disagree	£19.48	£9.39	£9.73	£15.08
P value	0.033	0.007	0.027	0.050
My lifestyle determines health				
Agree	£17.07	£7.06	£6.61	£9.73
Disagree	£5.06	£9.84	£9.61	£8.92
P value	0.846	0.034	0.183	0.833
I am motivated				
Agree	£7.18	£6.86	£5.96	£6.11
Disagree	£29.47**	£9.79	£10.51	£18.46**
P value	0.004	0.227	0.526	0.032
Major achievement				
Agree	£13.04	£6.13	£6.71	£7.07
Disagree	£23.25	£13.00*	£9.41	£16.09
P value	0.441	0.218	0.401	0.049
I am at high risk				
Agree	£19.17	£6.57	£7.51	£10.95

Disagree	£3.01*	£9.95	£6.80	£7.24
P value	0.053	0.739	0.274	0.183
I live for today				
Agree	£20.42	£8.62	£9.61	£12.52
Disagree	£6.26	£6.91	£5.03	£7.39
P value	0.147	0.722	0.460	0.962
I can wait for things				
Agree	£8.60	£6.34	£6.91	£7.03
Disagree	£22.39	£9.95	£7.70	£13.51
P value	0.159	0.339	0.523	0.428
NHS should offer incentives				
Agree	£12.95	£7.12	£9.28	£10.14
Disagree	£15.77	£8.12	£6.04	£9.49
P value	0.400	0.018	0.001	0.117

P values are non-parametric tests (Wilcoxon for two groups, Kruskal Wallis for three groups); *Significant at 95% level (t-test for two groups, ANOVA for three groups); **Significant at 99% level (t-test for two groups, ANOVA for three groups)

Table 58: Pooled time-point descriptives – $WTA_{Uncertain}$ by health behaviour

	Smoking	**Diet**	**Exercise**	**Alcohol**
Health behaviours				
BMI				
<25	-	£16.07	£7.18	-
25-30	-	£5.61	£6.58	-
>30	-	£8.39	£8.18	-
P value		0.696	0.943	
AUDIT Score				
<4	-	-	-	£4.62
>=4	-	-	-	£11.21
P value				0.587
Difficulty of change				
Easy	£18.60	£7.92	£4.22	£7.12
Difficult	£14.02	£7.44	£9.20	£15.22
P value	0.733	0.405	0.030	0.003
Discount rate				
<20%	£25.32	£9.55	£4.43	£6.66
20%-100%	£14.86	£6.94	£6.92	£7.59
>100%	£11.76	£6.85	£10.08	£14.26
P value	0.597	0.981	0.241	0.391

P values are non-parametric tests (Wilcoxon for two groups, Kruskal Wallis for three groups); *Significant at 95% level (t-test for two groups, ANOVA for three groups); **Significant at 99% level (t-test for two groups, ANOVA for three groups)

12.2.5.2. $WTA_{Commitment}$

Table 59: Pooled time-point descriptives – $WTA_{Commitment}$ by demographics and attitudes

	Smoking	Diet	Exercise	Alcohol
Socio-demographics				
Age group				
<=59	£39.62	£40.24	£42.46	£51.41
>59	£43.30	£32.71	£36.70	£34.56
P value	0.987	0.276	0.012	0.185
Sex				
Female	£14.00	£33.12	£35.26	£26.63
Male	£54.83	£39.05	£42.85	£52.98
P value	0.087	0.214	0.150	0.036
Income group				
<£2000 pm	£44.81	£25.86	£37.11	£45.74
>=£2000 pm	£35.65	£47.44	£43.63	£44.31
P value	0.419	0.087	0.600	0.251
Attitude questions				
I am in control				
Agree	£23.98	£30.31	£30.27	£28.48
Disagree	£60.78	£48.20	£58.30*	£76.43**
P value	0.075	0.022	0.004	0.008
My lifestyle determines health				
Agree	£43.94	£34.53	£36.06	£46.43
Disagree	£26.94	£43.86	£54.56	£33.44
P value	0.531	0.276	0.093	0.701
I am motivated				
Agree	£33.68	£33.85	£36.11	£38.63
Disagree	£56.54	£44.02	£49.68	£58.20
P value	1.000	0.504	0.657	0.981
Major achievement				
Agree	£45.03	£41.32	£44.22	£49.39
Disagree	£19.36	£24.02	£27.65	£35.23
P value	0.720	0.493	0.245	0.804

