Trading off dietary choices, physical exercise and cardiovascular disease risks

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Abstract

This paper analyses how individuals trade-off health risks against lifestyle choices. The work uses a choice experiment (CE) survey for a representative sample of the Northern Ireland population. Unlike most CE studies for valuing public health programs, this questionnaire uses a tailored exercise based on the individuals' baseline choices. A fat screener links actual cardiovascular diseases (CVD) risk to each specific choice set in terms of diet. Individuals are informed about their real status quo risk of a fatal cardiovascular event, based on an initial set of health questions. Thus, actual risks, real diet and exercise choices are the elements that constitute the choice task. Our results show that our respondents are willing to pay for reducing mortality risk and, more importantly, are willing to change physical exercise and dietary behaviours. In particular, subjects with Body Mass Index (BMI) in the range of overweight or obese seem more inclined to practise physical exercise than to modify their diet to reduce their CVD risks.

1. Introduction

Obesity and overweight have become a growing problem affecting most of Western societies. According to the World Health Organization (WHO), in 2008 there were about 1.5 billion overweight adults; this figure is increasing dramatically due to the sedentary lifestyle and worsening eating habits with high-caloric diets (WHO, 2011). In Northern Ireland almost 70% of adults are either overweight or obese and this figure is growing according to the Public Health Agency.[1] This epidemic has become an economic burden (Muller, 2007), as well as a major health problem, as it increases the risk of type 2 diabetes, cancer and cardiovascular diseases (CVD). As a result, governments and public agencies are diverting a considerable amount of resources to prevent obesity and promote healthy lifestyles (WHO, 2001; Fit Futures, 2006; Foresight Report, 2007; DHSSPS, 2010).

[1] http://www.healthpromotionagency.org.uk/work/Publicrelations/PressReleases/obesity.htm

In this context it is relevant to explore strategies that help people to choose healthier lifestyles and to estimate people's willingness to pay for improvements in their health and reduction in illnesses related to obesity. This will help to allocate public resources more efficiently and provide insights into public health programs aimed at changing people's eating and exercise behaviour.

A choice experiments (CE) survey is the appropriate framework to analyse individuals' stated behaviour in response to a broad range of hypothetical choices (Ben Akiva and Lerman, 1985; Louviere et al, 2000; Train, 2003; Carlsson and Martinsson, 2003; Ryan et al, 2008). CE allow researchers to analyse to what extent, and under what conditions, individuals are willing to change their unhealthy lifestyles for healthier ones. This health improvement is presented here in terms of a reduction of the risk of suffering from CVD, which are among the most serious obesity-related health issues. We analyse this problem in terms of risk because when individuals choose a particular lifestyle, characterized by dietary habits and amounts of physical activity, they incur risks to their health in the long run. In fact, it is a case of risk when choices can lead to consequences that cannot be measured with certainty, as in this case.

Food choices and risk have been analysed with respect to genetically modified food (Rigby and Burton, 2005; 2006) traceability (Van Rijswjk and Frewer, 2008) and food safety (Lobba et al, 2007). Most of these works are based on one single choice or a set of single choices. Conversely, in our study, we are setting a more realistic framework of dietary choices, which implies a series of regular choices over many years. In addition, we are not asking the respondent to choose between artificial scenarios that might be distant to his/her own food choices and amount of physical activity. We tailor our CE questions using individuals' actual diet, level of physical activity and CVD risk they face.

Dietary choices are based on habit but are the result of a trade-off between taste (sensory perceptions), health and cost, among other attributes, attitudes, values and beliefs (Furst, Connors, Bisogni, Sobal, and Falk, 1996). On the one hand, the problem that we are addressing here, cardiovascular diseases, is known to be highly correlated with high levels of cholesterol in a subject's blood (Mente et al 2009). Part of this cholesterol comes from excess of saturated fat intake from diet. At the same time, the presence of fat is extremely correlated with taste in food. On the other hand, a sedentary lifestyle is also highly correlated with high levels of cholesterol (Lakdawalla and Philipson, 2009, Auchincloss et al, 2009). Despite its well-known benefits, the majority of people in the UK do not engage in regular physical activity. Physical activity levels are on the decline in Northern Ireland (NI), with 23% of the population currently classed as sedentary (Northern Ireland Health and Social Wellbeing Survey 2005/06). Identification of patterns of physical activity interacting with dietary choices is essential to plan Public Health strategies in this field.

In this paper, our CE asks a sample representative of the population of Northern Ireland to choose between their current lifestyle, described in terms of their own dietary habits, levels of physical activity and actual risk of suffering a fatal CVD in the next ten years, and other hypothetical lifestyles described by different combinations of diet, exercise, risk of fatal CVD in the next ten years, and cost. Cost is shown as increases from respondents' current expenditures. Diets are presented as reductions in the consumption frequency of the most unhealthy (in terms of fat intake) food items consumed by respondents, whilst levels of physical activity are described in terms of increments from respondents' current levels.

