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Final report

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# Contents

<b>Executive Summary</b>	<b>i</b>
<b>1. Background and rationale for the study</b>	<b>1</b>
<b>2. Methodology</b>	<b>3</b>
2.1 Overview	3
2.2 The Questionnaire	4
2.3 Specific design issues of questionnaire	8
<b>3. Results</b>	<b>10</b>
3.1 Summary Statistics	10
3.2 Examining the Underlying Model	15
<b>4. Follow-up interviews</b>	<b>22</b>
4.1 Overview	22
4.2 Findings	23
4.3 Concluding Remarks on Follow-Up Interviews	33
<b>5. Policy implications</b>	<b>35</b>
5.1 Value of a one year gain in life expectancy in normal health	36
5.2 Value of a one year gain in life expectancy in poor health	38
5.3 Value of avoiding a respiratory hospital admission	41
5.4 Value of avoiding a day's breathing discomfort	41
5.5 Comparison with the EAHEAP findings	42
<b>6. Concluding remarks</b>	<b>44</b>
<b>7. References</b>	<b>46</b>
<b>Annex 1. Report on piloting</b>	<b>47</b>
<b>Annex 2. Main survey final questionnaire</b>	<b>59</b>
<b>Annex 3. Tables of responses within the main study (Phase 2 of the survey)</b>	<b>74</b>

# Rationale for the study

If scarce resources are to be allocated efficiently and to greatest advantage then public sector investment and regulatory decisions concerning air quality improvement require monetary measures of the benefits of reductions in air pollution so that these benefits can be compared directly with the costs of effecting them.

In 1998-9, an *ad hoc* expert group – the Economic Appraisal of the Health Effects of Air Pollution (EAHEAP) – noted the lack of direct empirical evidence on monetary valuation of the health benefits of reducing air pollution. Attempts to infer possible values from other contexts entailed extensive uncertainties. EAHEAP recommended that a purpose-built willingness to pay (WTP) study approach would be the most suitable method for deriving the relevant values. In October 1999 the (then) Department of the Environment, Transport and the Regions commissioned such a study whose specified aims were:

- to generate empirical estimates of how much people in the UK are willing to pay for reductions in the health risks associated with air pollution;
- to determine the direction and magnitude of any functional relationships which may exist between WTP bids and potential explanatory factors (e.g. age, income, perceived risk, expected quality of life).

Following early discussion with the Project Steering Group and the Expert Advisory Group, it was agreed that the study should focus particularly on four adverse health effects of air pollution:

- chronic mortality – the impact on life expectancy of long-term exposure to average levels of pollutants in the air;
- acute mortality – the deaths brought forward (particularly among those in poor health) by episodes of high pollution;
- emergency admissions to hospital occasioned by such episodes;
- days of breathing discomfort caused or aggravated by raised levels of pollution.

# Methodology

An extensive programme of piloting was carried out prior to the main survey, reflecting the novelty and difficulty of the research. On this basis, an interview protocol was evolved, the main aims of which were to:

- inform respondents of the possible effects of air pollution on them and any other members of their household;
- elicit their household's WTP on an ongoing annual basis to achieve reductions in all four of the adverse health effects listed above, and to determine the relative importance attached to each benefit, as reflected in the way total WTP is apportioned between them;

- test for appropriate sensitivity of responses to variations in the nature and size of the benefits being valued. In particular, this involved randomising respondents between three subsamples, each of which was asked to value different extensions of life expectancy in both normal and impaired health: for one subsample, the gain was 1 month of life per person; for the second subsample, 3 months; and for the third subsample, 6 months extra. However, all respondents were presented with the same 'hospital admission' and 'days of breathing discomfort' scenarios, irrespective of which subsample they were allocated to.

The main survey was implemented by the National Centre for Social Research (NatCen) between November 2002 and January 2003. A representative (random probability) sample was drawn from England, Scotland and Wales, and interviews were carried out on a one-to-one basis in respondents' own homes using an interactive Computer Assisted Personal Interview (CAPI) programme. The structure of the interview and the design issues it raised are discussed in the main report. The text of the interview and the demographic characteristics of the respondents are reproduced in the Annexes.

## Results

A total of 665 interviews were completed. Of these, 10 respondents declined to answer the key WTP questions without giving any reason, while another 138 gave "zero" responses for 'protest' reasons. A further 46 respondents gave zero WTP responses, but since this was for non-protest reasons these were included in the total of 517 responses upon which the analysis of monetary values is based.

Regression analysis was used to examine whether WTP responses were sensitive to key variables. Responses showed significant, if somewhat muted, associations in the expected directions. In particular:

- WTP increased with the number of months of extra life expectancy in normal health, but not in full proportion to the amount of extra time;
- WTP increased with *per capita* income/ability to pay;
- WTP increased with the number of people in the household, although again, not in full proportion;
- WTP increased with the perceived likelihood that at least some members of the household would benefit in the ways specified.

As is usual in this sort of study, the frequency distribution of responses was right-skewed with a few extreme upper-tail outliers. Such outliers can have a strong influence on sample means and confidence intervals and may be of dubious reliability/credibility, so various levels of trimming were explored. Full sample statistics are reported in the report, but the main policy recommendations are based on sample means calculated after trimming the top and bottom 4 responses from each subsample (about 2.5% from each end of the distribution). The trimmed mean and median household willingness to pay for each of the four health benefits were as follows:

## Executive summary

### Trimmed mean and median WTP (£ per year per household)

	N (1/3/6 Months Extra in Normal Health)	P (1/3/6 Months Extra in Poor Health)	H (Avoiding Hospital Admission)	D (Avoiding Breathing Discomfort)
<b>1 month sub-sample</b>				
Trimmed Mean	60.15	15.86	36.49	40.17
Median	25	0	10	6
<b>3 month sub-sample</b>				
Trimmed Mean	67.72	11.53	35.34	31.31
Median	30	0	10	10
<b>6 month sub-sample</b>				
Trimmed Mean	80.87	17.31	35.15	33.52
Median	40	1	10	6

The benefits H and D were specified in exactly the same way across all three subsamples and, as expected, the mean values are broadly the same across the subsamples. For extra time in poor health, more than half of the sample gave a zero valuation: there was considerable ambivalence among respondents about whether extending their lives in such poor health was indeed a benefit. By contrast, extending life in normal health was viewed by the majority as the most highly valued benefit, although the values given were not proportional to the amount of extra time: on average, respondents were willing to pay only about a third more for 6 extra months than for 1 extra month. Possible reasons for this lack of proportionality, and the issues it raises for policy, are discussed in Section 5 of the report.

## Qualitative interviews

Qualitative interviews - aimed principally at exploring the thought processes that underpin responses to the type of question posed to respondents in the main study – were conducted with 26 respondents (13 in Stockton-on-Tees and 13 in Norwich) by two members of the research team.

The main findings of these interviews were as follows:

- Many people decided upon the sums that they were willing to pay by considering the sort of amount that they could afford to pay without undue disruption to their normal expenditure patterns: this notional 'budget constraint' contributed to the insensitivity of WTP responses to the size of the benefit.
- Although they were given estimates of how much an ongoing payment would add up to over the rest of their lives, respondents tended to ignore this information and focused on the real value of current monthly/annual amounts whose nominal value might be expected to increase roughly in line with inflation.
- 'Protest' zero WTP responses were typically a reflection of scepticism about whether the specified health benefits of reduced air pollution would actually be forthcoming and/or expressed a feeling that existing tax revenues could be more effectively deployed.
- When dividing up their total willingness to pay between the four benefits, there was a tendency to focus on the *nature* of the various forms of adverse health effects and to pay less attention to the actual *likelihood* of being affected in the various ways described; hence those at low risk of suffering in particular ways may not have discounted their responses sufficiently to allow for the smallness of their risks.
- There were indications that these respondents considered a gain of one month of life expectancy in normal health for 1000 people to have much the same value as 2 people each gaining about 40 years as a result of reductions in road traffic fatalities: that is, 1000 person-months gained from reducing air pollution was not valued very differently from 1000 person-months gained from reducing road accidents.

## Policy implications

Suppose some package of air pollution control measures is being contemplated which is expected to deliver some combination of the kinds of health benefits considered in this study. How should the monetary value of these benefits be calculated on the basis of the results of the main survey?

The total value of the set of benefits will be the sum of the values of the different benefits, so we may consider each in turn, starting with increases of life expectancy in normal health (N). Suppose it is calculated that the envisaged reductions in air pollution will increase life expectancy in ways that, aggregated across the population, will add up to a gain of 5 million person-years (e.g. 60 million people each getting, on average, an extra month). On the basis of the data, we

## Executive summary

can estimate a 'value of a person-year in normal health',  $V_N$ . However, because WTP for extra time in normal health was not proportional to the amount of time valued by the different subsamples, the estimate of  $V_N$  varies according to which subsample it is derived from. The three estimates derived from the three subsamples are as follows:

- from the 1-month subsample,  $V_N = £27,630$
- from the 3-month subsample,  $V_N = £9,430$
- from the 6-month subsample,  $V_N = £6,040$

If a single figure has to be adopted, there are arguments for favouring the figure derived from the 1-month subsample, namely:

- any realistic package of measures appears more likely to achieve gains of the order of one month per person than three or six months;
- a 1-month gain is more nearly marginal than either the 3- or 6-month gains and is therefore more directly comparable with other WTP-based values of health and safety, such as the value of preventing a statistical fatality (VPF) in road accidents, which was derived from WTP for essentially marginal risk reductions;
- respondents in the qualitative study appeared to regard aggregate gains in life expectancy in normal health resulting from reductions in air pollution as being of roughly equal value to corresponding aggregate gains from road safety, suggesting a value for  $V_N$  similar to that entailed by the current roads VPF (currently about £1.25m which, if regarded as the value for preventing the loss of about 40 years of life, would work out at approximately £30,000 per life-year).

If those arguments are accepted, 5m extra person-years of life in normal health would be valued at  $5m \times £27,630$ , i.e. at a total of £138,150m. Whether this figure should be discounted to allow for the way in which the 5m years would be spread over time – and if so, how that discounting factor should be applied – is discussed in the main report.

Similarly, a 'value of a person-year in poor health',  $V_P$ , may be estimated. Relative to a figure of £27,630 for  $V_N$ , a  $V_P$  in the range £7,280 to £14,280 is compatible with the main study data.

The WTP-based value of preventing a respiratory hospital admission,  $V_H$ , is estimated as lying in the range £1,310 to £7,110. This figure is intended to represent individuals' aversion to experiencing such an admission: the full value of preventing such an admission would also have to take account of other factors such as the cost savings to the NHS.

The value of preventing an average of 2 or 3 days of breathing discomfort every year throughout a person's life,  $V_D$ , is estimated as lying in the range £1,280 to £5,580. Put another way, the survey results suggest that avoiding a typical day of such discomfort is valued somewhere between £7 and £30.

# Background

## 1.1 Rationale for the study

In air quality policies, some measure of the importance of the health benefits is needed so that they can be compared with other implications of the policy. To compare the costs and benefits directly, the benefits need to be expressed in the same units as the costs. A monetary value for the benefits that reflects the preferences of those at risk can be obtained by finding out what they would be willing to pay to reduce a particular risk. Although reductions in risks are not marketable goods, people do bear the costs of measures to reduce risks one way or another (for example, through taxes, or in the form of higher prices for goods and services) and so people are in practice trading off small (changes in) risks against other things which are important to them. The desired levels of such trade-offs can, in principle, be investigated in carefully designed studies.

More specifically, until the 1980s most countries that explicitly addressed the public sector health and safety valuation issue tended to use some variant of the so-called "gross output" or "human capital" approach. Under this approach the primary component of the "cost" of the injury, illness or premature death of an individual is treated as the discounted present value of that individual's future output extinguished as a result of his or her injury, illness or premature demise. In some countries (including the UK) a further more-or-less arbitrary allowance was then added to the gross output figure to reflect the "pain, grief and suffering" of the victim and/or his/her surviving dependents and relatives. Values for the prevention of injury, illness or premature death are then defined in terms of the costs avoided.

Not surprisingly, many economists have objected to the gross output approach on the grounds that most people almost certainly value health and safety largely because of their aversion to the prospect of their own and others' death, injury or illness as such, rather than because of a concern to preserve current and future levels of output and income (Schelling, 1968; Mishan, 1971; Jones-Lee, 1989). Given this, it has been argued that values of health and safety ought ideally to be defined so as to reflect people's "pure" preferences for health and safety, *per se*, rather than in terms of effects on output and income, as in the gross output approach. However, in order to define and estimate values of health and safety in this way we clearly require some means of measuring people's preferences for health and safety and, more particularly, their *strength* of preference. How can one do this? Arguably, the most natural measure of the extent of a person's preference for anything is the maximum amount that he or she would be willing to pay for it. This amount reflects not only the person's valuation of the desired good or service relative to other potential objects of expenditure, but also the individual's *ability* to pay – which is itself a manifestation of society's overall resource constraint.

So, under what has naturally come to be known as the "willingness-to-pay" (WTP) approach to the valuation of health and safety, one first seeks to establish the maximum amounts that those affected would individually be willing to pay for (typically small) improvements in their own and others' health and safety. These amounts are then simply aggregated across all individuals to arrive at an overall value for the health or safety improvement concerned. The resultant figure is thus a clear reflection of what the health or safety improvement is "worth" to the affected group, relative to the alternative ways in which each individual might have spent his or her

## Section 1

limited income. Furthermore, defining values of health and safety in this way effectively “mimics” the operation of market forces – in circumstances in which markets typically do not exist – insofar as such forces can be seen as vehicles for allowing individual preferences to interact with relative scarcities and production possibilities to determine the allocation of a society’s scarce resources.

In 1998 an Expert Group - the Economic Appraisal of Health Effects of Air Pollution (EAHEAP) - was set up by the Department of Health. EAHEAP were asked to advise on whether the monetary valuation of health effects of reduced air pollution is appropriate and, if so, whether appropriate values could be derived. Their report was published in 1999<sup>1</sup>.

When the EAHEAP group examined the different ways in which the benefits to health of reductions in levels of air pollution could be expressed, they decided that the Willingness to Pay (WTP) approach was the most suitable method to use. The report, however, noted the lack of direct empirical evidence on monetary valuation of the reduction in risk of deaths brought forward by air pollution, and concluded that it would not be appropriate simply to take values from the road traffic accident context and apply them, without adjustment, to the air pollution context. The report went on to provide some guidance about the range of WTP values that might be expected for acute deaths brought forward by air pollution (based on knowledge of the effect on WTP of various factors such as the age of those affected) but acknowledged the extensive uncertainties in the range of estimates<sup>2</sup> suggested.

A key recommendation of EAHEAP and the subsequent 1999 IGCB Report<sup>3</sup> was to undertake empirical studies of WTP for health benefits associated with reductions in air pollution. As a result, this study was commissioned with the aim of generating a range of monetary values for various key mortality and morbidity benefits.

The study focused on two types of mortality effects – chronic (loss of life expectancy in normal health) and acute (loss of life expectancy when elderly and in poor health); and two types of morbidity effects – a hospital admission with breathing difficulties, and breathing discomfort on 2 or 3 days every year.