I am at high risk				
Agree	£49.41	£41.40	£47.78	£52.52
Disagree	£17.14	£28.32	£26.09	£29.15
P value	0.442	0.747	0.293	0.511
I live for today				
Agree	£33.04	£42.55	£49.07	£43.15
Disagree	£51.78	£31.49	£30.58	£44.68
P value	0.148	0.888	0.641	0.330
I can wait for things				
Agree	£38.79	£38.06	£40.29	£40.08
Disagree	£43.16	£34.19	£38.84	£50.29
P value	0.381	0.945	0.673	0.893
NHS should offer incentives				
Agree	£52.18	£38.49	£46.23	£55.35
Disagree	£34.27	£35.92	£36.67	£38.72
P value	0.213	0.207	0.122	0.751

P values are non-parametric tests (Wilcoxon for two groups, Kruskal Wallis for three groups); *Significant at 95% level (t-test for two groups, ANOVA for three groups); **Significant at 99% level (t-test for two groups, ANOVA for three groups)

Table 60: Pooled time-point descriptives – $\text{WTA}_{\text{Commitment}}$ by health behaviour

	Smoking	Diet	Exercise	Alcohol
Health behaviours				
BMI				
<25	-	£17.60	£26.50	-
25-30	-	£35.93	£39.95	-
>30	-	£32.64	£37.61	-
P value		0.464	0.742	
AUDIT Score				
<4	-	-	-	£26.54
>=4	-	-	-	£49.91
P value				0.771
Difficulty of change				
Easy	£18.75	£32.33	£31.00	£31.75
Difficult	£44.38	£39.40	£45.98	£74.66*
P value	0.378	0.653	0.823	0.047
Discount rate				
<20%	£67.17	£38.91	£37.86	£46.02
20%-100%	£38.33	£47.92	£46.87	£43.54
>100%	£33.87	£15.62	£31.47	£42.80
P value	0.721	0.053	0.657	0.068

P values are non-parametric tests (Wilcoxon for two groups, Kruskal Wallis for three groups); *Significant at 95% level (t-test for two groups, ANOVA for three groups); **Significant at 99% level (t-test for two groups, ANOVA for three groups)