The remainder of the paper is structured as follows. Section two describes the economic model of CE and the econometric models used in the analysis; section three gives an overview of the questionnaire used to sample the population of Northern Ireland and also reports the descriptive statistics of the sample; section four reports the results of the econometric models; and section five concludes the paper with policy implications.

2. Theoretical background of Choice Experiments

In this section we briefly explain the Choice experiments (CE) method, which is based on the idea that individuals make choices among alternatives by considering the characteristics of the alternatives (Lancaster, 1966). When facing a set of *J* alternatives, individuals will pick the one providing the highest utility. Discrete CE are grounded in random utility theory, which states that individual's choices produce certain utility, *U*, which contains a modelled part, *V*, that can be measured in terms of the attributes of each alternative, and another part, ε, that cannot be observed by researchers and therefore it is considered a random term and named the unmodelled part of the utility. Examples in health economics can be found in Ryan et al. (2008), whilst a review of the literature of CE in health economics is presented in Ryan and Gerard (2012).

By observing peoples' choices, the modeller can estimate the weights attached to each attribute; these, in turn, allow for the calculation of the willingness to pay (WTP) for improving each of these characteristics. As shown in (1), the utility associated with option *j* can be decomposed into *V*, the modelled component, and ε, the error component. The first term can be expressed as the sum of the product of k attributes *x* multiplied by their weights β_k; these parameters are the ultimate object of the estimation process:

$$U_j = V_j + \varepsilon_j = \beta_{0j} + \beta_{1j}x_1 + \beta_{2j}x_2 + ... + \beta_{kj}x_k + \varepsilon_j \quad (1)$$

Assumptions made about the distribution of the random error component lead to different types of model. The simplest one is the multinomial logit (MNL) model which is derived assuming that errors are independent and identically distributed (IID) according to a Type 1 extreme value distribution. For a linear utility, it can be proven that the probability of choosing alternative *j* among *i* alternatives in choice set C facing individual *q* is given by (McFadden, 1974):

$$P_{jq} = \frac{\exp(\lambda_q \cdot V_{jq})}{\sum_{i \in C} \exp(\lambda_q \cdot V_{iq})} = \frac{\exp(\lambda_q \cdot \underline{\beta} \cdot \underline{x})}{\sum_{i \in C} \exp(\lambda_q \cdot \underline{\beta} \cdot \underline{x})} \quad (2)$$

Where the parameters *β* are considered as not varying among the population, which implies that there is no difference in individuals' tastes (i.e. the weight or coefficient of price is the same for all individuals); λ is an unidentifiable scale parameter (Walker, 2002) inversely related to the unknown standard deviation of the error distribution.

Unlike the MNL, a Random Parameter Logit (RPL) model allows differences in tastes by assuming that the parameters βs are not fixed, but vary across respondents. This model may be more realistic than the MNL as it allows for random variation in tastes. The common formulation is that the βs differ in terms of taste intensity (Train, 1998), leading to the following utility specification:

$$U_{qj} = \tilde{\beta}_q x_{qj} + \varepsilon_{qj} \quad (3)$$

Where the random taste parameters $\tilde{\beta}_q$ depend on the values of the parameters θ of an underlying "mixing distribution" $f\ (\beta|\theta)$. Researchers have to make assumptions on the distributions of the random component. It is generally assumed that this part is distributed following the normal, lognormal, or triangular distribution (see Train, 2003). In the case of the RPL model, the probability of choosing alternative *j* for individual *q* is conditioned to a particular value of β:

$$P_{qj} = P_{qj}(\beta)P(\beta = b) \quad (4)$$

3. Questionnaire and data collection

3.1 Questionnaire

We used computer assisted personal interviews (CAPI) to administer a questionnaire which was divided into five parts: health questions and physical activity questions, diet questions, a risk tutorial, the CE questions, and socio-demographic questions. Unlike most stated preference surveys, these CE questions were tailored and individually generated to take account of each respondent's current dietary choices, levels of physical activity and CVD risk, thus making the experiment realistic to the subject.

We begun with general questions about health and asked details about health conditions related to diabetes, smoking, arthritis, systolic blood pressure, cardiovascular diseases, family history of cardiovascular diseases and individual's weight and height.[2] We then asked questions about age, gender and postcode address. This medical information was then fed into the QRISK1 prediction algorithm[3] developed by the University of Nottingham for CVD risk in the British population (Hippisley-Cox et al., 2008) to estimate respondents' own CVD risks. The outcome of the algorithm, in terms of percentage risk of having a heart attack or stroke in the next ten years was then shown to respondents and later reported in the status quo option in the CE questions.[4] Physical activity questions were based on the version of the International Physical Activity Questionnaire (IPAQ) (Craig et al, 2003) used by the National Health Service of the UK which includes five questions that elicit respondents' engagement

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[2] The health questions were adapted from the MOS SF 36 Health questionnaire (McHorney et al. 1994).