The methodology employed is outlined in the next section.

<sup>1</sup> Ad hoc Group on the Economic Appraisal of the Health Effects of Air Pollution “Economic Appraisal of the Health Effects of Air Pollution”, Department of Health, 1999.

<sup>2</sup> EAHEAP acute mortality values ranged between £2,600 to £1.4 million for a death brought forward.

<sup>3</sup> Interdepartmental Group on Costs and Benefits (IGCB) Report “An economic analysis of the National Air Quality Strategy: an interim report”, 1999.

# Methodology

## 2.1 Overview

Having decided that WTP-based values of health, safety and longevity constitute the appropriate benefit measure in the air pollution context, the next crucial question to address is how such values are to be estimated. Broadly speaking two variants of empirical estimation procedure have been employed to derive WTP-based values of health and safety. These are known respectively as the “revealed preference” (or “implied value”), and the “contingent valuation” (or “stated preference”) approaches.

Basically, the revealed preference approach involves the identification of situations in which people actually do trade off income or wealth against physical risk – for example, in labour markets where riskier jobs can be expected to command clearly identifiable wage *premia* (Smith, 1983; Viscusi and Moore, 1989). By contrast, the contingent valuation approach involves asking a representative sample of people more or less directly about their individual WTP for improved health or safety, (or, sometimes, their willingness to accept compensation for increased risk).

The difficulty with the revealed preference approach when applied to labour market data is that it depends on being able to disentangle risk-related wage differentials from the many other factors that enter into the determination of wage rates. The approach also presupposes that workers are well-informed about risks that they actually face in the workplace. In addition, those whose jobs do carry clearly identifiable wage premia for risk may not be representative of the work force as a whole, in that such people almost certainly have a below-average degree of physical risk-aversion (Gegax et al., 1991).

The great advantage of the contingent valuation approach is that it allows the researcher to go directly and unambiguously to the relevant wealth/risk trade-off – at least, in principle. On the other hand, the contingent valuation approach has the disadvantage of relying upon the assumption that people are able to give considered, accurate and unbiased answers to hypothetical questions about choices that are relatively unfamiliar and with which most respondents will have little prior experience.

In spite of these potential difficulties, it was decided that the contingent valuation approach offered the most promising way forward, particularly as there is hardly an abundance of data concerning market-based choices in the field of air-pollution. The rationale for the particular variant of the contingent valuation approach chosen for this study is provided below.

The principal research tool was a questionnaire administered to a random probability sample of the general population. A substantial period of time was spent developing and piloting the questionnaire in collaboration with researchers from the National Centre for Social Research (NatCen). The developmental stage and piloting is outlined in more detail in Annex 1.

The final pilot involved conducting a larger scale field test of the questionnaire (this is referred to as “Phase 1 of the main survey”). This took place in Edinburgh and Norwich in June and July 2002. We refer to the main survey itself as “Phase 2” and its aims were to interview a larger,

## Section 2

representative sample of the UK population. The fieldwork for this phase took place during November and December 2002 and early January 2003 in England, Scotland and Wales. In terms of the sampling approach, the study used a random probability sampling method involving 2 stages. After stratifying by region and socio-economic status, 41 postcode sectors were randomly selected. Using the Postcode Address File, 35 addresses were randomly selected within each sector (1435 addresses in total). Of these, 216 were 'out of scope' (e.g. empty or non-residential properties, occupiers ill/incapable), leaving 1,219 addresses 'in scope'. Within each selected household, an individual aged 18+ was randomly selected. The aim was to conduct a total of approximately 750 completed interviews. In the event, the total number of completed interviews was 665 – a response rate of 54.6%. A summary of the demographic characteristics of the respondents who took part in the study is shown in Annex 3 (Tables 1a and 1b).

As in Phase 1, interviews were carried out on a one-to-one basis in respondents' own homes and were conducted by 48 experienced NatCen interviewers using a structured interactive Computer Assisted Personal Interview (CAPI) programme on lap-tops with interviews lasting, on average, 29 minutes. All of the quantitative results described in Section 3 are based only on the Phase 2 responses.

### 2.2 The questionnaire

The full version of the questionnaire used in Phase 2 is shown in Annex 2.

The initial stage of the questionnaire asked respondents general questions about their household. This included naming the persons in their household (including spouses or children) who were part of the same financial unit. The respondents at this stage were not told the ultimate purpose of the interview, except that it was a survey to investigate what value members of the public place on various health improvements. In one of the opening questions, respondents were asked to consider a wide range of different public health risks (of which air pollution was just one) and were asked to consider the three biggest threats to their own health (Table 2 in Annex 3 shows the percentages of respondents who considered air pollution as one of the three biggest threats to their health). The reason for this approach was to see to what extent respondents identified air pollution as a high priority concern for them, and to put air pollution in some context: i.e. that there are a range of public health risks, of which air pollution is just one. Following this question the respondent was told the focus for the rest of the interview would be on health risks from air pollution.

The next section of the interview asked the respondent to consider various ways that air pollution might affect people's health, including the impacts on mortality (chronic and acute) and morbidity (respiratory hospital admissions and days of breathing difficulties). Exhibit 1 presents the four impacts that respondents were asked to consider. These descriptions of the health impacts were developed in consultation with the Department of Health to provide as accurate a description as possible based on current epidemiological evidence and the need for brevity and simplicity. This is important as any values derived from the study will need to be consistent with the health benefits quantified.

Exhibit 1: Mortality and morbidity impacts of air pollution on health

Chronic mortality	Acute mortality
<p>"Faster ageing. Some chemicals in the air may cause wear and tear on our bodies, so that people living in areas with more pollution may age faster and die younger than people in low pollution areas. Some experts think that the average person in Britain might lose about a month of life in this way. Others think the average loss of life might be as much as a year."</p>	<p>"Death brought forward when elderly and in poor health. On a few days every year, air pollution reaches unusually high levels. For some people in their 70's and 80's with existing heart or lung disease, the unusually high level of pollution on a bad air day can put so much extra stress on their breathing that their heart fails and they cannot be revived. Often these people are not expected to live very much longer anyway, but a bad air day can bring their death forward. If the bad air day had not occurred, they could have lived a few weeks or months longer, although this time would have been spent in their existing poor state of health."</p>
Respiratory hospital admission	Days of breathing discomfort
<p>"Hospital admission. Another possible effect of bad air days is that some people need hospital treatment. The people affected in this way are mostly in their 70's and 80's with some kind of lung disease, although some of those affected may be younger people with asthma or other chest conditions. The unusually high pollution can cause them to suffer an attack of coughing, wheezing, chest pains and struggling for breath which becomes so bad that they need to be admitted to hospital. They may have to stay in hospital for anything from a day or two, up to a couple of weeks, followed by a period of time resting at home."</p>	<p>"Breathing discomfort on 2 or 3 days every year. For people of all ages who have asthma or various other allergies or chest conditions, bad air days can bring on a cough and a feeling of discomfort in the chest. If they do any heavy work or vigorous activity they may wheeze or feel breathless. As soon as the bad air day is over, they return to normal health. But, on average, they are likely to suffer 2 or 3 days of breathing discomfort every year throughout their lives."</p>

Respondents were also asked about how they thought that air pollution in their area compared to the average for other areas of Britain, and whether or not they or anyone else in their household had any personal experience with occasional days of breathing discomfort or admission to hospital with breathing difficulties (Tables 3 and 4 in Annex 3 show the percentages of respondents with first-hand experience of these health impacts.)

## Section 2

The remaining set of questions focused on eliciting willingness to pay (WTP) for four possible benefits that might be associated with reducing air pollution. The four benefits they were presented with are shown in Exhibit 2.

Exhibit 2: The four benefits of reducing air pollution valued by respondents

N (Chronic mortality)	P (Acute mortality)
<p>"X MONTHS MORE LIFE IN NORMAL HEALTH. By reducing the general level of air pollution that causes wear and tear and faster ageing, everyone could live longer. That would mean that you {and everyone else in your household} could expect to live about X months longer in your {their} normal state of health."</p>	<p>"X MONTHS MORE LIFE IN POOR HEALTH WHEN ELDERLY. This would be most likely to benefit elderly people with heart or lung disease. By reducing the number of bad air days, such people could expect to live about X months longer, although this extra time would be spent in their existing poor state of health."</p>
H (Respiratory hospital admission)	D (Days of breathing discomfort)
<p>"AVOIDING AN ADMISSION TO HOSPITAL WITH BREATHING DIFFICULTIES. This would be most likely to benefit people in their 70's and 80's who have some kind of lung disease, or younger people with asthma or other chest conditions. By reducing the number of bad air days, such people would be less likely to develop attacks of breathing difficulties which require admission to hospital."</p>	<p>"AVOIDING 2 OR 3 DAYS OF BREATHING DISCOMFORT <u>EVERY YEAR</u>. This would be most likely to benefit people with asthma or various other allergies or chest conditions for whom bad air days can bring on coughing and wheezing. By reducing the number of bad air days, such people would avoid 2 or 3 days of breathing discomfort like this every year from now on."</p>

In the case of N (X months more life in normal health) and P (X months more life in poor health when elderly) the value of X was randomly set at *either* 1, 3 or 6 months<sup>4</sup>. Varying the length of the gain in life expectancy provides us with a **test of sensitivity to scope** (i.e., as the scope of the good increases from 1 to 3 to 6 months, the values should increase) which is an important indicator of expectations-based validity. Of the 665 respondents interviewed, 224 were asked to value a 1 month gain, 228 valued a 3 month gain, and 213 valued a 6 month gain.

For each of the benefits in turn (D was presented first, followed by H, P and N) respondents were asked to think about how much benefit, if any, it would be to their **household**, on a five-point

<sup>4</sup> At the time of the study, the available epidemiological evidence suggested that this was the most appropriate range of values for P: that is, that most deaths brought forward typically involved losses of 6 months or less. It also seemed unlikely that any realistic package of measures could increase life expectancy in normal health by more than about 6 months – see Hurley *et al.* (2000). Given the uncertainties about how much benefit could be delivered, it seemed prudent to explore values for three different lengths of time spread across what was judged to be the most plausible range.

scale from “no benefit at all” to “a very big benefit”. Before giving these ratings for D and H they were asked to rate how unpleasant they thought the experience would be and how likely or unlikely they thought it was that they or the named members of their household would experience the problem in the future. For P and N they were asked how desirable or undesirable they thought it would be to live for that time (X months) either in a poor state of health when elderly, or in normal health; and in the case of P to indicate how likely or unlikely they thought it was that they or the named members of their household *would* suffer from heart or lung disease when they were elderly (Tables 5-8 in Annex 3 summarise the ratings provided by respondents to these questions.)

The interviewer explained that there were various ways that air pollution could be reduced in order to tackle those health problems, such as reducing emissions from factories and traffic and using cleaner fuels. But the cost of these measures would be likely to increase prices of all kinds of everyday goods and therefore increase the cost of living for their household.

They were told that they would shortly be asked whether or not they would be willing to pay anything for any of the benefits. But before getting to that, they were encouraged to think about their budget constraint and **disposable income**. This was done by asking them to indicate which of the following statements best represented their household’s situation as regards money (Table 9 in Annex 3 summarises the responses given to this question).

- A. “I/We normally have enough money for anything we want”
- B. “We have enough money, so long as we plan our spending carefully”
- C. “We have enough money for basic things, but we can’t afford anything unnecessary”
- D. “Sometimes it is hard for us to afford even the basic things we need”

Having considered their household finances, respondents were then reminded of the benefit ratings they had given to each of N, P, H, and D. Having recapped these ratings (and modified any of them if they so wished), each respondent was asked first of all whether or not they would be willing to pay anything at all in the form of higher prices for any of these four benefits. They were told to focus just on the benefits to them personally and the other named members of their household and not to answer on behalf of anyone else. If they responded that none of these benefits was worth paying anything at all for, the reasons for this were explored further by asking them to indicate which of the following statements best described their reason. This was in order to identify ‘protest’ responses (those who selected D, E, F or G) from those who genuinely did not value the health benefits (A, B or C).

- A "These things are of no value to me (or anyone else in my household)",
- B "I (my household) cannot afford anything at all for these things",
- C "I (we) would rather spend our money on other things",
- D "The money should come from existing taxes",
- E "The costs should be paid by whoever causes the air pollution",
- F "I don't believe that reductions in air pollution will produce these results",
- G "Some other reason".

## Section 2

Those who said it was worth paying something then embarked on a **random card sorting** procedure to help them identify the most they would be willing to pay each year for the rest of their lives to get all four of those benefits.

This procedure involved the interviewer shuffling a pack of 12 cards showing different amounts that their household might pay each year (printed in red) or month (printed in blue)<sup>5</sup>. Having been shuffled, the cards were turned over one at a time and for each in turn, the respondent was asked whether or not it would be worth paying that amount **every year for the rest of their life for all four benefits**. Each time a card was shown the interviewer provided the respondent with an estimate of how much it would add up over the rest of their life based on the average for someone of their age and gender. By sorting the 12 values into three piles (amounts they “certainly would pay”, amounts they “certainly would not pay” and amounts they were “unsure” about) the random card sorting procedure, like the payment card approach<sup>6</sup>, allowed for uncertainty in respondents’ preferences.

Having identified the highest amount sorted into the “certainly would pay” pile, respondents were given the opportunity to revise or fine tune that value up or down. They were then asked to divide this total WTP amount between the four benefits. The respondent was asked to identify which of the four benefits was seen as of most importance to their household and estimate how much would be set aside for that benefit out of the total WTP. The same approach was then taken for the second most important benefit, the third and then the least. The interviewer then summarised the respondent’s decisions and provided an opportunity for them to revise the values if they wished to do so. The final part of the questionnaire collected socio-economic information on the respondent and their household.

The questions concerned with rating and then valuing the various benefits are reproduced in the full text of the questionnaire in Annex 2.

### 2.3 Specific design issues of questionnaire

There are a number of specific aspects of the questionnaire design worth highlighting. The **payment vehicle** explicitly provided was in terms of higher prices on everyday goods and services which could increase the cost of living. WTP was elicited at a **household** level, one of the main reasons for this being that it is at this level that the budget decision is generally taken and it is difficult to separate out at an individual level. The payments were in the form of an **on-going annual payment**. The choice of this format was because provision of goods such as clean air tend to be on a continuous basis rather than in terms of one off capital investments, and therefore tend to impose a long-term stream of costs upon households<sup>7</sup>. In the questionnaire, annual payments were translated into a lifetime total WTP figure by multiplying up by estimated remaining life expectancy. In terms of elicitation format for WTP, a **random card sorting** procedure was adopted. The rationale, endorsed by the Expert Group, was that such a

<sup>5</sup> The annual amounts shown on the cards were £1, £2.50, £5, £10, £25, £50, £100, £250, £500, £1000, £2500, £5000

<sup>6</sup> The payment card process, by contrast, presents all the potential WTP amounts on one single card.