12.2.6. Additional figures for $WTA_{Uncertain}$ and $WTA_{Commitment}$

Figure 28: $WTA_{Uncertain}$ by difficulty of change

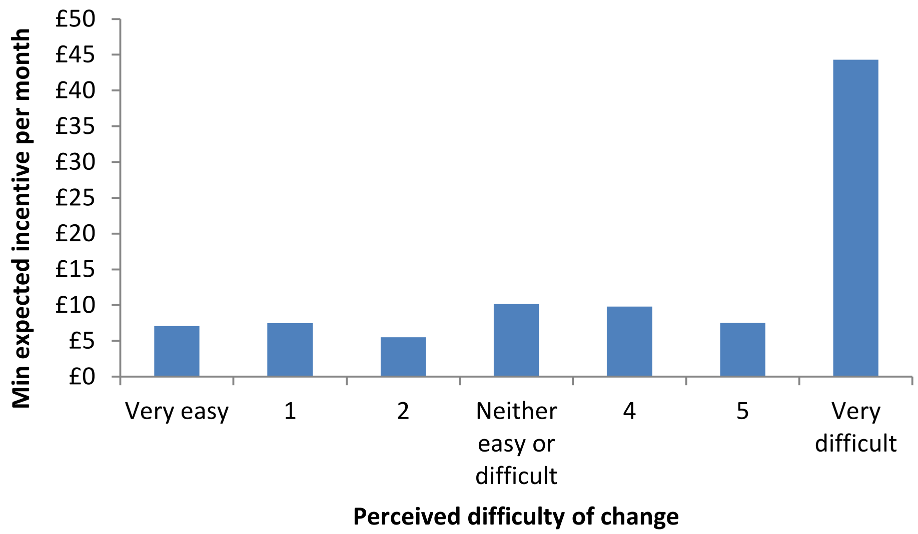


Figure 29: $WTA_{Commitment}$ by difficulty of change

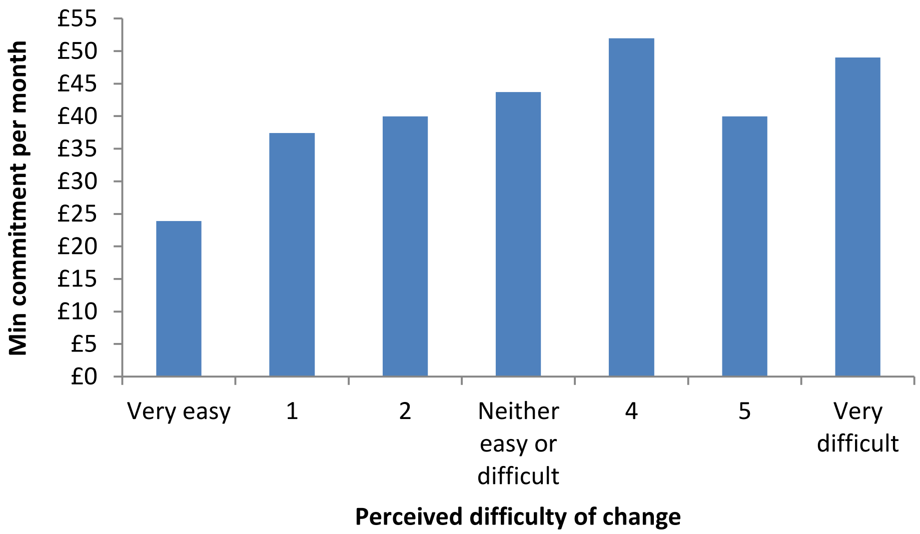


Figure 30: $WTA_{Commitment}$ by motivation

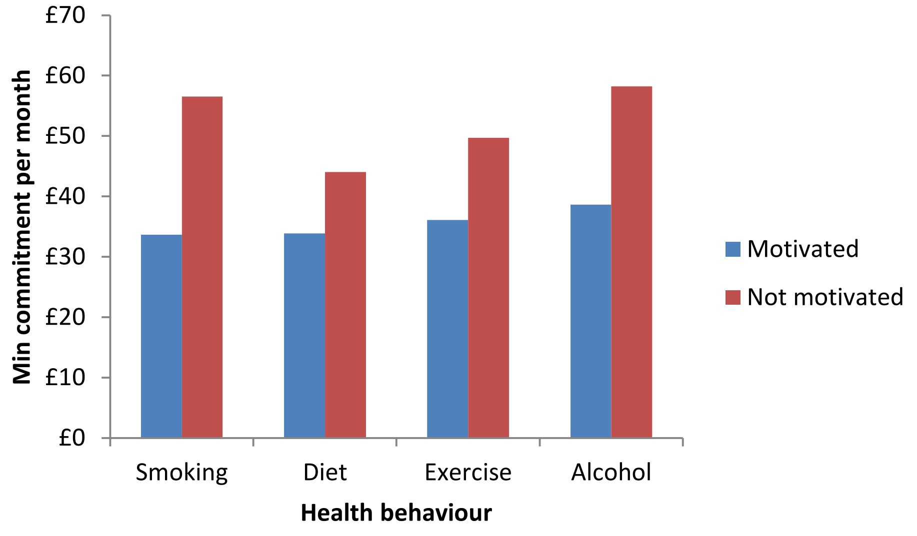
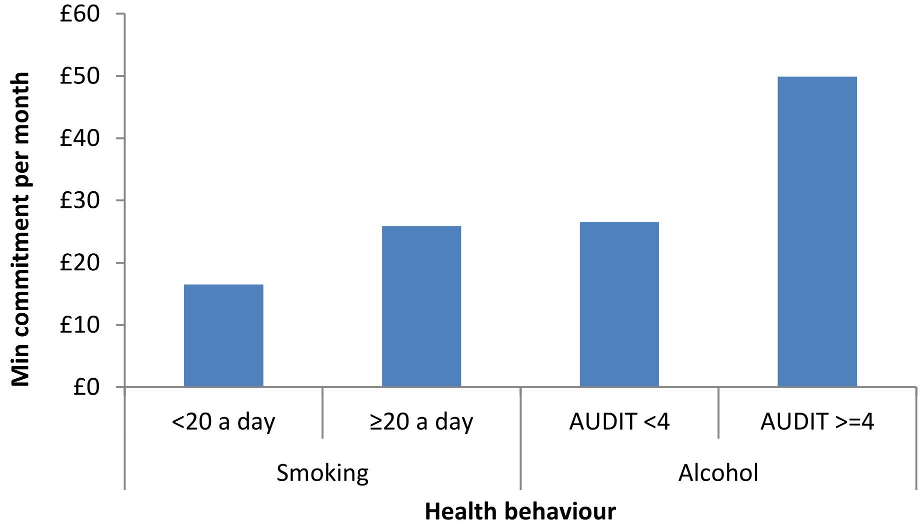