[3] This algorithm can be implemented through a special program under a licence and is available at http://www.qrisk.org/.

[4] Krupnick et al (2002) describe risk in terms of 10^3 since changes in risk for air pollution are small. We tried to use this measure, but when piloting the questionnaire we found that respondents felt confused. Therefore we decided to keep the 100 per cent base.

with very moderate activities (household, gardening, shopping), moderate exercises (walking, cycling) and vigorous physical activities (gym, swimming, jogging, aerobic, etc).

In order to ask people their willingness to modify their diet in exchange for health improvements it was necessary to obtain information about respondents' current eating habits. This is a complex task that usually involves asking respondents to report a diary of their food intake during one week.[5] As this task would have been very lengthy and not compatible with an in-person interview, we only focused on eliciting respondents' consumption of food items with a high fat content, as these items could lead to high levels of blood cholesterol and, therefore, likely to contribute to CVD. We followed the Block Questionnaire (Block, 2000), a tool developed in the nutritional literature, that offers a rapid snapshot of an individual's levels of fat intake through questions about the frequency and the portion size of eating 17 selected items. We adapted the Block Questionnaire to the Irish diet considering the main sources of fat (Joyce et al, 2007), by selecting 17 fatty items often found in the Northern Irish diet.[6] Subjects in the sample were asked the frequency of consumption of these items from 'never' to 'five or more times a week.' Each item was presented in a separate screen (see Figure 1). After the frequency, individuals were asked about portion sizes and cooking styles. We would later use the answer to the Block Questionnaire to build the 'diet' attribute for the CE questions, as described below.

[5] Irish University Nutrition Alliance (2001). North/South Ireland food consumption survey Published by: Food Safety Promotion Board, Dublin.

[6] The seventeen items are: 1. Salad dressings (not low-fat); 2. Chicken or other poultry (eg. Turkey); 3. Beef: roast, steak, mince, stew or casserole; 4. Corned beef, Spam, luncheon meats; 5. Boiled, mashed, instant or jacket potatoes; 6. Chips and savoury snacks; 7. Cheese; 8. Pork: roast, chops, stew or slices; 9. Beefburgers; 10. Butter; 11. Savoury pies, eg. Meat pie, pork pie, pasties, steak & kidney pie, sausage rolls; 12. Roast potatoes; 13. Biscuits, pastries and cakes (not low-fat); 14. Bacon; 15. Sausages; 16. Potato salad; 17. Whole milk.

Figure 1: Question about butter within the diet habits part of the questionnaire

The third part of the questionnaire includes a risk tutorial where the individual receives an explanation of the concept of probability using visual aids. Following a tutorial developed by Alberini et al. (2004) and Alberini and Chiabai (2007) to assess the willingness to pay for reducing mortality risk for cardiovascular and respiratory causes, the concept of probability is taught at first with simple examples of flipping a coin and throwing a dice, and then, increasing the degree of complexity and abstraction, respondents are shown with a grid square, with red blocks representing the chances of suffering a fatal CVD risk, and white blocks representing the chances of not suffering any such risk. To test whether respondents understood the concept of probability, they were asked to choose among two hypothetical scenarios described by different fatal CVD risks. Those that understood the concept of probability would choose the alternative with the lowest risk, corresponding to the graph with the smaller number of red blocks. Respondents that failed this test, were shown the probability tutorial once more until they grasped the concept. This tutorial and its test support the internal validity of the questionnaire in terms of valuation of risk reduction.

The fourth part of the questionnaire presents ten CE questions. Each CE question entails three alternatives: the respondent's current lifestyle and two alternative hypothetical lifestyles. Each alternative is described by a diet, an amount of physical activity, a fatal risk of a CVD in the next ten years and a cost to the respondent. An example of CE is shown in figure 2.

Just immediately before the CE questions, a "cheap talk" (Carlsson et al. 2005) text was used to emphasise research findings on the correlation between sedentary lifestyle, excessive fat consumption, poor intake of fruit and vegetables and coronary heart diseases. To introduce the hypothetical scenarios, respondents were told: "Suppose a doctor gives you the option to choose between your current lifestyle and other alternative lifestyles characterized by more physical activity and a replacement of part of your weekly fat consumption by fresh fruit and vegetables, this would have an impact upon your risk of a heart attack in the next ten years. Which option would you choose in each case?" Cost increases were justified on the grounds of this statement: "these alternative lifestyles will also impact your budget because fruit and vegetables are usually more expensive than other food and physical exercise might also have a cost."