<sup>7</sup> In earlier pilots the idea of annual payments over a 10 year period was tried but it was found that respondents tended to ignore the fact that the payment was for a fixed period.

procedure might be better than a payment card (where respondents might get 'cues' from the range of values on the card) and, by explicitly making the order of cards random, might avoid or reduce 'starting point' effects whereby respondents attached undue significance to the first amount they were asked about. Finally, it is important to note that the approach taken to valuation involved eliciting a **total WTP for all 4 benefits** together and then **dividing up the total WTP among the 4 benefits**. This approach was advocated for a number of reasons: in earlier piloting, when respondents were asked how much they were willing to pay for each of the 4 health benefits separately, many respondents were giving similar amounts for each and seemed to be thinking more about what they could afford; and thus there was considerable concern that the sum of the 4 individual responses would be far greater than the amount they would actually be willing or able to pay in total for all 4 benefits together. Since many policies to reduce air pollution would, if successful, deliver some bundle of the various benefits - rather than any one on its own - it seemed more appropriate to start by asking for total WTP for all 4 benefits together, and then asking about the relative weight assigned to each, as represented by the proportion of the total WTP allocated to each benefit.

## Results

As noted in Section 2.1, a total of 665 respondents were interviewed, representing a response rate of 54.6%. This was lower than expected, and a comparison between sample characteristics and those of the population reflects the fact that males – and in particular, those males between 16 and 29 years of age – were disproportionately likely to refuse to participate (although females in the same age group were also somewhat under-represented). In terms of social class, the sample had a somewhat smaller proportion of professional and managerial/technical respondents and a correspondingly larger proportion of skilled and semi-skilled manual respondents than in the population as a whole.

### 3.1 Summary statistics

Exhibit 3 shows *household* willingness to pay per year for the various benefits, whereas Exhibit 4 shows WTP on a *per-person* basis. It should be noted that the WTP results presented here exclude the data from 148 respondents – 10 of whom declined to answer the WTP question without giving reason and 138 of whom gave zero WTP responses for ‘protest’ reasons. The responses of 46 respondents who gave zero WTP responses for non-protest reasons were however included (see Table 10 in Annex 3 which shows the percentages of respondents giving each of these reasons).

The level of protest responses (22.5% of the total sample) in this Phase 2 main study was higher than the 12% in the Phase 1 pilot, which was disappointing, although many other valuation studies have similar levels of protest responses (e.g., Smith and Desvousges, 1987). Subsequent analysis suggested that those registering protest responses were significantly older than non-protesters and significantly more likely to refuse to give information about their income; they also tended to have rated the benefits lower, and there was *some* tendency for males to be more likely to protest than females.

As shown in Exhibit 3, the full sample mean WTP responses are substantially higher than the medians (i.e., £222<sup>8</sup> vs. £100 for household WTP for all four benefits). This is notwithstanding the ‘spike’ of non-protest zeroes, and reflects the fact that the distribution of responses is positively skewed, as shown in Figure 1. Although some positive skewness is not unusual in WTP studies, it can be seen from Figure 1 that the dataset includes a minority of extreme outliers which could arguably be exerting an unduly strong influence on the mean responses.

For this reason in Exhibits 3 and 4 we also present trimmed means with the 4 largest and 4 smallest values trimmed from the datasets for each subsample (a level of trimming equivalent to less than 2.5% at each end of the distribution)<sup>9</sup>. It can be seen that this rather modest level of trimming has a marked effect on both means and standard deviations, with means falling to

<sup>8</sup> Mean response rounded to the nearest £.

<sup>9</sup> Other levels of trimming were explored: top and bottom 2, 6 and 10 from each subsample: however, the falls in means became much less pronounced after trimming 4 top and bottom, so we present those figures.

between two-thirds and three-quarters of their full-sample values, while standard deviations drop to approximately one-third of the full-sample figures. While acknowledging that such trimming may be somewhat arbitrary, it is arguably a precaution against extreme hypothetical and/or strategic bias on the part of a small handful of respondents exerting disproportionate influence on policy. Thus in the discussion of the implications for policy in Section 5 below, the focus is upon the more modest trimmed means. However, those who take the view that no responses should be trimmed have the option of using the full-sample figures.

Exhibit 3: Summary statistics of WTP responses (£ per year for everyone in household)

	TOTAL N+P+H+D	N (Extra Time in Normal Health)	P (Extra Time in Poor Health)	H (Avoiding Hospital Admission)	D (Avoiding Breathing Discomfort)
<b>Full Sample</b>					
Original n	665	665	665	665	665
Protest zeros/ declined to provide WTP (%)	148 (22.2%)	148 (22.2%)	148 (22.2%)	148 (22.2%)	148 (22.2%)
Processed n	517	517	517	517	517
Non-protest zeros (%)	46 (8.89%)	90 (17.4%)	278 (52.8%)	162 (31.3%)	186 (36.0%)
Median	100	25	0	10	9
Mean (Std. Dev)	221.56 (561.10)	96.89 (281.92)	21.80 (138.65)	48.36 (147.35)	54.51 (235.55)
Trimmed Mean (Std. Dev) 95% Confidence Interval	154.86 (191.63) 137.9 – 171.8	69.51 (99.62) 60.7 – 78.3	14.80 (37.69) 11.5 – 18.1	35.65 (61.44) 30.2 – 41.1	34.90 (75.43) 28.2 – 41.6
<b>1 month version</b>					
Original n	224	224	224	224	224
Protest zeros/ declined to provide WTP (%)	56 (25.0%)	56 (25.0%)	56 (25.0%)	56 (25.0%)	56 (25.0%)
Processed n	168	168	168	168	168
Non-protest zeros (%)	19 (11.3%)	38 (22.6%)	97 (57.7%)	60 (35.7%)	67 (39.9%)
Median	100	25	0	10	6
Mean (Std. Dev)	194.21 (441.39)	65.47 (118.73)	17.93 (52.85)	56.18 (176.33)	54.63 (177.47)
Trimmed Mean (Std. Dev) 95% Confidence Interval	152.67 (205.31) 120.9 – 184.5	60.15 (95.40) 45.4 – 74.9	15.86 (48.38) 8.4 – 23.4	36.49 (63.93) 26.6 – 46.4	40.17 (89.39) 26.3 – 54.0

### Section 3

	TOTAL N+P+H+D	N (Extra Time in Normal Health)	P (Extra Time in Poor Health)	H (Avoiding Hospital Admission)	D (Avoiding Breathing Discomfort)
<b>3 month version</b>					
Original n	228	228	228	228	228
Protest zeros/ declined to provide WTP (%)	44 (19.3%)	44 (19.3%)	44 (19.3%)	44 (19.3%)	44 (19.3%)
Processed n	182	182	182	182	182
Non-protest zeros (%)	14 (7.7%)	28 (15.4%)	99 (54.4%)	51 (28.0%)	57 (31.3%)
Median	100	30	0	10	10
Mean (Std. Dev)	221.91 (608.39)	110.08 (377.91)	27.51 (223.37)	39.69 (93.32)	44.63 (162.09)
Trimmed Mean (Std. Dev) 95% Confidence Interval	145.91 (174.25) 120.0 – 171.8	67.72 (91.35) 54.1 – 81.3	11.53 (29.01) 7.2 – 15.8	35.34 (60.83) 26.3 – 44.4	31.31 (62.09) 22.1 – 40.5
<b>6 month version</b>					
Original n	213	213	213	213	213
Protest zeros/ declined to provide WTP (%)	46 (20.2%)	46 (20.2%)	46 (20.2%)	46 (20.2%)	46 (20.2%)
Processed n	167	167	167	167	167
Non-protest zeros (%)	13 (7.8%)	24 (14.4%)	82 (49.1%)	51 (30.5%)	62 (37.1%)
Median	100	40	1	10	6
Mean (Std. Dev)	248.68 (614.45)	114.12 (275.08)	19.47 (49.84)	49.93 (162.99)	65.15 (334.53)
Trimmed Mean (Std. Dev) 95% Confidence Interval	166.85 (196.08) 136.4 – 197.3	80.87 (111.28) 63.6 – 98.2	17.31 (33.56) 12.1 – 22.5	35.15 (59.92) 25.8 – 44.5	33.52 (73.55) 22.1 – 45.0

Exhibit 4: Mean household WTP responses adjusted to give equivalent WTP amounts per person  
 - i.e. (household mean x total number of households) / total number of individuals

	TOTAL N+P+H+D	N (Extra Time in Normal Health)	P (Extra Time in Poor Health)	H (Avoiding Hospital Admission)	D (Avoiding Breathing Discomfort)
<b>Full Sample</b>					
<b>Untrimmed dataset</b> 517 households, 1107 individuals Mean	103.47	46.65	10.18	23.06	25.46
<b>Trimmed dataset</b> 493 households, 1048 individuals Mean	72.85	32.70	6.96	16.77	16.42
95% Confidence Interval	64.9-80.8	28.6-36.8	5.4-8.5	14.2-19.3	13.3-19.6
<b>1 month version</b>					
<b>Untrimmed dataset</b> 168 households, 342 individuals Mean	95.40	32.16	8.81	27.60	26.84
<b>Trimmed dataset</b> 160 households, 326 individuals Mean	74.93	29.52	7.78	17.91	19.72
95% Confidence Interval	59.3-90.6	22.1-36.8	4.1-11.5	13.1-22.8	12.9-26.5
<b>3 month version</b>					
<b>Untrimmed dataset</b> 182 households, 414 individuals Mean	97.55	48.39	12.09	17.45	19.62
<b>Trimmed dataset</b> 174 households, 390 individuals Mean	65.10	30.21	5.14	15.77	13.97
95% Confidence Interval	53.5-76.7	24.1-40.7	3.2-7.1	11.7-19.8	9.9-18.1
<b>6 month version</b>					
<b>Untrimmed dataset</b> 167 households, 351 individuals Mean	118.32	54.30	9.26	23.76	31.00
<b>Trimmed dataset</b> 159 households, 332 individuals Mean	79.91	38.73	8.29	16.83	16.05
95% Confidence Interval	65.3-94.5	30.5-47.0	5.8-10.8	12.4-21.3	10.6-21.6

### Section 3

Figure 1: Distribution of Household WTP

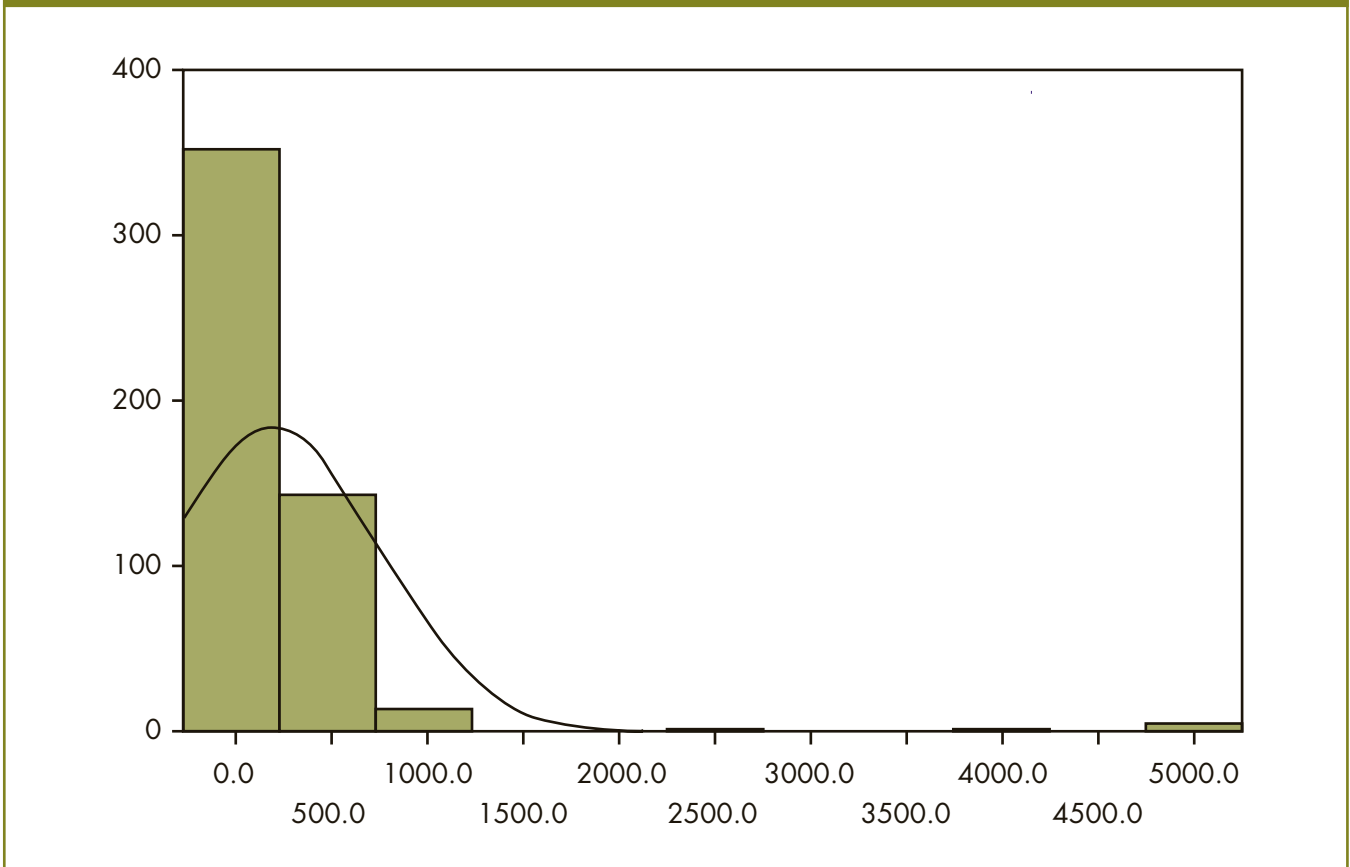


Exhibit 3 clearly shows that N was the most valued of the four benefits with, on average, 44.9% of the total WTP amount allocated to this benefit, and with only 17.4% of respondents assigning no value to this benefit. This contrasts with P, which was the least valued of the four benefits, with respondents allocating an average of 10.1% of their total WTP amount to P and with more than half of them (52.8%) assigning no value to it at all. The other two benefits, H and D, were allocated intermediate proportions of the total (23.0% for H and 22.5% for D) and were assigned no value by about a third of respondents (31.3% and 36.0%). T-tests confirmed that for all three variants, the mean household WTP amounts were significantly higher for N than for P and not significantly different between H and D (see Table 11 in Annex 3).