Figure 31: $WTA_{Commitment}$ by health behaviour strength



12.2.7. Analysis diagnostics – choosing GLM family

Table A includes the results from the Modified Park Test. The coefficients result from the respective GLM model to predict squared residuals using a log of the target independent variable as a predictor. The beta on the log value indicates which family is appropriate for the data where: 0 = Gaussian; 1 = Poisson; 2 = Gamma; 3 = Inverse Gaussian. Table B tests for significant difference between the beta and specified beta value (0-3). Insignificant Chi^2 indicates the respective family would be appropriate.

Table 61: Results of the Modified Park Test for GLM

A		Beta on Log Variable							
Family	**Link**	**Smoking**		**Weight loss**		**Exercise**		**Alcohol**	
Gamma	Log	1.64		1.31		1.66		1.39	
Gamma	Identity	Not converge		Not converge		5327.26		Not converge	
Poisson	Identity	Not converge		3922.23		4446.16		Not converge	
Poisson	Log	1.26		0.85		1.09		0.7	
Gaussian	Log	0.91		0.66		0.65		0.01	
Gaussian	Identity*	N/A		N/A		N/A		N/A	
Inv Gaussian	Log	Not possible		Not possible		Not possible		Not possible	
Inv Gaussian	Identity	Not possible		Not possible		Not possible		Not possible	
B		**Smoking**		**Weight loss**		**Exercise**		**Alcohol**	
		Chi^2	**P**	**Chi^2**	**P**	**Chi^2**	**P**	**Chi^2**	**P**
Gamma family and Log link									
Gaussian=0		44.13	0.000	7.34	0.0067	37.87	0.000	41.1	0.000
Poisson=1		6.72	0.0095	0.41	**0.5244**	6.02	0.0142	3.22	**0.0725**
Gamma=2		2.12	**0.1451**	2.06	**0.151**	1.56	**0.2121**	7.95	0.0048
Inv Gaussian=3		30.33	0.000	12.31	0.0005	24.49	0.000	55.28	0.000
Poisson family and Log link									
Gaussian=0		8.51	0.0035	7.7	0.0055	4.81	0.0283	10.98	0.0009
Poisson=1		0.37	**0.5418**	0.23	**0.628**	0.03	**0.8581**	1.91	**0.1672**
Gamma=2		2.88	**0.0898**	14.02	0.0002	3.37	**0.0663**	36.91	0.000
Inv Gaussian=3		16.03	0.0001	49.06	0.000	14.83	0.0001	115.99	0.000