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CHOICE 3 of 10 - Which option would you choose?

	Current Choice	Option A	Option B
Diet			
Boiled, mashed, instant or jacket potatoes	1-2 times week	1 per month	2-3 times a month
Beef: roast, steak, mince, stew or casserole	1-2 times week	1 per month	2-3 times a month
Savoury pies, eg. Meat pie, pork pie, pasties, steak & kidney pie, sausage rolls	2-3 times a month	1 per month	1 per month
Whole milk	Whole Milk	Skimmed Milk	Semi Skimmed Milk
Spread fat (different from butter) but not low-fat	2-3 times a month	1 per month	1 per month
Expenditure Increase in weekly expenditure in food(£)	No changes	£15 more	£5 more
Exercise Increase in moderate exercise(daily)	No changes	40 minutes	20 minutes
Cardio-vascular risk Your risk of a heart attack in the next 10 years(chances over 100%)	5.00 %	2.50 %	3.75 %
	Current Choice	Option A	Option B
I would choose			

Back OK Clear

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Figure 3: Example of a choice card

The final part of the questionnaire asked a set of follow-up Likert scale questions to measure attitudes, perceptions and beliefs about the individuals' health, and concluded eliciting respondents' socio-demographic characteristics.

3.2 Attributes and levels

Hughes et al, (2010), in explaining the determinants of coronary heart diseases in Northern Ireland, highlight that "obesity and physical inactivity are of major concern. More aggressive policies to promote healthy food and increase physical activity may therefore be needed to decrease future coronary heart disease deaths." We therefore decided to study these two attributes, diet and physical activity, because of their importance in terms of health policy and their simplicity to explain to respondents. This approach allowed us to develop individually tailored CE questions without creating much complicated tasks. In addition, it allowed us to present respondents with credible scenarios of health improvements driven by changes in dietary patterns and levels of physical activity. Physical exercise was defined as minutes spent in a moderate physical exercise per day. The levels of this attribute were: the current level of physical activity, and increases by 10, 20, 30, or 40 minutes per day compared to the current level. The CVD risk was defined as the probability of a fatal risk of a heart attack in the next ten years. The level for the current life style was the one resulting from the QRISK1 prediction algorithm. The levels for the other alternative scenarios were calculated as a reduction in such a risk by 40%, 50%, 60%, 75% and 85%. Therefore, for a respondent whose current risk was equal to 5%, a 50% reduction would result in a risk of 2.5%. Cost was described as an increase in the money spent on food and physical exercise per week. The levels for this attribute were defined in focus groups where we had asked a contingent valuation question to elicit focus groups participants' willingness to pay per week for a medicine that reduces their risk of suffering a heart attack in the next ten years. From this initial point we set different price levels for healthier lifestyle choices.

The diet attribute was the most complex to define. In focus groups we ruled out the idea of using a hypothetical food basket described in terms of an abstract nutritional content, as such description would not well convey the information of the 'taste' of food and the 'sacrifice' resulting from reducing the consumption of favourite food products and from increasing the consumption of fruit and vegetables. We also discarded the possibility of using flagship unhealthy food items, such as pizza, chicken curry, fish and chips, or Irish Breakfast, as they might not have been relevant to all respondents, making the CE not credible, hence seriously questioning the incentive compatibility of the survey instrument. Therefore, we decided to use the information collected in the second part of the questionnaire from the Block Questionnaire. For each respondent, we selected the five food items mostly and most frequently consumed.[7] This information was presented to respondents under the current choice. The alternative hypothetical scenarios were described in terms of reduction in the consumption of these five items and an increase in food and vegetables. We selected four levels for the diet attribute defined in terms of overall fat content. Considering the current diet as the reference value, we defined light, medium, high and restricted diets, corresponding to reductions in fat intake by 10% (light), between 20% and 30% (medium), between 40% and 50% (high) and between 60% and 75% (restricted) from the current diet respectively. This approach allowed us to compare diets across respondents and build a variable expressed in terms of reduction of grams of fat from the current diet.[8] Table 1 shows the attributes and their levels used in this CE.

[7] In five focus groups we found that individuals were able to answer choice experiments questions described by five food items, and were struggling when additional food items were included. The CAPI we designed automatically selected the five items from the Block Questionnaire that were mostly and most frequently consumed by each respondent and used these five items to build the CE questions.