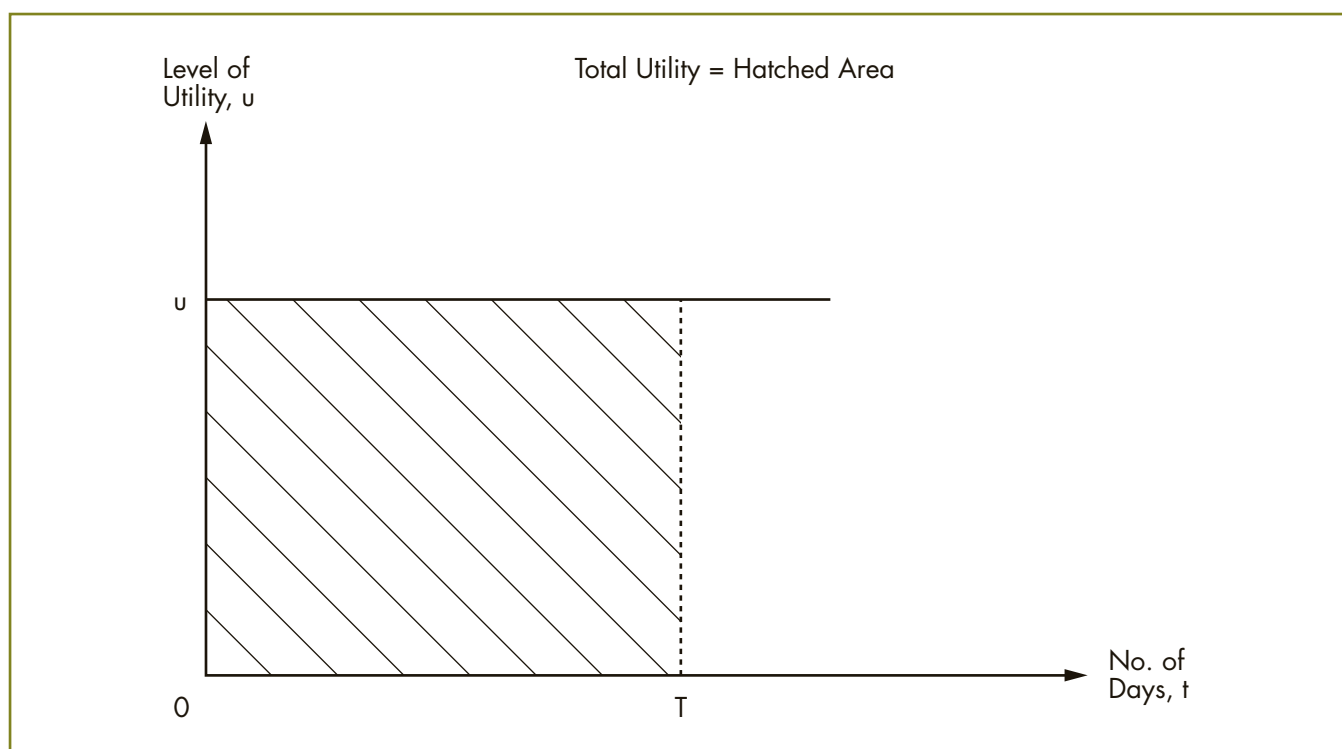
These results suggest that, when allocating their WTP amounts between the four benefits, respondents were sensitive to the nature and the quality of the good being valued. In particular, it appears that they valued a gain of life expectancy in *normal* health more highly than a gain of life expectancy in *poor* health. In WTP studies scope sensitivity is generally regarded as an important indicator of expectations-based validity since from the standpoint of economic theory one would expect values to increase as the quality of the good increases.

One possible reservation about this result is that respondents were being asked to value the *certainty* of an extra X months in normal health, as compared with the *chance* of an extra X months in poor health (that chance depending on the likelihood of one day being in the vulnerable poor health state typical of those whose death may be brought forward by days of

unusually high pollution levels). If the typical respondent considered that each member of their household had, say, a 20-25% chance of getting into such a state, then the fact that the means for P are approximately 20-25% of the means for N would suggest that people value extra life in that poor health state P not significantly less than extra life in normal health. On the other hand, if respondents were ignoring the issue of likelihood and were thinking about P as if it were as certain as N, then the results suggest that P is indeed regarded as very different from and inferior to N (not just in terms of the means, but also with the medians for P being 0 or 1). The extent to which respondents were attending to or ignoring the likelihood issue was explored further both in the regression analyses reported in Section 3.2 and in the follow-up qualitative study, described and discussed in Section 4 below.

### 3.2 Examining the underlying model

Our study design also allowed us to examine whether respondents were sensitive to the quantity as well as the quality of the gain in life expectancy. Consider the following diagram, depicting in simplified form a way of modelling individual welfare.



The vertical axis ( $u$ ) represents the level of utility an individual anticipates experiencing each day, while the horizontal axis ( $t$ ) shows the number of days. Total utility anticipated over any period of time  $T$  is represented by the area under the line over the interval  $t = [0, T]$ . For relatively small periods of time, there might be no strong reason to expect daily utility to vary markedly, so again for simplicity we depict the level of utility per day as a horizontal line. On this basis, total utility ( $U$ ) gained by an individual is simply  $u \times T$ : for an individual assigned to the subsample where  $T = 6$  months, the total utility from this benefit will be twice that anticipated by the

### Section 3

corresponding individual assigned to the subsample where  $T = 3$  months, and six times that for the comparable individual assigned to the 1-month subsample. For a household consisting of  $S$  such individuals, total household utility, HHU, will be given by  $HHU = S \times T \times u$ .

Of course, we cannot observe  $u$  and HHU directly. Instead of HHU, what we observed was household annual willingness to pay for extra months in normal health, which we denote by WTP-N. So we might expect WTP-N to be some increasing function of those variables on the right hand side of the expression above, and we might therefore write this as:

$$WTP-N = f(S \times T \times u) \quad (1)$$

The question then is what determines the level of  $u$ . Clearly,  $u$  may vary from one individual to another for all sorts of reasons, many of which we did not (and possibly never could) observe. But it would be quite standard in economic theory to suppose that  $u$  is a positive and increasing function of income  $Y$  (with the usual assumption being that this is a concave function, reflecting diminishing marginal utility of income). Other variables might also affect  $u$ , perhaps through some interaction with income. For example, it might be the case that an individual who perceives normal health as being one where income can be enjoyed to the full may put a high 'quality of life' weight ( $q$ ) on income, while someone who thinks of normal health as being somewhat more limited may apply a lower  $q$  weight to income: in such a case,  $q$  might operate multiplicatively, so that  $u = g(qY)$  would be an appropriate functional form. While it is easier to think of examples of other factors that might also operate multiplicatively, we would not rule out the possibility of variables that contribute separately and additively to  $u$ . In the absence of very strong *a priori* expectations in this respect, we might simply represent 'other' observable variables by  $Z$  and write the function rather generally as  $u = g(Y, Z)$ , where  $Y$  is individual income (which in terms of our data set we compute as the individual's average share of household income) and  $Z$  are other variables which appear to correlate with WTP-N. Substituting for  $u$  in the expression above, we get:

$$WTP-N = f(S \times T \times g(Y, Z)). \quad (2)$$

Although we cannot know for sure whether all the  $Z$  variables really do interact multiplicatively with  $Y$ , for the purposes of exploring the data we assumed that they do. On that basis, we can write:

$$WTP-N = \alpha S^{\beta_1} T^{\beta_2} Y^{\beta_3} Z_1^{\beta_4} Z_2^{\beta_5} \dots Z_n^{\beta_{n+3}} \eta \quad (3)$$

where  $\eta$  is a lognormally distributed error term and the  $\beta$ 's reflect the contribution of the particular variables to household WTP. Taking logs of both sides gives

$$\ln(WTP-N) = \ln(\alpha) + \beta_1 \ln(S) + \beta_2 \ln(T) + \beta_3 \ln(Y) + \dots + \varepsilon \quad (4)$$

which may be estimated using Ordinary Least Squares<sup>10</sup>.

<sup>10</sup> In order to be able to include all the cases where WTP was zero, the procedure required adding 1 to all WTP responses before taking logs. And in the case of WTP-P, where a very large number of responses were zero, possibly signifying that a proportion of the sample positively disliked the idea of extra life in poor health and would, if permitted, have assigned a negative value to  $P$ , a Tobit regression was used. This technique assumes that the WTP data have been truncated or censored at zero and calculates a revised distribution of the WTP responses under the assumption that the sample is normally distributed, thereby allowing some of the zero responses to be treated as though they are negative amounts.

We decided to adopt the same broad framework to explore household willingness to pay for the other possible benefits, denoted by WTP-P, WTP-D and WTP-H – the main modification being that WTP for each of these might be expected to be influenced by respondents' perceived likelihood of benefiting in the various ways. We examined the bivariate correlations between the variables (see Table 12 in Annex 3) to guide us as to which other variables to include on the right hand side, and settled on the following set (not all of which were expected to be significant explanators of all four WTP's). In case S, T and Y are not particularly transparent labels, we refer from now on to right-hand-side variables by names which may better convey their nature. The set we used was as follows:

**HHSIZE:** The number of people in the household (S in the expressions above)

**NUMMONTH:** The number of extra months per person (T above)

**PERCAP:** Per capita income (i.e., total household income divided by the number of people in the household)

**AGE:** The age of the respondent

**NUMCHILD:** The number of children (under 16) in the household

**EXPER:** This variable gives a sum of the number of "yes" responses to the three questions about whether any relative or member of their household had had experience of heart/ lung disease when elderly (Q5), respiratory hospital admission (Q6) or days of breathing discomfort (Q9).

**LIKELY-D/H/P:** The respondent's perception of the likelihood that they (or any other member of their household) would experience days of breathing discomfort / be admitted to hospital with breathing difficulties / suffer from heart/lung disease when elderly. Certain respondents were unable to give a value for these likelihoods, so in order not to lose those respondents (and thereby run the risk of biasing the results), we substituted the median value for those respondents.

**STARTCARD:** The value on the first 'shuffle' card shown to those who said they would pay something and recorded some positive WTP. Of course, those who gave non-protest zero WTP responses were not presented with a first card and were recorded as 'missing values' for this variable. In order not to lose those respondents (and thereby run the risk of biasing the results by omitting 46 genuine zeros), we substituted the average start card value for those respondents.

We started by regressing each of the WTP dependent variables on this set of independent variables (plus the constant term,  $\alpha$ ). The following hypotheses/conjectures/issues were examined:

**HHSIZE:** Since it was specified that each and every member of the household could expect to get the extra life in normal health, the expectation was that the coefficient on this variable in the WTP-N regression should be significantly greater than zero. Predictions about the signs of the corresponding coefficients for WTP-P, WTP-D and WTP-H are less clear. To the extent that larger households were more likely to have at least one member experience these benefits, there would be some positive relationship. However, for those who regarded extra life in poor health as worth

## Section 3

nothing (or even undesirable and negatively valued), a larger household size might be associated with greater aversion and a stronger probability of a zero response.

**NUMMONTH:** For WTP-N, we should expect a significantly positive coefficient on this variable. If such gains were all treated as if they were marginal changes, we should expect the coefficient to be close to, but slightly less than, 1. The argument for this is that if the marginal utility of 6 extra months is not very much less than six times the marginal utility of 1 extra month, and if even an extra 6 months is a sufficiently marginal change that no strong income effects are induced, WTP should be only just less than proportional to the amount of extra life expectancy. On the other hand, if the larger benefits are regarded as non-marginal, and if people respond as if budget constraints are severe, the coefficient may fall significantly short of 1. For WTP-P, the question is whether any extra time in such poor health is regarded as a good thing: if it is not, the coefficient will not be significantly greater than 0; and if enough respondents regard extra P months as being strictly undesirable, the coefficient may be negative. Finally, the benefits D and H were the same for all three subsamples, so should not vary with NUMMONTH: the prediction is therefore that in these regressions, the coefficient should not be significantly different from zero.

**PERCAP:** To the extent that each benefit is positively valued, the monetary expression of that value can be expected to increase with the income of the individual recipient, proxied in this case by PERCAP: hence the prediction that the coefficient should be significantly greater than zero for all four (with perhaps some caveat regarding P).

**AGE:** Since respondents were asked to answer on behalf of their household, the respondent's own age might be expected not to matter, all other things being equal. However, to the extent that respondents are not able to answer simply as representatives who are knowledgeable about other household members' values and are, in fact, liable to be influenced by their own perspective/perceptions, AGE appeared to be a factor, as indicated by some of the correlations and earlier exploratory regressions. We had no strong priors about its impact. But since AGE is inversely correlated with HHSIZE and NUMCHILD, either/both of which might be expected to be positively related to WTP, it is possible that AGE will for that/those reason(s) appear to have a negative effect on WTP.

**NUMCHILD:** This variable is clearly positively correlated with HHSIZE, but was included separately on the grounds that extra weight may be given by adult respondents to their children's health – especially in the context of air pollution, where it may be thought that it is 'too late' for parents to get much benefit in their own right, but that measures to improve air quality may work in time to benefit children. And for D – avoiding 2 or 3 days of breathing discomfort every year for life – the benefits are liable to be greatest for those with most years ahead of them.

**EXPER:** One possibility is that those with most experience of relevant health conditions might place a greater weight on improvements. However, it is also possible that those *without* experience of some conditions (e.g. asthma) may be more apprehensive than those accustomed to dealing with the condition. We had no strong priors, but initial data exploration suggested that this might be a variable worth including.

**LIKELY-D/H/P:** All other things being equal, the greater the likelihood of suffering some adverse effect of air pollution, the greater the value attached to reducing the risks of that adverse effect. To the extent that respondents took account of this likelihood when giving their WTP, the coefficient on this variable should be positive.

**STARTCARD:** Ideally, respondents' answers should be unaffected by theoretically irrelevant features of the elicitation procedure. However, it is well known that responses are liable to be affected by such things as range effects and starting point biases, and although the 'random card sort' procedure was designed to try to disarm such effects, simple correlation analysis suggested that total WTP *did* appear to be positively correlated with the amount on the first card presented. While acknowledging that including it multiplicatively might not be the ideal way to handle it, the analytical difficulties of doing otherwise seemed daunting, and we therefore included this variable to test whether, in this formulation, the coefficient was significantly greater than zero (indicating a significant bias) or – as standard theory would require – not significantly different from zero.

Exhibit 5 below summarises the results of regressing each of the WTP amounts on the set of independent variables described above<sup>11</sup>.

Starting with WTP-N, it appears that, as theory would lead us to expect, WTP is an increasing function of household size (HHSIZE), the number of extra months per person (NUMMONTH) and per capita income (PERCAP) – although the coefficient on the number of extra months falls far short of 1, suggesting that for one reason or another there is limited sensitivity to the size of the extension of life expectancy<sup>12</sup>. In addition, respondent's AGE appears to have a significant impact – the negative power coefficient indicating that WTP falls as respondent's age increases. If the respondent were answering purely on behalf of the household, age *per se* should not have an impact; on the other hand, if AGE was picking up other influences, or else if the respondent's age was influencing his/her view of the quality of extra life in normal health, a negative coefficient might be understandable.

<sup>11</sup> When the initial regressions were run, it was found that the N, H, and D estimates suffered from heteroscedasticity. To counteract this problem 'semi-robust' standard errors were calculated which adjust for the underlying cause of the heteroscedasticity. Only the latter estimates are reported.

<sup>12</sup> From the standpoint of conventional economic analysis, this might be attributed to the non-marginality of the benefit: the average age of all of the members of the households included in the regression was 47, and their average remaining life expectancy was about 31 years, so an extra 6 months for them amounted to an increase of just over 1.5%, which might arguably be regarded as a large enough change to encounter significant budget constraints. However, an alternative explanation is that respondents simply did not discriminate much between the different magnitudes of the benefit.