*Equivalent to normal distribution

12.2.8. Predicting $WTA_{Uncertain}$ and $WTA_{Commitment}$

12.2.8.1. Individual behaviours

Table 62: Predicting $WTA_{Uncertain}$ for individual behaviours

Smoking			**AIC =**	**6.669**		**n = 38**
Log Pseudo likelihood =		**-122.70**	**BIC =**	**-52.61**		
	Coef.	**SE**	**z**	**P > z**	**L 95% CI**	**U 95% CI**
I am motivated	1.91	0.52	3.64	0.000	0.88	2.94
EQ-5D VAS	-0.03	0.01	-2.71	0.007	-0.05	-0.01
Age group (60+)	-1.66	0.54	-3.07	0.002	-2.72	-0.60
Constant	3.55	0.82	4.36	0.000	1.95	5.15

Weight loss			**AIC =**	**6.19**		**n = 102**
Log Pseudo likelihood =		**-311.88**	**BIC =**	**-202.58**		
BMI group (vs. <25)						
25-30	-1.10	0.61	-1.80	0.072	-2.30	0.10
>30	-0.73	0.60	-1.21	0.225	-1.90	0.45
I am in control	0.37	0.38	0.98	0.325	-0.37	1.11
Constant	2.71	0.52	5.18	0.000	1.69	3.74

Exercise			**AIC =**	**5.27**		**n = 119**
Log Pseudo likelihood =		**-304.53**	**BIC =**	**-332.18**		
Income ≥£2,000	-0.83	0.31	-2.71	0.007	-1.43	-0.23
I am in control	0.55	0.28	1.98	0.048	0.01	1.10
NHS should offer incentives	-0.59	0.31	-1.89	0.058	-1.21	0.02
EQ-5D VAS	0.01	0.01	2.46	0.014	0.00	0.02

Education (primary)						
Secondary	0.54	0.36	1.49	0.136	-0.17	1.25
Intermediate	0.61	0.42	1.46	0.144	-0.21	1.42
University	2.19	0.43	5.09	0.000	1.35	3.03
Difficulty exercise	1.18	0.31	3.76	0.000	0.56	1.79
Constant	-0.01	0.56	-0.02	0.986	-1.11	1.09

Alcohol			**AIC =**	**5.57**		**n = 85**
Log Pseudo likelihood =		**-223.59**	**BIC =**	**-155.69**		
Visit (3 month)	1.78	0.36	4.91	0.000	1.07	2.49
Audit group (≥4)	1.40	0.55	2.53	0.011	0.32	2.48
Discount rate (<0.2)						
0.2<1	-0.95	0.40	-2.36	0.018	-1.74	-0.16
≥1	-0.02	0.49	-0.04	0.968	-0.99	0.95
Income ≥£2,000	1.10	0.48	2.29	0.022	0.16	2.04
I am in control	1.12	0.41	2.72	0.006	0.31	1.92
Sex (Male)	-0.85	0.37	-2.32	0.020	-1.57	-0.13
EQ-5D VAS	-0.03	0.01	-2.91	0.004	-0.04	-0.01
Education (primary)						
Secondary	-0.39	0.45	-0.86	0.388	-1.27	0.49
Intermediate	-1.34	0.55	-2.44	0.015	-2.42	-0.27
University	0.36	0.74	0.49	0.627	-1.09	1.82
Difficulty Alcohol	0.21	0.46	0.45	0.653	-0.69	1.10
Constant	0.18	0.78	0.23	0.815	-1.35	1.72

Table 63: Predicting $WTA_{Commitment}$ for individual behaviours

Smoking			**AIC =**	**8.69**		**n = 36**
Log Pseudo likelihood =		**-144.41**	**BIC =**	**-41.21**		
	Coef.	**SE**	**z**	**P > z**	**L 95% CI**	**U 95% CI**
Visit (3 month)	1.91	0.53	3.63	0.000	0.88	2.95
Discount rate (<0.2)						
0.2<1	-1.66	0.84	-1.97	0.049	-3.31	-0.01
≥1	-1.31	0.79	-1.66	0.097	-2.87	0.24
Income ≥£2,000	-0.59	0.40	-1.49	0.136	-1.37	0.19
I am in control	0.36	0.32	1.15	0.250	-0.26	0.99
I am motivated	-0.81	0.34	-2.40	0.016	-1.47	-0.15
I can wait for things	0.66	0.50	1.32	0.186	-0.32	1.64
Sex (Male)	1.67	0.25	6.57	0.000	1.17	2.17
EQ-5D VAS	-0.03	0.01	-1.85	0.064	-0.05	0.00
Education (primary)						
Intermediate	0.09	0.52	0.18	0.859	-0.92	1.11
University	1.32	0.66	2.00	0.046	0.03	2.62
Difficulty smoking	0.60	0.42	1.45	0.147	-0.21	1.42
Constant	1.44	0.99	1.45	0.146	-0.50	3.37