[8] We are aware that this approach may lead to a researcher bias, as in our econometric model we assume that respondents trade off grams of fat when choosing different life styles. However, we are unaware of a more efficient approach to investigate comparable dietary choices across respondents in a tractable way for a CE survey. Our approach leads to comparable choices, and choices meaningful to respondents. In focus groups we tried adding the information of 'grams of fat', but this information appeared to convey a wrong message, as respondents would only grasp the unhealthy message conveyed by 'grams of fat' and were unable to consider the 'taste' and 'sacrifice' elements of reducing the consumption of their favourite food items.

Table 1: Attributes and levels

Attribute	Levels
Diet (reduction of the consumption of the respondent's five most unhealthy food items)	Current, light, medium, high and restricted diet
Cost (GBP per week)	0, 2, 5, 7, 10, 15, 18
Physical Exercise (increase in daily minutes)	0, 10, 20, 30, 40
Percentage risk reduction from respondent's actual risk	40, 50, 60, 75, 85

Once the attributes and levels were decided, an experimental design was developed to determine the combination of attribute levels in each alternative attribute bundle. We used a Bayesian D-efficient experimental design (Bliemer and Rose, 2008; Scarpa, Campbell and Hutchinson, 2007; Ferrini & Scarpa, 2007) whereby the levels of the chosen attributes, between alternative bundles, are those combinations producing most information for the model. The design was implemented in two waves, obtaining new priors after modelling half of the sample data, improving the design for the rest of the data and finally pooling all the data. Each respondent was presented with 10 different choice scenarios. Research has shown that setting between 6 to 13 choice situations (Caussade et al., 2005) seems to be optimal because this range minimises the error variance of the estimates.

3.3 Data collection

A survey of 493 respondents was administered to randomly selected households providing a representative sample of the Northern Ireland population. The target population was restricted to individuals between 40 and 65 years old. These boundaries were set for the sake of realism since it was found very difficult for younger people to consider their risk of dying in the next 10 years.[9] In addition, the actual CVD risk for people younger than 40 is close to zero (Conroy et al. 2003). As the actual risk was used as the baseline scenario from which improvements in risk reductions were calculated, these improvements would have looked negligible to the eye of potential respondents younger than 40 years. The questionnaire was administered by a professional survey firm (Survey Marketing S). There were two waves of surveys in February and July 2011. Results from the first wave were modelled and used to improve the experimental design for the next wave.

Table 2 provides descriptive statistics for the whole sample. Average net annual income per household was £29,051. Women are slightly more represented here with 57% of the individuals in the sample. Regarding Body Mass Index (BMI), the mean was 26.85 which is the upper boundary of overweight, almost obese. These figures are coherent with population data of Northern Ireland, according to the *Obesity Adults Health and Social Wellbeing Survey 2006* from the Northern Irish Government.[10] In fact, 37% and 26% are the actual figures in Northern Ireland for the proportions of overweight and obese respectively among the adult population. Therefore, this sample quite well represents the adult population of Northern Ireland.

[9] Krupnick et al, 2002 sampled a similar population for valuing mortality risk reduction from public programs aimed at reducing air pollution.

[10] Data available at http://www.ninis.nisra.gov.uk/mapxtreme/DataCatalogue.asp?button=Health

Table 2: Socioeconomic statistics for the sample

SE statistics		
Income (annual income per household)		
Less than 3120		10.02%
3121-4160		9.83%
4161-5200		10.40%
5201-6240		7.90%
6241-7280		7.90%
7281-10400		9.06%
10401-15600		13.10%
15601-20000		13.49%
20000-40000		42.77%
More than 40000		0.00%
Mean		29,051
Age		
40-50		47.06%
50-55		21.91%
More than 55		31.03%
Mean		50.73
BMI		
Underweight BMI < 18.5		4.67%
Normal BMI 18.5-25		37.93%
Overweight BMI 25-30		31.03%
Obese BMI > 30		26.37%
Mean	26.85	
		Sex
Male		43%
n		493

4. Results

4.1 Modelling

The econometric models use the variables *Fat*, *Exercise*, *Cost* and *Risk*. *Fat* represents the sacrifice of following a diet in terms of grams of fat per week that the individual has to give up. As we explained earlier, each individual faced a particular set of items and individual specific diets. This information was then translated into grams of fat using the detailed study of calories and fat provided by McCance and Widdowson (2002). *Exercise* in the CE data analysis was translated into metabolic equivalent of task (MET) which is a unit that expresses the amount of energy necessary to execute each type of physical activity per minute (see Ainsworth et al., 1993). This variable was calculated considering the current level of physical activity, using the answers to the IPAQ, and the different units of MET that each minute of moderate, medium or vigorous exercise represent. Therefore, its coefficient represents the contribution to utility of one additional unit of MET.[11] *Cost* is the payment for changes in lifestyle, justified in terms of increasing food costs of healthy diets, measured in GBP per week. *Risk* is the risk of suffering a fatal event of CVD during the next ten years in 100 per cent basis. In addition to a specification that includes only the attributes of the CE, we run model specifications interacting the CE attributes with socio-economic dummy variables, which are described in Table 3.