## Section 3

Exhibit 5: Regression Results

		WTP-N		WTP-P		WTP-H		WTP-D	
No. of obs		481		480		481		479	
CONSTANT	$\ln(\alpha)$	0.518		6.428	***	0.626		0.471	
HHSIZE	$\beta_1$	0.715	***	-0.905	**	-0.094		-0.103	
NUMMONTH	$\beta_2$	0.215	**	0.235		-0.031		-0.070	
PERCAP	$\beta_3$	0.580	***	-0.030		0.356	***	0.397	***
AGE	$\beta_4$	-0.866	***	-1.745	***	-0.604	***	-0.825	***
NUMCHILD	$\beta_5$	-0.433		0.935	*	0.423		0.722	**
EXPER	$\beta_6$	0.104		-0.600		0.139		0.339	*
LIKELY	$\beta_7$	n/a		0.746	*	0.731	***	0.833	***
STARTCARD	$\beta_8$	0.028		0.088		0.032		0.072	**
F statistic		11.33		n/a		6.35		12.16	
R <sup>2</sup>		0.125		n/a		0.081		0.157	

\*\*\*, \*\*, and \* denote that these coefficients differ significantly from zero at, respectively, the 1%, 5% and 10% levels (2-tailed test). The Tobit regressions for WTP-P do not generate F statistics; however the equivalent LR test has a statistic of 37.15, and the pseudo R<sup>2</sup> estimate is 0.025.

As the results show, the other right-hand-side variables made no significant contribution to WTP-N in this specification; even the STARTCARD value, which appeared to correlate positively with WTP-N in a simple bivariate comparison<sup>13</sup>, did not appear to have a significant impact here. If we want to simplify the function, we could estimate a regression with only HHSIZE, NUMMONTH, PERCAP and AGE on the right hand side, in which case we would get

$$\text{WTP-N} = \text{HHSIZE}^{0.488} \times \text{NUMMONTH}^{0.213} \times \text{PERCAP}^{0.602} \times \text{AGE}^{-0.726} \quad (5)$$

with all coefficients significant at the 5% level or better.

Alternatively, if we rule AGE out on a priori grounds, the CONSTANT term becomes significant and we get

$$\text{WTP-N} = 0.053 \times \text{HHSIZE}^{0.606} \times \text{NUMMONTH}^{0.197} \times \text{PERCAP}^{0.611} \quad (6)$$

again with all coefficients significant at the 5% level or better.

<sup>13</sup> The Pearson correlation coefficient between WTP-N and STARTCARD was 0.142 for all those who were included in the regression analysis; this was significant at the 1% level.

In practice, there is no great difference between the two expressions as far as fitting mean values for WTP-N for 1, 3 and 6 months. For the observations used in the regression, the average HHSIZE was 2.14, average PERCAP was £12,450 and average AGE was 51.2. If we put these values into the first expression, and compute WTP-N for NUMMONTH set at 1 or 3 or 6, we get values of £23.30, £29.61 and £34.40 respectively; if we put the same mean values into the second expression, we get £25.91, £32.41 and £37.30.

These are, of course, all a great deal smaller than even the trimmed mean values reported in Exhibit 3 (£60.15, £67.72 and £80.87). The reason is that the regressions above were run on the basis of taking the natural logarithms of the variables: it thereby 'normalised' the skewed distribution of raw WTP-N responses, effectively placing less weight on higher values than on lower values. Plugging in the mean values for each independent variable therefore produces fitted values for WTP-N closer to the medians than to the means of the raw responses. However, the purpose of the regression analysis was principally to examine whether responses moved in the direction suggested by theory. To the extent that benefit valuation for policy purposes is to be based on mean rather than median responses, there is a case for reverting to the means from Exhibits 3 and 4. That is an issue we shall return to in Section 5. But first, we consider the regression results for P, H and D; and then the results of the supplementary qualitative study.

In the case of WTP-P, it is striking that neither the number of months nor the level of income have any significant impact, perhaps suggesting that there is ambivalence among respondents about whether extending their lives in such poor health was indeed a benefit. The strongest relationship appears to be that WTP-P is inversely related to age, possibly reflecting a greater aversion among older people to having their lives extended if they are in poor health. Oddly, HHSIZE and NUMCHILD (which are strongly positively correlated with each other) appear to work in opposite directions. The coefficient on LIKELY has the expected sign and is just significant at the 10% level. This result implies that at least some of the respondents may not have been treating the extra time in poor health as a certainty.

For WTP-H too there appears to be an inverse relationship with age (albeit with a smaller coefficient). However, in this case WTP is positively related to PERCAP and there was, overall, a willingness to pay at least something on the part of the majority of respondents, some of whom clearly regarded the prospect of such a hospital admission with considerable apprehension.

As we should have expected, neither WTP-H and WTP-D were significantly affected by NUMMONTH; and as expected, they were both positively related to PERCAP and LIKELY (as with WTP-P, implying that the avoidance of a hospital admission and days of breathing discomfort was not valued by all respondents as if it were a certain benefit). Also, in the case of WTP-D, the coefficients on both NUMCHILD and EXPER were significantly positive: the idea that WTP-D is higher for households with children and households with experience of breathing discomfort seems plausible.

Before we discuss how the findings of this study might be used to generate money values for the health benefits of reducing air pollution, we turn our attention to the qualitative follow-up interviews. These interviews were conducted to offer additional insights into the results we have just summarised.

## Follow-up interviews

### 4.1 Overview

Between 17<sup>th</sup> and 25<sup>th</sup> July 2003, 26 interviews were conducted by two members of the research team: JC conducted 13 in Stockton-on-Tees and GL conducted 13 in Norwich. In both areas, a quota sample was recruited by local market research companies in order to provide an approximately equal number of respondents of each gender, with approximately one third below the age of 35, one third between 35 and 55, and one third over 55. Overall, roughly one quarter of respondents were single person households.

The structure of each interview was as follows. First, respondents were asked to answer the same questions as in the main survey, with half of them being presented with the version involving a month more life in normal/poor health while the other half were asked about six more months in those states. We encouraged respondents to **think aloud**, and at various points we asked them to expand upon their answers. In particular, we wished to know more about the following issues:

If they *were not* willing to pay anything, we wanted to explore their reasons.

If they *were* willing to pay at least something, we probed to discover more about:

- What they were thinking about when arriving at the total they said they would be willing to pay for all four benefits.
- Whether they thought certain members of household would benefit more than others and/or how they would have reacted to being asked to give separate WTP responses for themselves and for each member of their household.
- Whether the respondent was focusing more on the monthly, annual or total amount.
- Whether the payments were viewed as real or nominal.

And then, during or after the process of dividing up the total between the four benefits, we tried to gain a fuller understanding of how they were making their allocation: in particular, how far they were attending to the (un)desirability of the event as compared with the (un)likelihood of being affected; and how differently they might have reacted if they had been asked about a different period of extra life in normal/poor health.

Having completed the CAPI schedule, we then presented respondents with five supplementary **matching questions** of various forms (each of which is spelled out in more detail below, when we come to discuss the results):

- A *risk trade-off* question which asked them to compare various chances of an extra 1 (or 6) month(s) in normal health (N) with the certainty of an extra 1 (or 6) month(s) in the poor health state (P), as viewed from their personal/household perspective.

- A risk trade-off question which asked them to compare various risks of 2 or 3 days of breathing discomfort every year for the rest of their lives (D) with various risks of an admission to hospital because of breathing difficulties (H).
- The next two questions entailed corresponding sets of options, but this time in the *person trade-off* format. So the third question began by asking the respondent to choose between giving 1,000 people an extra X months in normal health as opposed to giving 4,000 people an extra X months in poor health; and then varied the parameters in a manner which corresponded with the options available in the first question above. Likewise, the fourth question began by asking the respondent to choose between preventing 100 people from suffering D as opposed to preventing 100 people experiencing H; and then varied the parameters in a manner which corresponded with the options available in the second question above.
- Finally, respondents were asked to compare reductions of the numbers of deaths on the roads with extensions of life in normal health due to reductions in air pollution. The initial choice was between giving 2 people an extra 40 years each in normal health or else giving 1,000 people an extra month each in normal health. This initial choice involved approximately equal numbers of months in total. Depending on the answer, subsequent questions either decreased (to one week per person) or increased (to 3 or 6 months) the size of the benefit offered by reduced air pollution.

## 4.2 Findings

In what follows, we report the main themes emerging from the qualitative interviews, and give details of the quantitative components of people's responses. *However, it is important to bear in mind throughout that these 26 respondents are in no sense a representative sample, and little weight can be attached to the quantitative data they generated, other than to illustrate degrees of within-subject consistency between responses, both quantitative and qualitative.*

### 4.2.1 Why did some respondents give zero willingness to pay responses?

A minority of our sample – 4 out of 26 – said they were not willing to pay anything. This is a smaller proportion than in the main survey. This may in part be due to the fact that these were respondents who had made the effort to come to our offices and were being paid for participating, whereas in the main survey they were arguably less committed and/or willing to give their time. It might also be due to the fact that the main survey interviewers were not primed to explain that the payments were not simply extra taxes, but the consequences of regulations etc. working through in the form of higher prices. The fact that the interview tried to make the 'higher price' scenario clear did not stop several respondents making references to taxes and/or expressing some scepticism about whether money spent by government to reduce pollution would really be effective.

We each had a couple of people who initially indicated a **reluctance to pay more taxes**, and in those cases we took a few moments to explain the mechanism more carefully, after which they said that they were willing to pay something. For example, one respondent seemed initially inclined to protest:

## Section 4

“Well, in some ways my immediate reaction would be yeah I certainly would pay that amount. But in another way I think to myself, well we already pay taxes, we’ve got a ridiculously high defence budget, so I don’t see why I should – maybe I’m undecided because of that ... I’ve got a feeling that’s going to be my response regardless of the money.” *(Male, 35, single household)*

But once the mechanism and the purpose of the survey were explained, he said he was willing to pay something (in fact, £250 per year). We each had a couple of cases of this kind, and if we had simply taken them as zeros, we would have had a total of 7 or 8 not willing to pay – broadly in line with the proportion in the main survey.

Those who did protest gave either **‘the money should come from existing taxes’** or **‘those who cause the pollution should pay’** as their reason:

“The government gets enough money as it is ... what have we achieved from the council tax?” *(Female, 39, multiple person household)*

“We pay enough council tax, the petrol’s gone up ... they just waste money.” *(Male, 78, single person household)*

However, both of the above rated the various benefits positively – each rating 3 out of 4 either ‘quite big’ or else ‘very big’ benefits.

On the other hand, the one respondent who gave a ‘true’ zero could have recorded a positive WTP, because although he thought the possible benefits were of no real value to *his* household, he was concerned with the public good:

“If it’s our household, rather than a general ideological position, it’s not enough probably to be worth paying a great deal for, but insofar as it’s a communal decision affecting other people’s health ... what we can afford is what we’ll pay ... but for our household it’s not a sufficient concern, other things are our priority.” *(Male, 48, two person household)*

### 4.2.2 How did those who said they would pay reach their total WTP figure?

The great majority of respondents interviewed based their total WTP figure on the **amount that could be afforded** and that would be a **manageable extra expense** on top of their other outgoings (often expressing the sentiment that they would pay more if they could):

“I’m on a limited income. Yes £8 a month I could afford.... I think it’s too little but it’s what I can afford” *(Female, 68, single person household)*.

“What I can afford that could go as extra, really ... if I had a highly paid job I’d donate a larger amount ... it’s purely financial at the moment.”  
*(Female, 36, single mother with child)*

Some respondents thought about **'luxuries' they could (or should) give up:**

"Well, I was thinking of ... what I'd have to knock on the head to afford it and I'm giving up smoking so I thought I'd give them that money. I only spend £3-4 a week on fags, so I wouldn't go to £20 per month, but anything up to £10-15 I would."

*(Female, 35, single mother with child)*

Other respondents **compared the amount with things like health or life insurance**, or other goods or services, or the typical amount that they might pay by **direct debit to a charity:**

"I pay three times that for water, for clean drinking water, and this is just as important as clean drinking water, so I'd have to say that is quite cheap in comparison to know you've got clean air." *(Female, 36, single person household)*

"I'm comparing it with direct debits for charities that I pay which are about £2 a month and my personal health insurance which is £8 – so somewhere in between those is a reasonable figure" *(Male, 34, multiple person household)*.

Issues about what would be a adequate, reasonable or **fair amount** to pay also came into play:

"I think that (£100 per year) would be fair because I mean if everyone's paying it they'd have lots of money and they'd be able to do almost anything with that. I think they wouldn't need any more than that." *(Female, 35, single mother with child)*

"£50 each year. What's a pound a week. I don't do the lottery or anything. A fair amount for an increase in general prices" *(Female, 51, single household)*.

"Off the top of my head if the mechanism was something like fuel tax then I'd expect it to come in at around say £150 to £200" *(Male, 50, multiple person household)*.

Direct comparisons of the benefits of what they would get for the money if they put it towards something else instead were also used occasionally:

"I wouldn't pay as much as £200 per month, because you could get BUPA cover for that instead" *(Male, 66, single household)*.

However, it was quite rare to find respondents making reference to payments requiring sacrifices of essential goods:

"If you had to pay more for less pollution, you wouldn't be able to eat a reasonable diet, a healthy diet, because you'd have to cut back on essentials." *(Female, 53, two person household)*

The same respondent also expressed some concern about the possible impact of higher prices on the poor/elderly who couldn't afford adequate food and heating as it was and who might "die of hypothermia rather than coughing".

## Section 4

On the other hand, some respondents gave the impression that they were **wanting to express the importance of reducing air pollution** by stating amounts that were at or beyond the limits of what they could really manage:

“Whatever it costs to cut the pollution levels has to be paid, doesn’t it? And everyone’s going to benefit, so we should be prepared to pay whatever is necessary providing it doesn’t leave us short of food or basics.” At £100 per year: “That’d be alright – bearing in mind that I probably don’t even have it, but on the assumption that I’ve got it, yes, that would be reasonable.” (*Female, 36, single person household*)

In fact, this respondent subsequently said she would pay £250 per year, and spoke of doing extra hours/shifts and cutting down on cigarettes to pay it.

### 4.2.3 Who were respondents thinking would benefit?

Some respondents in multiple person households were asked to think about whether some household members would benefit more than others and whether, if they had been asked about WTP for different members, they would have given different amounts. Several of those with children mentioned them as being more likely to benefit, either because they perceived that pollution was likely to get worse, or because it was too late for the adults to get much benefit now. However, there was some **reluctance to differentiate within the household**:

“If anything happened to any of them, it would affect each of us. So I can’t say my sons are more important because their Mum’s important to them and I’m important to them ... it’s a big unit.” (*Male, 29, multiple person household*)

However, a number of respondents spoke of the **benefits accruing not only to their own household members but more widely** – to other members of the extended family, to neighbours, to the elderly, to everyone in the population.

It was also apparent that a number of respondents construed the benefits of the reductions in air pollution to be somewhat broader and more general than the four specific benefits described. Some things they said suggested that they **thought they were getting more for their money**:

“I definitely think it’s worth paying more for cleaner air and a better environment” (*Male 32, single household*).

“I’m having difficulties excluding the other benefits. So if you were conducting this interview and looking at the environmental benefits I’d have no difficulty paying £200 per year for those sorts of benefits” (*Male, 50, multiple person household*).