Weight loss			**AIC =**	**8.70**		**n = 98**
Log Pseudo likelihood =		**-414.21**	**BIC =**	**-222.98**		
Visit (3 month)	0.49	0.28	1.77	0.077	-0.05	1.03
BMI group (vs. <25)						

25-30	0.71	0.41	1.73	0.084	-0.09	1.51
>30	0.98	0.33	2.93	0.003	0.32	1.63
Discount rate (<0.2)						
0.2<1	-0.42	0.36	-1.15	0.250	-1.13	0.29
≥1	-1.30	0.36	-3.60	0.000	-2.00	-0.59
Income ≥£2,000	0.56	0.30	1.91	0.056	-0.01	1.14
I am in control	0.53	0.33	1.60	0.109	-0.12	1.17
I am at high risk	-0.73	0.32	-2.25	0.024	-1.37	-0.09
Education (primary)						
Secondary	1.46	0.37	3.96	0.000	0.74	2.18
Intermediate	1.34	0.40	3.35	0.001	0.56	2.13
University	0.63	0.57	1.10	0.269	-0.49	1.74
Constant	0.83	0.54	1.54	0.123	-0.22	1.88

Exercise			**AIC =**	**9.07**		**n = 122**
Log Pseudo likelihood =		**-541.24**	**BIC=**	**-274.68**		
Discount rate (<0.2)						
0.2<1	-0.10	0.33	-0.30	0.764	-0.76	0.56
≥1	-0.64	0.37	-1.72	0.085	-1.36	0.09
Income ≥£2,000	0.48	0.28	1.72	0.086	-0.07	1.02
I am in control	0.81	0.37	2.20	0.027	0.09	1.53
I am at high risk	-0.92	0.26	-3.58	0.000	-1.43	-0.42
EQ-5D VAS	0.01	0.01	1.46	0.144	-0.01	0.03
Education (primary)						
Secondary	1.63	0.46	3.56	0.000	0.73	2.53

Intermediate	1.42	0.47	3.02	0.003	0.50	2.35
University	0.36	0.54	0.66	0.508	-0.70	1.41
Age group (60+)	-0.39	0.29	-1.38	0.167	-0.95	0.17
Difficulty exercising	0.74	0.34	2.16	0.031	0.07	1.41
Constant	1.09	0.69	1.57	0.117	-0.27	2.44

Alcohol			**AIC =**	**9.06**		**n = 88**
Log Pseudo likelihood =		**-387.64**	**BIC =**	**-178.89**		
Visit (3 month)	1.09	0.34	3.25	0.001	0.43	1.75
Audit group (≥4)	1.05	0.32	3.27	0.001	0.42	1.68
Income ≥£2,000	0.64	0.38	1.71	0.088	-0.09	1.38
I am in control	1.11	0.36	3.08	0.002	0.40	1.81
I am motivated	-0.93	0.35	-2.63	0.009	-1.62	-0.24
I am at high risk	-0.87	0.37	-2.36	0.018	-1.59	-0.15
Education						
Secondary	0.83	0.53	1.56	0.120	-0.22	1.88
Intermediate	1.47	0.60	2.46	0.014	0.30	2.65
University	2.18	0.63	3.48	0.000	0.96	3.41
Difficulty Alcohol	0.55	0.41	1.33	0.185	-0.26	1.36
Constant	-0.37	0.71	-0.53	0.599	-1.76	1.01