Table 3: Socioeconomic variables

Name variable	Description: Dummy variable	Mean (sd)
Unemployed	Equal to one if the respondent is unemployed, and zero otherwise	0.12 (0.33)
Male	Equal to one if the respondent is male, and zero if female	0.43 (0.49)
Home	Equal to one if the respondent practises home physical activity (such as gardening, household works or taking care of children) for, at least, two hours per week, and zero otherwise	0.80 (0.39)
Overweight	Equal to one if the respondent is either overweight or obese, and zero otherwise	0.31 (0.46)
Travellers	Equal to one if the respondent walks and/or cycles at least two hours per week, and zero otherwise	0.76 (0.52)
Vigorous	Equal to one if the respondent engages is regular vigorous physical activity, and zero otherwise	0.41 (0.36)
Very good health	Equal to one if the respondent declares he/she is in very good health, and zero otherwise	0.25 (0.42)
Educated	Dummy variable equal to one if the respondent has a graduate degree, and zero otherwise	0.24 (0.42)
Children	Dummy variable equal to one if the respondent has dependent children, and zero otherwise	0.61 (1.07)

Table 4 displays the output of the estimated models. The first model is a simple MNL model with the attributes and the current choice as explanatory variables. The output shows that all parameters are highly statistically significant and have the expected signs. In general, respondents like following a diet, as the parameter for 'fat' is positive. Reducing fat intake in diet may therefore be seen as something positive for different reasons, including general health improvements and aesthetic reasons. Individuals are, on the other hand, unhappy with their current choice (current choice) and would prefer to change life style. The parameter on exercise is positive, which means that individuals in the sample consider physical activity as positively affecting utility. The coefficient estimate for risk is negative and significant, suggesting that respondents shy away from alternatives with high risk of fatal CVD. To

[11] Respondents saw minutes rather than MET but using one or the other does not affect modelling results. However, MET is more useful in terms of analysis and widely used in epidemiological studies. Using MET allows us to compare diet and exercise in terms of energy.

investigate heterogeneity of preferences across respondents we add interaction terms between socio-economic characteristics of the respondents and the attributes (MNL-2).

Table 4: Modelling results

		MNL-1		MNL-2		RPL		WTP	
Name		**Value**	**t-test**	**Value**	**t-test**	**Value**	**t-test**	**Value**	**t-test**
Current choice		-0.343	-6.80	-0.362	-6.96	-2.58	-18.24	-2.45	-25.34
Cost	μ	-0.0942	-15.24	-0.101	-15.66	-0.158	-10.22	-0.113	-15.57
	σ					0.178	13.49	0.227	15.59
Exercise	μ	0.0207	5.78	0.000783	3.77	0.00301	8.33		
	σ					0.00341	10.20		
	μ_w							0.00302	2.29
	σ_w							0.0113	9.37
Fat	μ	-0.00204	-4.21	0.00337	3.77	0.00346	2.02		
	σ					0.00307	1.59		
	μ_w							0.0596	4.77
	σ_w							0.0441	5.21
Risk	μ	-0.0664	-4.47	-0.0635	-3.94	-3.16	-9.75		
	σ					5.24	21.58		
	μ_w							-0.686	-5.20
	σ_w							5.93	12.99
Cost*Unemployed				-0.0303	-3.68	-0.714	-1.91	-0.0853	-3.10
Exercise*Male				0.000289	2.26				
Exercise*Home				-0.00230	-10.20	-0.00323	-4.21		
Exercise*Overweight				0.000624	3.88				
Exercise*Travellers				-0.00106	-3.35				
Exercise*Vigorous				-0.000548	-3.35	-0.00133	-2.54		
Exercise*Very good health				0.000287	1.94				
Fat*Overweight				-0.00151	1.50				
Fat*Educated				-0.00155	1.76				
Fat*Vigorous				0.00425	-3.59				
Risk*Children				-0.0194	-1.44				
Log likelihood		-5450.409		-5165.533		-3617.548		-3590.320	
n		4930		4930		4930		4930	
Individuals		493		493		493		493	
ρ^2		0.024		0.043		0.332		0.335	
k		5		16		11		10	