“It’s not just affecting people, it’s the whole planet, the food and water.” (*Female, 35, single mother with child*).

#### 4.2.4 Which amount were they paying attention to?

Almost all of the respondents in our sample said that they were **focusing on the monthly or annual figures**, or equivalent weekly amounts that they would be willing to pay:

"The total is insignificant. All I can do is budget monthly or yearly. £4 a month is about right" (*Male, 34, multiple person household*).

"I was thinking monthly – the overall figure didn't even enter my consciousness really – it's not relevant unless you're paying in a block amount." (*Female, 53, two person household*).

"If you look at anything over the rest of your life, it's a silly amount anyway so you've got to break it down to bite-sized chunks." (*Male, 29, multiple person household*).

"I was focusing on these two (monthly and annual) really. Although I listened, I didn't really listen to the final figure because I know that I'd never have to pay that in a bulk ... I don't relate to it." (*Female, 35, single mother with child*).

"In a way, all three ... really, for me, monthly ... I can't really think ahead further than a week financially at the moment." (*Male, 35, single person household*).

One of the few suggestions that the lifetime total had made some impact was couched in terms of **trying not to attend to the lifetime total**:

"I tried not to think about the long-term total cost for the extra month because it would have to be some sort of fantastic life ..." (*Female, 36, single person household*).

#### 4.2.5 Were respondents thinking more in real or in nominal terms?

The majority of those we asked about this indicated that they were **thinking in current/real/proportional terms**:

"The current value, because obviously it would rise as the cost of living rose I suppose." (*Female, 53, two person household*).

However, a couple of respondents took a different view:

"Staying fixed – it would probably end up worth less and less." (*Male, 20, single person household*).

"I thought it might get less ... I think it would only be about 5 or 6 years before they had it sorted – so just one generation cop it, so I didn't think I'd be paying that for the rest of my life." (*Female, 35, single mother with child*).

### 4.2.6 How did they divide the total between the four benefits?

Most respondents seemed to take some **notice of the relative benefits** that they perceived they would get. In some cases this is reflected in very different amounts being allocated to the four benefits:

*"I'm really not going to benefit from these other things [P, H, D]"  
(Male, 64, multiple person household – division N £50, P £0, H £0, D £0).*

*"These [P, H] are the ones I'd see as most beneficial if I was of ill-health when I'm older and atmospheric pollution was then going to have an influence on me"  
(Male, 50, multiple person household – division N £0, D £50, H £100, D £0)*

*"Very simple really. It's down to how likely these things are to happen"  
(Male, 34, multiple person household – division N £40, P £1, H £3, D £6).*

However, other respondents were somewhat more **reluctant to allocate very different amounts to the four benefits**. In some cases this seemed to be because respondents were thinking of the benefits to people outside the household:

*"Split it evenly. Not for me personally but for other people as well. Everybody shares the air" (Female, 51, single person household).*

*"I wasn't thinking about the household. Then I probably wouldn't put anything in at all [to P]. It's really to help other people"  
(Female, 68, multiple person household – division N £30, P £5, H £15, D £10)*

But even some of those who were focusing primarily on their own household had some tendency to start from (and indeed, finish up with) **equal shares**:

*"My initial thought was to split it four ways but I suppose I would consider this (N) more important and I would expect to pay a bit more in terms of having that"  
(Female, 36, single mother with child).*

That respondent initially allocated £40 (out of a total of £120) to N. She identified H as next most valuable "because that would be horrible" and allocated £30 to it. Of the remaining two, she picked P – "As you're talking in terms of life in a way it takes precedence over a few days of discomfort" – even though she had rated D as a bigger benefit earlier – and split the remaining £50 30:20. When prompted to compare £40 for N with £30 for P, she said "It seems I should put a lot more emphasis, I'd rather pay a lot more to get that ... I don't know how you work it out." In the end, she went for £50 for N and £20 for P; but without such prompting (of the kind NatCen interviewers would/should not have done) would not have discriminated even this much.

One or two others saw the **benefits as intertwined** and either did not want to separate them – "It all goes for the same end product, doesn't it?" – or else justified putting a lot into one on the grounds that it would spill over into others – (£90 out of £100 allocated to N) "because if you sorted that out, these wouldn't be a problem."

One rule of thumb used on several occasions was to allocate about half of the available sum to the benefit identified as most valuable of those still on the table, and when the point was reached where there was no particularly desirable candidate, to split the remaining amount equally. There was some reluctance to give zeros – a notion of putting at least something towards each, as a kind of insurance, seemed to be at work.

When probed about the relative weight of feelings about the nastiness/desirability of the experience as opposed to the likelihood of it happening, the feelings about the experience often seemed primary. This appeared to be particularly so for the hospital admission.

For example, one respondent identified H as the most valuable benefit:

“Probably avoiding admission to hospital, because that’s quite extreme, I think.”  
(*Male, 29, multiple person household*).

Since he had rated H as ‘quite a big benefit’ as compared with rating N (6 months for all four household members) as ‘a very big benefit’, he was asked why he had selected H rather than N.

“Really, it’s going to be a more enjoyable life if you don’t get into that situation and get admitted ... whether you live 6 months longer or not makes no odds if you’re in hospital all your life.”

It was explained that the intention was that people came out after a couple of days, or at most a week or two, but he wasn’t persuaded, and was focused on the underlying health state rather than the admission scenario:

“If you get breathing difficulties and end up in hospital, it’s going to happen again, in my eyes, things won’t get better and that’s going to be with you forever, that’s the way I’m thinking.”

Others also referred to what hospital might signify in terms of the underlying health state – “Things have got to be pretty serious to go into hospital is the way it seems to me.” – and/or their strong aversion to hospitalisation – “No-one wants to go into hospital, do they, and it can kill old ladies off and you can get that black skin disease from going into hospital”. Several also made reference to the costs to the NHS, the blocking of beds, etc.:

“I wasn’t really thinking about the likelihood of it happening to me when I gave that response a moment ago. I was thinking as I said, yes, certainly there was a thought of the nastiness of it, but mainly the social aspect of it, the fact that it’s a potentially unnecessary use of the Health Service.” (*Male, 35, single person household*).

### 4.2.7 What if the extra time in N and P had been different?

Some respondents were asked to consider how their answers might have differed if they had been presented with a different amount of extra life in normal and poor health. It is, of course, very difficult for people to do this, but our thought was that, if anything, they would think we were expecting them to give a different answer and might therefore be liable to overstate the

'true' adjustment. In fact, most of those asked said it would make little or no difference – the main theme being (especially for those who were asked to consider 6 months instead of 1) that they had stated what they could afford, so there wasn't much room for adjustment. Even in the 'easier' case where they were being asked about 1 month instead of 6 and where they could have reduced the response within the limit of what they could afford, P was more likely to be reduced than N, and the value on N fell (if at all) by much less than one-sixth.

### 4.2.8 How did alternative (non-monetary) ways of scaling benefits compare to the monetary proportions?

In the first additional question added to the end of the interview we tried to measure how much better respondents thought it would be to live longer in normal health rather than in poor health using a 'risk trade-off' format.

That is, they were initially asked to choose between a 25% (1 in 4)<sup>14</sup> chance of N and the certainty of P. If they favoured the normal health option, the question was repeated, but with the chance of N reduced progressively to 10% and then 5%; if they initially favoured the P option, the chances of N were progressively increased to 50% and then 75%. Thus we could infer, within bounds, the relative value of extra time in poor health compared with extra time in normal health. For example, a respondent who initially opted for a 25% chance of N but then preferred the certainty of P to a 10% chance of N would be reckoned to value poor health at between 0.1 and 0.25 the value of normal health. Similarly, someone who initially chose the certainty of P, and continued to do so when the chances of N were increased to 50%, but switched when the chances of N were raised to 75%, would be reckoned to rate poor health as being worth between 0.5 and 0.75 the value of normal health. In some cases, a respondent identified a particular choice as one where the alternatives were just about equally balanced, and in such cases we inferred a point estimate of the relativity between the two.

The answers to these questions can be compared on a within-subject basis to the relative amounts of the total WTP allocated to P and N. Bearing in mind that the benefits of P were dependent on the likelihood of the respondent suffering from heart or lung disease when they were elderly, we would expect that if the respondent preferred a 1 in 4 (or 1 in 10 or 1 in 20) chance of the extra time in normal health to the certainty of the extra time in poor health then they should assign *at least* 4 (or 10 or 20) times as much of their total amount to N as to P.

What we found was that 17 of the 26 respondents preferred a 5% chance of the extra time in normal health to the certainty of the time in poor health, which we take to signify that they considered normal health to be at least 20 times as desirable as the poor health state. Two of those 17 gave 'protest' zeros. For the other 15, the average WTP contribution to N was approximately 7 times their average for P. Of the 8 respondents who preferred either a 10% or a 25% chance of N (i.e. thought N less than 10 times better, but at least 4 times better than P), 1 gave a protest zero. The other 7 allocated, on average, just under 3 times as much money to N as to P. In short, even treating P as a certainty (and in fact only 5 of our respondents perceived

<sup>14</sup> Respondents were given all probabilities both in percentage and in fraction form.

this state as 'very likely', while almost half of our sample thought it was either 'quite unlikely' or 'very unlikely'), **the apportionment of money substantially understated the extent to which respondents regarded normal health as superior to the poor health state.**

The third of our supplementary questions (we will discuss the second question shortly) also examined the N:P relationship, but this time using a '*person trade-off*' form of question involving parameters designed to correspond with those in the first question. Thus the third question began by asking the respondent to choose between giving 1,000 people an extra X months in normal health as opposed to giving 4,000 people an extra X months in poor health. Respondents who chose to extend the 1000 lives in normal health were then presented with choices between 400 (and possibly then 200) lives in normal health versus 4000 lives in poor health. Respondents who initially chose to extend the 4000 lives in poor health were then presented with choices between 2000 (and possibly then 3000) lives in normal health versus 4000 lives in poor health.

16 of the 26 respondents gave effectively the same answer to the third question as they had done to the first; and although there were differences in the answers given by the other 10, these more or less offset one another, so that **the aggregate picture produced by the risk trade-off and person trade-off questions was very similar**: 16 or 17 rated N at least 20 times better than P; another 2 or 3 rated it at least 10 times better; another 5 or 6 rated it at least 4 times better; and one or two rated it better, but less than 4 times.

The second and fourth supplementary questions used, respectively, risk trade-off and person trade-off formats to examine the relationship between H and D.

The second question began by inviting respondents to imagine that they faced a 10% risk of 2-3 days of breathing discomfort each year for the rest of their lives **and** a 10% risk of being admitted to hospital with breathing difficulties at some time in the future, and then asked them which one of these risks they would prefer to eliminate if they could only eliminate one of them. Depending on their answer, one of the risks was adjusted. That is, if they initially chose the D option, they were asked to consider a 50% risk of H: if they still preferred to eliminate the 10% risk of D, they were asked whether the certainty of H would cause them to respond differently; alternatively, if they preferred to eliminate a 50% risk of H rather than a 10% risk of D, they were then asked to consider a 25% risk of H. For those who initially chose to eliminate the 10% risk of H, the risks of D were manipulated in the same manner. From respondents' sequences of choices we could infer, again within bounds, the relative value to them of D and H. As before, in cases where a respondent identified a particular choice as one where they felt both alternatives to be equally good, we took that to be a point estimate of the relativity between D and H.

The fourth question presented corresponding options, but this time expressed in '*person trade-off*' form. That is, they were initially asked to choose between a policy that would reduce by 100 the number of people suffering from D and a policy that would reduce by 100 the number of people requiring an admission to hospital. Depending on their answers, the numbers of people that could be helped by the alternative policies were increased to 250, 500 or 1000.

Ten of the 26 respondents indicated the same relativities in response to both questions. Most of the within-subject differences among the other 16 were not great and tended to offset one another, so that once again the aggregate picture was quite similar: for both questions, 15

## Section 4

respondents said that an admission to hospital was at least 5 times worse than 2-3 days of breathing discomfort each year, with 10 (8) of these in the second (fourth) question saying it was at least 10 times worse; against that, just 6 (4) indicated that they thought D was worse than H.

It is not so straightforward to compare the relativities elicited by the second and fourth questions with the relative WTP responses, since those WTP responses were supposed not only to take into account the relative unpleasantness of the health problems but also respondents' perceptions of their likelihood of occurrence. However, of the 15 who indicated in the second question that they considered H at least 5 times worse than D, 13 had given the same or a higher personal/household likelihood rating to D as to H; after excluding one protest zero, the remaining 12 allocated about 75% more money to H than to D. So once again, it would appear that **the apportionment of money substantially understated the strength of preference for H over D as expressed via the supplementary trade-off questions.**

The last of our five supplementary questions asked respondents to consider their preferences for extending 2 people's lives by 40 years each (by reducing road accident risks) over extending 1000 people's lives by a month each (by reducing air pollution). Depending on the answer, subsequent questions either decreased (to one week per person) or increased (to 3 or 6 months) the size of the benefit offered by reduced air pollution.

Our respondents can be divided into three groups. Nine initially favoured extending 2 lives by 40 years each, with most of these continuing to favour that option even if reductions in air pollution would offer everyone 3 months extra life in normal health. To the extent that they gave reasons, the idea of giving people 'a whole life' rather than a little bit extra on top of a full quota of years seemed to be at work. On the other hand, another 9 respondents favoured the air pollution option even when the projected gain was just a week. Here, scepticism about the effectiveness of road safety measures, together with a feeling that road safety is to some extent a matter under people's personal control whereas air pollution is not, seemed to be the principal factors. One respondent – a car salesman – said:

"If you're careful, you can do something about it, to a degree ... some of it can be prevented. The other side of it, the pollution, it can't be – it's there, what are you going to do, move to the countryside? It's completely out of your hands, it's other people inflicting themselves on to you, more than having some sort of control over it."

Between those two groups, another 8 respondents initially favoured giving everyone a month, but switched if the size of the benefit was reduced to a week. Partly this appeared to be a desire for large numbers of people to receive roughly equal benefits, and partly it may have been explained by some respondents thinking more widely than just the health benefits.