12.2.8.2. Pooled health and time-point regression for $WTA_{Commitment}$

Table 64: Pooled health and time-point regression for $WTA_{Commitment}$

	Number obs =	350				
	AIC =	9.059				
	BIC =	-1251.9				
Log pseudolikelihood =	-1574					
	dy/dx	**SE.**	**z**	**P>z**	**L 95% CI**	**U 95% CI**
Baseline vs 3 months (VisitCycle)	£23.24	12.14	1.91	0.038	-0.56	47.04
Income >£2000 pm	£23.12	12.77	1.81	0.042	-1.91	48.15
Sense of Control	£18.21	11.57	1.57	0.092	-4.46	40.88
At high risk	-£28.70	10.50	-2.73	0.006	-49.28	-8.11
Age	-£1.11	0.61	-1.82	0.052	-2.31	0.09
Perceived difficulty (Easy)						
Vs Moderate	£8.06	7.34	1.10	0.276	-6.33	22.45
Vs Difficult	£17.90	12.32	1.45	0.114	-6.24	42.04
Education (Primary)						
Vs Secondary	£27.47	9.56	2.87	0.010	8.74	46.20
Vs Intermediate	£35.04	10.73	3.26	0.003	14.00	56.08
Vs University	£21.41	12.41	1.72	0.061	-2.92	45.74
Constant	£41.62	5.94	7.00	0.000	29.97	53.26

12.3. Weight loss study search strategy

The literature searches were conducted in August 2014. Searches were restricted to studies published after January 2012. Only human and English language studies were included.

The following literature databases were searched:

- Embase
- MEDLINE
- PsycINFO
- EconLit

Search Terms:

1. (Incentive$ or financial reward$ or monetary reward$ or contingency management or contingency payment$ or financial payment$ or deposit contract$ or cash transfer$ or voucher$ or coupon$ or token$).mp. [mp=hw, ab, ti, ct, sh, tn, ot, dm, mf, nm, an, ui, tc, id]

2. limit 1 to english language

3. limit 2 to humans

4. (weight loss or lose weight or diet$ or obes$ or overweight).m_titl.

5. limit 4 to english language

6. limit 5 to humans

7. 3 AND 6

12.4. Decision model parameter search terms

The literature searches were conducted in October 2013. There were no year restrictions.

The following literature databases were searched:

- Embase
- MEDLINE
- PsycINFO

Search Terms:

1. diabetes.mp. [mp=ti, ab, sh, hw, tn, ot, dm, mf, dv, kw, nm, kf, ps, rs, ui]

2. type 2.mp. [mp=ti, ab, sh, hw, tn, ot, dm, mf, dv, kw, nm, kf, ps, rs, ui]

3. bmi.mp. [mp=ti, ab, sh, hw, tn, ot, dm, mf, dv, kw, nm, kf, ps, rs, ui]

4. body mass index.mp. [mp=ti, ab, sh, hw, tn, ot, dm, mf, dv, kw, nm, kf, ps, rs, ui]

5. type ii.mp. [mp=ti, ab, sh, hw, tn, ot, dm, mf, dv, kw, nm, kf, ps, rs, ui]

6. stroke.m_titl.

7. 4 and 6

8. uk.mp. [mp=ti, ab, sh, hw, tn, ot, dm, mf, dv, kw, nm, kf, ps, rs, an, ui]

9. england.mp. [mp=ti, ab, sh, hw, tn, ot, dm, mf, dv, kw, nm, kf, ps, rs, an, ui]

10. united kingdom.mp. [mp=ti, ab, sh, hw, tn, ot, dm, mf, dv, kw, nm, kf, ps, rs, an, ui]

11. 8 or 9 or 10

12. 7 and 11

13. HEART ATTACK.m_titl.

14. MYOCARDIAL INFARCTION.m_titl.

15. 13 or 14

16. 4 and 11 and 15

17. remove duplicates from 16

18. cost.m_titl.

19. cancer.m_titl.

20. 6 and 18

21. 15 and 18

22. diabetes.m_titl.

23. 18 and 22

24. Mortality.m_titl.

25. 24 and 1 or 6 or 15

26. 25 and 11