Firstly, we notice that unemployed respondents are more reluctant to pay, a result that shows that our data are internally valid. More interesting is the interaction with *fat*, *exercise* and *risk*. Heterogeneity in the fat parameter seems to be better explained by the socioeconomic interactions, whereas for risk and price this variation is better captured in the random parameter (RPL) model, as discussed below. Interaction with exercise accounts for most of the systematic variability with six interaction terms being statistically significant at the 1% level. There are both positive and negative interactions and, in some cases, these change the effect of the main coefficient. The results show that males, overweight or obese respondents, and interviewees that consider themselves to be in very good health are more likely to select options that entail an increase in physical exercise compared to their current level. When we look at the magnitude of the coefficients of these three interaction terms, we also notice that being either overweight or obese is the major determinant in driving respondents to choose programs that entail an increase in physical exercise. Therefore, we should consider that people from this group will favour more exercise in order to improve their health. Finally, those who declared themselves to be in a very good health also have a positive interaction parameter with exercise, which is coherent with the expectation that these people are in a better condition for undertaking physical activity.

The other interaction terms with exercise and three other dummy variables capturing the characteristics of physical exercise that the respondents do, Home, Travellers and Vigorous, are all negative. These coefficients suggest that respondents that are already doing some physical exercise are less willing to improve their amount of physical exercise. Alternatively, these coefficient estimates can be interpreted suggesting that respondents that do not engage in vigorous physical exercise, do not walk or cycle at least two hours per week, or do not engage in homemaking activities such as gardening and taking care of children, are more likely to choose alternatives that offer an increase in their amount of physical exercise. The fat coefficient is, in general, positive which might reflect the desire of people to make their eating habits healthier. To explore respondents' heterogeneity of preferences for diet, we interact fat with *Overweight*, *Educated* and *Vigorous* dummy variables. Respondents that are overweight or obese do not appear to have different preferences in terms of diet from respondents who are of normal weight or underweight, as the coefficient for the interaction term fat*overweight is not statistically significant at the 10% level of significance. Respondents that have completed a university degree appear to have a slight reluctance for a low fat diet as the coefficient for the interaction term between *Fat* an *Educated* is negative, but is statistically significantly different from zero only at the 10% significance level. Finally, the last interaction term between *Fat* and *Vigorous* is positive and significant, indicating that respondents who undertake vigorous physical activity would prefer a healthier diet.The last interaction term, between risk and a dummy variable equal to one if respondents have dependent children, is negative, but not statistically significant, suggesting that having children does not make respondents more risk averse than respondents that do not have to look after children.

The third model, a Random parameter logit (RPL) improves considerably the goodness of fit of the previous two models, as can be seen by the improvement in the log likelihood function. The RPL model uses random parameters for all coefficients, although for *fat* the spread parameter σ is not statistically significant at the 10% significance level. We used normal distributions for all random parameter except for *risk* which follow a lognormal distribution in order to force its distribution in the negative range.[12] The output shows large coefficient estimates for the current choice and for risk, strengthening the results of the previous two models: respondents would prefer to change their life style and would favour alternatives with lower risks of fatal CVD. Random heterogeneity is captured by the random parameters. Except for *fat*, all spread coefficients are statistically significant, suggesting that preferences vary among respondents. For example, the results show that some respondents are not willing to increase their time spent in physical exercise. When we further look at the effects of socio economic variables, we confirm the findings from the MNL: our survey is internally valid, respondents that engage in homework activities are less likely to increase the amount of their physical exercise, and respondents already doing vigorous physical activity are more likely to reduce the fat intake in their diet.

4.2 Willingness to pay

For the MNL, the marginal willingness to pay (WTP) for an attribute is calculated as the negative of the ratio between that attribute coefficient and the cost attribute. Whenever random parameters are used, this formula is not so straightforward. For example, when the

[12] When estimating the RPL model, we changed the sign for the coefficient of 'risk' as the lognormal distribution restricts the sign of the coefficient estimates to be positive.