### 4.3 Concluding remarks on follow-up interviews

The main conclusions we draw from the follow-up study – and we emphasise again that this was by no means a representative sample, and that a considerable degree of interpretation and judgment is involved – can be summarised as follows:

- To the extent that some respondents were unwilling to pay something for the health benefits, the main reasons were a degree of scepticism about whether the improvements would actually be delivered, and a feeling that existing taxes should be better used and/or redirected to address the problems. It was rarely the case that the benefits themselves were zero-valued.
- Most respondents were willing to pay something. The main factor determining the total amount they said they were willing to pay appeared to be their judgment of what they could afford. In particular, many seemed to be focusing on amounts that might be considered 'discretionary' – i.e. amounts that they could find on top of their existing expenditure without requiring them to make any significant inroads into current spending patterns. This would help to explain the rather modest coefficient on NUMMONTH and the limited sensitivity of subsample mean values of WTP-N to the magnitude of the benefit. It may also be somewhat worrying, in the sense that if respondents had been answering another survey about some other possible benefit – e.g. greater transport safety, or reduction of crime, or higher food standards – they would have emptied the same notional piggy-bank for any one of those; but it would almost certainly *not* be the case that they would be willing to pay the grand total sum obtained from each survey to obtain all of those benefits together. However, this latter issue is a general problem for CV methodology, and by no means peculiar to the present study.
- Respondents did seem able to focus primarily on their own household members, although there was *some* tendency to express some altruistic concern, and occasionally to refer to broader environmental benefits. A degree of insensitivity to the numbers of household members (as reflected by the coefficient on HHSIZE being less than 1) may well have arisen from the same source as the modest sensitivity to the number of extra months – i.e. the tendency to think principally about what they could afford.
- The information about the lifetime total payment was largely ignored. This is consistent with the evidence in the main study, and suggests that estimates of values should be derived from the annual amounts. A suggested approach is outlined in the next section.
- With a few exceptions, it seems that respondents were interpreting the payments as real rather than nominal – i.e. as sums that would be likely to move with prices generally, and therefore constitute an approximately constant proportion of their real income.
- When it came to dividing the total WTP between the benefits, most respondents were able to indicate their ordering with a degree of confidence. However, it appeared that the focus was much more on the *experience* of an outcome, and considerations about the *likelihood* of having that experience quite often seemed to have faded into the background. Although *some* respondents referred to likelihood as an influential consideration, it was often as though respondents were comparing X months in normal health with the certainty of X months in

## Section 4

poor health, or with the certainty of an admission (or indeed, more than one admission) into hospital. Combining this with some tendency to take equal splitting as a default, or at least some feeling that every benefit should receive at least something, it may very well be the case that the money-splitting results overweight P, H and D relative to N.

- The answers to the supplementary 'matching' questions lend further support to this proposition. On the basis of the responses of our unrepresentative sample to the first and third supplementary questions, extra time in the poor health state at the end of life would be judged as worth no more than 10% of the same extra time in normal health. Had the money-splitting exercise also been sensitive to the (un)likelihood of being in the relevant poor health state, the ratio should have been a good deal more extreme. If the (un)likelihoods of H and D were also being widely ignored, as would be the case if our respondents were representative of the sample in the main study, those benefits too would have been overvalued relative to N in the money-splitting task.
- Finally, the fifth supplementary question provides some grounds for thinking that 1,000 people each gaining a month in normal health as a result of reductions in air pollution may not be valued less than 2 people gaining a similar total number of months as a result of reductions in road traffic fatalities. Of course, this finding comes from a small and unrepresentative sample answering a person trade-off question, and might not be borne out by a larger and more representative sample answering from their own risk trade-off perspective. Moreover, other considerations (e.g. about wider environmental benefits) and perceptions (e.g. about degrees of responsibility and control among road users) may have exerted some influence. Nevertheless, our supplementary evidence, such as it is, does not suggest that gains in life expectancy from reducing air pollution should be valued significantly differently from similar gains produced by improved road safety.

## Policy implications

How might the findings of this study be used to generate money values for the health benefits of reducing air pollution in a form that can be used to aid policy decision making?

To recap, the willingness to pay (WTP) figures were elicited on an annual basis. In the questionnaire, respondents were reminded not only of the annual WTP but what that would imply in terms of total WTP (by multiplying up by an estimate of remaining life expectancy). However, analysis of the quantitative and qualitative data suggests that respondents focused primarily on the annual payment. There is little or no support for the idea that they thought of a benefit being worth some lump-sum amount and then adjusted their annual payment in the light of their remaining life expectancy.

One way of interpreting/using such responses is as follows. Suppose the government is contemplating some package of measures to bring about/sustain some reduction in pollution to a degree that is expected to give people a month more life expectancy in normal health than would be the case if the package of measures were not implemented. Suppose also that it is estimated that this package of measures, to be implemented and sustained for the indefinite future, would effectively impose costs of £25 per year (at current prices) for every member of the population.

If we track a typical cohort of individuals from birth to death, this would mean that during their earlier years when they are financially dependent on parents/guardians, the £25 for each of them is borne by those parents/guardians; when they become financially independent, they bear the cost themselves; and if they in turn come to have dependants, they bear the costs on behalf of those dependants; and for some people, there may even be a final phase when they once again become dependent in their old age, so that whoever is then responsible for them bears the cost.

If we want to know whether society is willing to pay the price of a package of measures that has this implication, one way to answer that is to take a representative cross-section of the current population of financial household units, embodying people at all of the above stages of life, and find out if these households would be willing to pay amounts that would cover the £25-per-head cost.

If we take the annual per person WTP values as shown in Exhibit 4, then for the one month gain in life expectancy in normal health, we should conclude that our cross section of households are willing to pay an average of £29.52 per person<sup>15</sup>.

Under this approach, calculating a per-person lump-sum figure might not be required; but if one were needed, then £29.52 per person per year every year for the entire life of the average person (i.e. for about 78 years, on the basis of current life expectancy), would come to £2,302 per person for a one month gain in life expectancy in normal health<sup>16</sup>.

<sup>15</sup> This figure is based on the trimmed mean response. The full-sample mean was £32.16 per person.

<sup>16</sup> 78 years is the mean period of time over which the benefit of a reduction in air pollution will be enjoyed by anyone *born after the reduction is effected*. However, if attention were to be restricted solely to the population *alive at the time of the introduction of the measure*, then the mean period over which its effects will be enjoyed by that population is approximately 44 years. In turn, if a 100-year planning period is employed then the mean period would be roughly 68 years while for a 200-year planning period it would be 72 years and for a 300-year planning period, 74 years. Other adjustments might need to be made for other planning horizons, or for changes in anticipated life expectancy occurring for other reasons.

## 5.1 Value of a one year gain in life expectancy in normal health

If it were considered desirable to have a standard unit, such as “the value of a year’s increase in aggregate life expectancy”, then if such a year were achieved by increasing 12 individuals’ life expectancy by one month, that standard unit (call it  $V_N$ ) would be valued at  $12 \times £2,302$  - i.e. £27,630. So from the one-month subsample we would have:

$$(a) \quad V_N = £29.52 \times 78 \times 12 = £27,630 \quad (7)$$

95% confidence interval: £20,690 to £34,440

Notice that there is no discounting in this calculation. The evidence from the study suggests that people were giving responses in terms of the current real value of their money, with those responses representing a cross-section of the population involving people at every stage in their lives. The payment due in twenty years time was therefore almost certainly being thought of as having the same purchasing power as a payment of £x now and as being made from the same level of real income as currently enjoyed by the respondent’s household. But why should this payment not be subject to discounting at, say, the current public sector discount rate of 3.5% per annum?

The first thing to notice is that the public sector discount rate is the sum of two components, the first reflecting the diminishing marginal utility of income (given that real income *per capita* can be expected to grow over time) and the second being a “pure utility discount rate” reflecting the view that, for example, the economic circumstances (and, indeed, continued existence), of future generations is subject to a degree of uncertainty when viewed from the present.

However, both theory and empirical evidence indicate that WTP-based values of safety and longevity will themselves grow in line with *per capita* real income and that such values will indeed be roughly inversely proportional to the marginal utility of income – see for example Jones-Lee (1976). Given this, there is no case for applying a diminishing marginal utility of income discount factor to future WTP figures expressed in real terms at the current price level and thought of by respondents as being made subject to current real income constraints.

This then leaves only the pure utility discount factor reflecting, *inter alia*, uncertainty about the circumstances and indeed continued existence of future generations. Currently, the Treasury sets this pure utility discount rate at 1.5% per annum (see the Treasury Green Book, Annex 6). In fact, at a discount rate of 1.5%, the discounted present value of a payout of £A per annum over a period of 78 years is £46A. However, there are those who would argue that the case for applying a non-zero pure utility discount rate is ethically indefensible and at least some members of the research team share that view. For this reason and in the interests of simplicity, in what follows we have therefore computed all values as 78 times reported annual willingness to pay. Should the reader wish to derive the values that would be entailed by application of a 1.5% per annum pure utility discount rate then all values reported below should simply be multiplied by  $\frac{46}{78}$  i.e. by approximately 0.6.

Applying the same procedure used for (a) to the means for the three-months and six-months subsamples involves multiplying the three month figure by 4 and the six month figure by 2. The results of these calculations, using the figures from Exhibit 4 with the top 4 and bottom 4 responses for each subsample trimmed out, and with the final figures shown rounded to the nearest £10, are as follows:

(b) Three-month subsample

$$V_N = £30.21 \times 78 \times 4 = £9,430 \quad (8)$$

95% confidence interval: £7,520 to £12,700

(c) Six-month subsample

$$V_N = £38.73 \times 78 \times 2 = £6,040 \quad (9)$$

95% confidence interval: £4,760 to £7,330

The fact that estimate (a) is between four and five times bigger than estimate (c) reflects the fact that people's stated valuations of benefit N were nowhere near proportional to the magnitude of the benefit. This is also true if the view were taken that even the most extreme values should be included where the estimates of  $V_N$  based on the full-sample means and variances would be: £30,100 (+/- £8,260) based on the 1 month sample; £15,100 (+/- £7,530) based on 3 months; and £8,470 (+/- £3,100) based on 6 months.

How should policymakers react to such a range of values for  $V_N$ ?

If it is felt that the lack of sensitivity is due to a high degree of arbitrariness on the part of respondents simply stating a general willingness to pay for something they recognise as a 'good thing', then little guidance can be offered: any  $V_N$  would, under those circumstances, be largely an artefact of the particular magnitudes of NUMMONTH selected by the researchers.

However, the regression analysis reported in Section 3 indicates that there was at least some degree of coherence and conformity with reasonable expectations about the variables which should be influential – although the strength of the associations are more muted than would be required to generate a single value of  $V_N$  which is consistent with all three subsamples' responses.

An explanation for this which is *broadly* consistent with standard theory is that budget constraints are biting: partly, perhaps, because increases of 3 and 6 months go beyond what would normally be considered to be marginal improvements; but mainly, we suspect, because respondents are not considering a more radical reconfiguration of their overall consumption patterns (as theory supposes) but are thinking in the more restricted terms of what they can afford from the 'discretionary' element of their income left over after other main consumption commitments are allowed for at their current levels.

One way of reacting, therefore, might be to suppose that if policies entail the imposition of costs over a long time period, during which people really *are* required to adjust their consumption patterns and are not so constrained by focusing on what is currently discretionary, their WTP for 3 or 6 months extra might indeed be more like three or six times the figure for 1 month; and on these grounds it might be argued that estimate (a) is the most appropriate of the three. This argument might further be supported by the thought that, on the basis of current epidemiological knowledge, the kinds of measures which are realistically available to

policymakers are more likely to generate benefits of the 1-month-per-person kind than of a greater magnitude, so that the figure from the 1 month subsample is the most relevant.

The counterargument is that if indeed respondents were focusing too much on a sort of 'discretionary fund' for 'good causes', but were not being reminded of the full set of alternative good causes which might also make claims on this fund, they might have allocated more to the health benefits of reducing air pollution than would be the case if the full set of alternatives was being considered. It is very hard to evaluate the strength of this counterargument – although one possible response to it is to point out that other WTP-based values have been elicited under similar single-issue surveys, and that they are therefore all vulnerable to this reservation. Until further research sheds more light on this question, perhaps the most that can be said is that even if the *absolute* values produced by the various single-issue surveys are all to some degree overestimated, the relativities between them – e.g. how the estimated figure for air pollution stands *relative* to the value of preventing a fatality in road accidents – may still be broadly acceptable.

Overall, then, it is clear that the data can do no more than indicate a range within which  $V_N$  seems likely to lie. Figures comparable to those used in the context of road safety lie within this range<sup>17</sup>, and the qualitative study – which, we reiterate, involved a small and unrepresentative sample – found people more or less evenly divided about whether it was better to extend two people's lives by 40 years or 1,000 people's lives by a month each; in which case, it could be argued that air pollution policy could quite defensibly use the same value as is currently used for road safety policy. Certainly, there does not seem to be any strong argument from the present study for using a value that is significantly different.

Suppose, then, that we were to take the figure from estimate (a) above. How might it be applied? If some package of measures were expected to generate an extra month of life expectancy for each member of a population of 60 million people, this could either be represented in lump-sum terms as an increase in aggregate life expectancy of 5 million years with a value of £138,150m (5m x £27,630), or else as a benefit worth £1,770m per year (60m x £29.52) at current prices.

## 5.2 Value of a one year gain in life expectancy in poor health

With the top and bottom 4 responses trimmed out, the one-month, three-month and six-month trimmed mean annual per person WTP-P responses were, respectively £7.78, £5.14, and £8.29. If we make the simplifying assumption that respondents were ignoring considerations of the (un)likelihood of being in the relevant health state and were (as the qualitative study seemed to suggest was often the case) responding as if it were a certain prospect, the implied value of a one-year gain in life expectancy in poor health,  $V_P$ , for each of the subsamples is as follows:

<sup>17</sup> If we take the current WTP-based figure for the prevention of a road accident fatality and divide by the 40 years or so of normal life lost on average as a result of such a fatality, we get a figure in the region of £30,000 per year.

- a) One-month subsample  
 $V_P = £7.78 \times 78 \times 12 = £7,280$  (10)  
 95% confidence interval: £3,840 to £10,760
- b) Three-month subsample  
 $V_P = £5.14 \times 78 \times 4 = £1,600$  (11)  
 95% confidence interval: £1,000 to £2,200
- c) Six-month subsample  
 $V_P = £8.29 \times 78 \times 2 = £1,290$  (12)  
 95% confidence interval: £900 to £1,680

It has been suggested to us that the loss of life expectancy resulting from the acute effects of air pollution when elderly and in poor health may vary widely, from just a few days to several months or even, in a minority of cases, several years. However, as the results reported in the regression and in Exhibits 3 and 4 indicate, there is little sensitivity to the length of time gained in poor health, and one possibility is simply to take the overall mean WTP irrespective of the length of time involved, and regard that as the basis for estimating the value of preventing a case of death brought forward when elderly and in poor health. Taking an average WTP per person of £6.96 per year over 78 years would give a figure of £540 per case. On this basis, a package of measures that reduces the number of such cases by 5,000 per year would be regarded as generating a benefit worth about £2.7m per annum.

Alternatively, it might be argued that if we are using a figure based on the 1-month subsample to generate the value of an extra year in normal health, we should, for the sake of consistency, use the figure of £7,280 for an extra year in poor health generated on the basis of the same subsample, as in (10) above. If the best estimate were that each case involved an average loss of 3 months, reducing the number of cases by 5,000 per year would produce a total of 1,250 extra years of life in poor health. If valued at £7,280 per year, the total value of the benefit would come to £9.1m per annum<sup>18</sup>.

The above figures are based on the assumption that respondents regarded the benefit as a certainty for all household members. Although the qualitative study supports this view in that, by the time they were allocating money between the four benefits, quite a few respondents seemed to be giving relatively little consideration to the (un)likelihood of being in the relevant state of health, regression analysis did show the coefficient on LIKELY to be positive and significant at the 10% level. In the light of this, the figures above might be regarded as being on the low side.