two random parameters distribute normally, their ratio is distributed as a Cauchy distribution, which has unknown moments (Armstrong et al., 2001). In such a case, the calculation of means and confidence intervals would be difficult, although the distribution itself may still exist. For this reason, it has been a common practice in recent years to estimate the marginal WTP in WTP space, rather than in preference space (Train and Weeks, 2005). WTP space is a transformation of the utility space that involves expressing all estimates as ratios of the cost coefficient. As discussed by Louviere (2006), if errors are i.i.d. type-one extreme value, there should be no difference in the fits of the two models, except for rounding errors. This reparameterization of the utility function[13] allows the estimation of population moments. The last model in table 4 shows the WTP estimates, in GBP per unit change, using the estimation in WTP space as applied to the RPL model. *Exercise* shows a positive and negative range meaning that part of the sample are willing to pay to undertake physical activity and part are reluctant to do it, and therefore should be compensated. Considering the spread of this coefficient across the sample, almost 65% of respondents consider exercise as positive *per se* and are willing to pay for it. On average, the payment is 0.00475 GBP per MET. Considering that 1 minute of moderate exercise such as stationary bicycling implies a consumption of 5.5 MET per minute that represents a WTP of approximately 1.7 GBP per hour, which is about one third of the cost of accessing a gym in Northern Ireland, and is about one fith of the minimum hourly wage, suggesting that one hour of moderate physical activity is valued quite low by our respondents. On the other hand, dietary change is considered positive for the majority of the sample and only 9% of the sample considers this attribute as a negative attribute. On average, participants are willing to pay 0.0452 GBP for a reduction of one gram of fat. It is not surprising that people are willing to pay to reduce their fat intake and, in fact, this is consistent with the attitude of the food industry that applies a price premium to low fat products. This result that we find might reflect the widespread awareness about health benefits and improvements in aesthetics resulting from a reduction in fat intake. Since CHD risk was inserted with a negative sign and using a lognormal distribution, its result falls entirely into the negative range. The WTP for reducing 1 percentage point of risk of a fatal CVD event is 1.14 GBP per week. This implies a value of 592.8 GBP per year considering a ten years reduction.

4.3 Marginal Rate of Substitution

It would be also interesting to analyze marginal rates of substitution (MRS) between parameters in the sample using the coefficients in Table 4. The MRS is obtained as the ratio of marginal utilities of each parameter of the model. This calculation helps to draw up a pattern of substitutions that might be useful in terms of policy, aside from the willingness to pay estimates. In our case, the model provides interesting relations between diet, exercise and health risks. Our results are shown in Table 5 and are based on the outcome of the RPL model.

[13] The idea is to re-write the utility function entering the WTP as a new parameter. This would be expressed for the k-attribute in this way $\beta_{cost} \cdot WTP_k = \beta_k$. Thus, replacing every parameter of the utility function by the product between WTP and the cost parameter allows us the direct estimation of the WTP.

Table 5: MRS

	1 met	1 gram of fat	1% reduction in CVD risk
1 met	1	-0.8699	-0.00095253
1 gram of fat	-1.14	1	-0.00109494
1% reduction in CVD risk	1049.83	-913.29	1

According to these results, substitution between exercise and fat leads to the equivalence of 1.14 METs to 1 gram of fat; that is, respondents would be willing to exchange 1.14 of MET for 1 gram of fat to keep their utility constant. Reducing fat intake will improve the individual's utility. To remain in the same utility level, exercise should be reduced in an equivalent amount. For instance, ingesting 10 grams less of fat per week will imply reducing moderate exercise of 4.6 minutes. In terms of risk, individuals would trade 1049.83 METs for 1% variation of risk. As one minute of moderate exercise represents 2.9 METs, a 1% reduction in CVD risk is equivalent to 362.01 minutes per week or 6.03 hours of moderate physical activity. In other words, one percent point risk represents more than 6 hours per week of moderate exercise, that is, approximately 51 minutes per day. Finally, the MRS between fat and risk shows that people would be indifferent to exchange 913.29 grams of fat per week for 1% variation of CVD risk.

5. Conclusions

Lifestyle choices, seen as long run decisions, imply certain risks on health. Individuals naturally trade off these risks, presented here as CVD risks, with money, physical exercise and changes in dietary habits. This work shows that people are unhappy with their current health situation and are willing to modify their lifestyles in order to improve their health. They would like to reduce their fat intake and, in general, would be willing to increase the time they spend in moderate exercise. Our results suggest that males are more likely to engage in physical exercise, as confirmed by other research (see, for instance Biddle and Mutrie, 2008). More interesting is the positive preference of overweight individuals towards exercise. In fact, up to 65% of the sample has a positive willingness to pay, on average 1.7 GBP for one minute of exercise. Fat is seen as undesirable and reducing its presence in diet has a positive effect on people's choices. Thus people are willing to pay 0.0452 GBP for one gram of fat reduction. The MRSs demonstrate an equivalence in terms of utility between 51 minutes of daily exercise and one point variation in the risk of suffering a fatal CVD disease. Finally, we found a willingness to pay for a reduction of one point in risk for a CVD disease during ten years equal to 592.8 GBP. For the current Northern Ireland population within 40 to 65 years old, this would represent a total of 3,32 millions GBP per year during ten years which should be accounted as the social welfare measure of a public program able to reduce one point percent the risk of a fatal CVD event. These results lead us to conclude that policies orientated to reduce health risks from illnesses linked to obesity will be more likely to succeed if these are planned into the diet domain. If the problem is people with a BMI in the overweight and obesity range, the work shows that these individuals are more inclined to do physical activity to improve their health. Hence, to improve the health of overweight and obese people in Northern Ireland, public moneys should be better spent for promoting physical activity rather than healthier diets.

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