<sup>18</sup> It has also been suggested to us that some proportion of those whose deaths are brought forward may be people in seemingly good health but with some underlying susceptibility to heart diseases that is unknown to them; and that if they had not been exposed to the stress associated with a period of unusually high pollution, they might have lived several years longer in something like normal health. The epidemiological evidence on this score at present appears to be somewhat hazy; but if it should turn out that, for example, in addition to the 5,000 deaths of people in poor health, a further 500 (say) deaths each year of people in seemingly good health could be avoided, giving them each an extra 2 years of life in normal health, this latter benefit could be valued on the basis of  $V_N$ : that is, as an extra 1,000 years of life expectancy in normal health, worth  $1,000 \times £27,630 = £27.6m$  per annum. This figure would then be added to the total value attributed to extending 5,000 lives of people in poor health.

## Section 5

It is therefore worth considering how the estimate would be affected if allowance were made for respondent's judgments of the likelihood of being in the state of health where they would stand to benefit from P. Thus suppose for illustrative purposes that all respondents were in fact assigning probabilities of occurrence,  $p$ , in the following way when giving their qualitative likelihood ratings in earlier questions<sup>19</sup>:

very unlikely	: $p = 0.2$
quite unlikely	: $p = 0.4$
quite likely	: $p = 0.6$
very likely	: $p = 0.8$

For those respondents who gave a "can't say" response, we substituted the median likelihood rating. On that basis, the WTP responses were then multiplied by the following conversion factors to give "certainty equivalent" WTP figures, the trimmed means of which could then be used to generate an alternative estimate of  $V_P$  (and in subsequent subsections, by the same procedure, to generate alternative estimates of  $V_H$  and  $V_D$ ):

very unlikely	: conversion factor = $1 \div 0.2 = 5$
quite unlikely	: conversion factor = $1 \div 0.4 = 2.5$
quite likely	: conversion factor = $1 \div 0.6 = 1.67$
very likely	: conversion factor = $1 \div 0.8 = 1.25$

To see the maximum impact this particular set of adjustments could have on the earlier estimates, consider a  $V_P$  derived from the 'converted' 1-month responses. The adjusted per person mean for that subsample is £15.26 instead of the £7.78 used in (10) above. This gives an estimate for  $V_P$  of £14,280 – approximately double the estimate derived on the basis of certainty, but still only about half of the  $V_N$  derived from the same 1-month subsample. Applying the 'likelihood-adjusted'  $V_P$  to the earlier example that involved reducing the number of deaths brought forward by 5,000 per year would give a total value for this benefit of just under £18m per annum.

By adjusting all the respondents' WTP responses in full accordance with their likelihood ratings the 'likelihood-adjusted'  $V_P$  estimate we have produced is arguably on the high side. Clearly not all respondents took the likelihood or unlikelihood of the situation into consideration. It should also be recalled that in those questions in the qualitative study where respondents were asked to make direct comparisons between extra time in normal health and extra time in poor health, poor health was heavily discounted vis-à-vis normal health: in fact, on the basis of *those* responses, extra time in the poor health state was rated about one-tenth as good as extra time in normal health. Judged on that basis (which, we stress, was a small and unrepresentative sample), even the unadjusted estimate of £7,280 from (10) above – which is roughly a quarter of the comparable figure for an extra year in normal health – may be on the high side.

<sup>19</sup> For P, the judgment was given in answer to Question 11b; for H and D, corresponding judgments were elicited by Questions 10b and 9b respectively. The particular assignment of probabilities used here is, of course, somewhat arbitrary, but corresponds with the coding used in the regression analysis.

### 5.3 Value of avoiding a respiratory hospital admission

With the top and bottom 4 responses trimmed out, the overall mean per-person WTP-H response was £16.77. On the assumption that people were thinking of this as a certain rather than a probabilistic benefit, this would yield a WTP-based estimate of the value of avoiding one respiratory hospital admission,  $V_H$ , equal to:

$$V_H = £16.77 \times 78 = £1,310 \quad (13)$$

95% confidence interval: £1,110 to £1,510

An alternative estimate could be derived on the assumption that respondents were thinking more in terms of avoiding one case per *household* rather than one case per person. Using the trimmed mean household WTP from Exhibit 3 gives:

$$V_H = £35.65 \times 78 = £2,780 \quad (14)$$

95% confidence interval: £2,360 to £3,200

However, if we calculate 'likelihood-adjusted' estimates on the basis outlined in the previous subsection<sup>20</sup>, we derive a 'per-person-based' mean WTP of £42.87 instead of the £16.77 used in (13), and a 'per-household-based' mean of £91.13 in place of the £35.65 used in (14). These figures would give, respectively,  $V_H = £42.87 \times 78 = £3,340$  and  $V_H = £91.13 \times 78 = £7,110$ .

Our own judgment is that the extent to which respondents factored likelihood into their responses lies somewhere between the conversion factors used to generate these last two estimates and the assumption that they were all valuing H on the basis that they were avoiding the certainty of a respiratory hospital admission. Thus we should be inclined to take the figure of £1,310 from (13) as a lower bound and the figure of £7,110 as an upper bound on the value to be assigned to the prevention of such an admission.

### 5.4 Value of avoiding a day's breathing discomfort

With the top and bottom 4 responses trimmed out the overall sample mean per person WTP-D response was £16.42. This yields a WTP-based estimate of the value of avoiding 2/3 days breathing discomfort each year throughout a person's life,  $V_D$ , equal to:

$$V_D = £16.42 \times 78 = £1,280 \quad (15)$$

95% Confidence interval: £1,040 to £1,530

This could be interpreted as a per person WTP-based value of avoiding a single day of breathing discomfort of between  $£16.42 \div 3$  and  $£16.42 \div 2$  - i.e. in the region of £5.50 to £8.20 per person per day of breathing difficulties. If a single whole-pound figure were required, £7 per day would be a 'best estimate'.

<sup>20</sup> The argument for doing so in the case of P was based on the fact that the coefficient on LIKELY was significant at the 10% level. For H (and for D) the coefficient was significant at the 1% level, which suggests that there is an even stronger argument for considering the weighted means for these two benefits.

## Section 5

However, if we took the same view as when estimating  $V_H$  – that is, if we assumed that respondents were thinking in terms of avoiding 2-3 days of breathing discomfort per household rather than in terms of 2-3 days for every individual household member – then the estimate based on the trimmed mean from Exhibit 3 would be:

$$V_b = £34.90 \times 78 = £2,720 \quad (16)$$

95% Confidence interval: £2,200 to £3,240

In turn, this could be interpreted as a value of something in the region of £11 to £17 for avoiding a day of breathing discomfort, with a 'best estimate' of £14.

If we then adjust for judgments of likelihood, those means of £16.42 and £34.90 used in (15) and (16) are replaced, respectively, by £33.66 and £71.56. On a per-person basis, this would give a mean value of around £14 per day of breathing discomfort avoided; on the per-household basis, the mean value would be in the region of £30 per day.

Overall, then, the data would appear to be consistent with a lower bound value of £7 per day of breathing discomfort prevented, and an upper bound of £30 per day.

### 5.5 Comparison with the EAHEAP findings

Given our estimates of  $V_N$  and  $V_P$ , it is natural to ask how these fit into the range of values suggested in the EAHEAP report, particularly as it was on EAHEAP's recommendation that our study was commissioned.

The first point to note is that since data concerning the chronic effects of air pollution were not available at the time at which the EAHEAP report was prepared, the monetary values discussed in the report were principally, if not exclusively, applicable only to acute effects. Secondly, the EAHEAP report used the value of preventing a statistical fatality (VPF) for road accident deaths (adjusted upwards to account for the involuntary nature of air pollution risks) as the base value. This base value was then adjusted to reflect the various factors that may affect WTP in the air pollution context. Consequently, the EAHEAP report's recommended range of values was highly speculative because no specific willingness-to-pay data for reductions in air pollution were available to the EAHEAP team at the time of the study. Hence the very wide range of values they recommended (i.e. from an upper bound of £1.4 million for a 12-year gain in life expectancy - based on adjusting the £2m VPF baseline down for age to account that the group affected are elderly - to a lower bound of £2,600 for a 1-month gain in life expectancy when elderly and in poor health). Updated to 2002 prices these figures would be roughly £1.7 million and £3,090 respectively.

If the lower bound of the EAHEAP range is converted to an annual  $V_P$  equivalent and compared to this study's  $V_P$  then, as far as acute effects are concerned our findings point towards values that are considerably more modest than even the lower bound of the EAHEAP range. With regards to chronic effects, as mentioned previously, there are no direct comparators in the EAHEAP report.

It must also be noted that the empirical evidence in this study verified some of the assumptions the EAHEAP report made about the direction in which the base value should be adjusted, to take account of how WTP would change in the air quality context. The EAHEAP report suggested that people's WTP for extending their life in poor health would be lower than their WTP for extending life in normal health, an assumption which the empirical results of this study verify. Furthermore, in the EAHEAP report the base value is adjusted to account for the expectation that the size of the gain in life expectancy would also affect the WTP, but not more than in proportion to the life expectancy gain. Indeed, the results from this study indicate that the difference between the WTP for a 1-month, 3-month and 6-month gain in life expectancy were indeed less than 3 or 6 times greater respectively.

## Concluding remarks

In any study of this kind, there are likely to be grounds for arguing that the estimates generated are too large, and other grounds for arguing that they are too small. For example, it could be argued that when people are asked to think about a single hazard and the benefits of reducing it, out of the context of all the other hazards and the potential benefits of reducing them, they may overvalue it – especially, perhaps, when they are being asked for their hypothetical WTP as opposed to being asked to make actual payments. On the other hand, the fact that respondents were being asked to value a bundle of four benefits and then allocate that total between the four separate components could be thought to have reduced the amount assigned to any one (as compared with a study that asked about any one of them in isolation); and the fact that we took as the basis the largest sum they said they were certain they would pay (as opposed to a figure between that and the higher figure where they became certain they would *not* pay) could be thought to have made the final estimates even more conservative. We cannot say for sure that we have got the balance right, but it represented our best judgment at the time, in consultation with the project Steering Group and with the help of input from other expert advisers.

On that basis, the indications are:

1. That the most highly valued benefit of reducing air pollution is the potential for increasing life expectancy in normal health, with this benefit not being valued significantly differently from increases in life expectancy brought about by reductions in road accident risks. If a figure in the region of £31,200 per life year gained in normal health is deployed in the evaluation of road safety measures, such a figure for evaluating the chronic health benefits of reducing air pollution seems entirely defensible. There is no strong evidence from the present study for using a figure which is either significantly higher, or else significantly lower, than the road safety value.
2. That when answering on their own/their household's behalf, respondents placed relatively low values on extending their lives for short periods if that time were to be spent in poor health: when the period of time is in the region of a few days or weeks, a figure of about £600 per case is consistent with the data from the present study; more generally, a figure of £7,280 for an extra year of life in poor health – a figure which is approximately one quarter of the corresponding figure for an extra year in normal health – would be supported if responses from the 1-month subsample were interpreted on the basis that respondents were contemplating the P scenario with certainty. If their responses were adjusted along the lines indicated earlier to allow for judgments of likelihood, a  $V_P$  of £14,280 could be derived. However, to the extent that there was a tendency for respondents to disregard uncertainties at the point where they were apportioning WTP, this last figure might be regarded as an upper bound on  $V_P$ .
3. That there is considerable aversion to the prospect of being admitted to hospital with severe breathing difficulties, and that a sum of money in the range £1,300 to £7,100 per admission to represent the strength of this aversion might reasonably be added to the other cost savings generated by reducing the numbers of such admissions.

4. That a positive value is attached to avoiding days of breathing discomfort occasioned by unusually high levels of pollution on particular days. On the assumption that respondents were thinking in terms of the certainty of such days, the data generated a mean figure in the region of £6 to £8 per person-day. But the evidence that at least some respondents were thinking in terms of probability rather than certainty suggests that this figure should be taken as a lower bound, and a figure several times higher would not be indefensible, with an upper bound of the order of £36 per person-day.

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# Report on piloting

## Background

The study was set up into a number of key phases:

- Developmental stage (covering questionnaire design and pilots);
- Conducting main survey;
- Analysis of data and production of final report.

It is the developmental stage and specifically the piloting that is discussed within this section of the report. The aim of this section is to present a brief summary of the main piloting that supported this study which has influenced the final questionnaire design. This section draws on material that the research team prepared over the course of the piloting.

The following pilots were conducted over the course of the study:

- Pilot 1 (January – February 2000);
- Pilot 2 (July 2000);
- Pilot 3 (November 2000);
- Pilot 4 - Cognitive testing (January – April 2002)

Note that within the main survey phase it was decided to proceed by first having a large scale final pilot before proceeding to the main survey [phase 1 of main survey]. This is discussed more fully elsewhere in the report.

## Rationale for piloting

The key rationale for piloting or pre-testing of the questionnaire is that it will improve the design of the questionnaire for the main study. When the study was set up, it was recognized that adequate time would be required for the questionnaire to be developed and revised in the light of feedback from the pilots. Piloting allows the opportunity to test for biases and identify any problems with the questionnaire itself; the information presented in, or supplementing the questionnaire; and the way in which the survey is being administered.

## Annex 1

### Summary of Pilot Stages

	Details of pilot	Valuation approach	Issues raised	Impact on questionnaire design
Pilot 1	<ul style="list-style-type: none"> <li>- Conducted January to February 2000 in York and Newcastle</li> <li>- 15 focus groups</li> </ul>	<ul style="list-style-type: none"> <li>- For mortality questions used Area A vs Area B approach</li> <li>- For morbidity questions used magic wand (direct WTP)</li> </ul>	<ul style="list-style-type: none"> <li>- Area A vs. Area B format did not work well: respondents struggled with information and results were not intuitive.</li> <li>- Magic wand questions appeared to work well</li> </ul>	<ul style="list-style-type: none"> <li>- Expert Group generally disagreed with Area A vs B approach. Issues included problem of embedding.</li> <li>- Decided to pilot alternative questionnaire format using magic wand and matching questions</li> </ul>
Pilot 2	<ul style="list-style-type: none"> <li>- Conducted July 2000</li> <li><b>Magic wand' WTP</b></li> <li>- Conducted in York and Newcastle</li> <li>- Focus groups with 32 usable questionnaires</li> <li><b>Matching questions</b></li> <li>- Conducted in Norwich and Newcastle</li> <li>- Focus groups with 33 usable questionnaires</li> </ul>	<ul style="list-style-type: none"> <li>- Both mortality and morbidity questions used magic wand and matching questions</li> <li>- Magic wand questions elicited WTP over 10 year period for 1, 6 and 12 months in poor and normal health (individual and household)</li> </ul>	<ul style="list-style-type: none"> <li>- Both magic wand and matching questions appeared to work well</li> <li>- Some concerns over matching questions which delivered some inconsistent relative valuations</li> <li>- Concerns raised that group interviews not working</li> </ul>	<ul style="list-style-type: none"> <li>- Study team recommends refining both the magic wand and matching questionnaires</li> <li>- Study team recommends conducting the 3rd pilot using one to one interviews instead of group interviews</li> </ul>
Pilot 3	<ul style="list-style-type: none"> <li>- Conducted Nov 2000 in Newcastle</li> <li>- one to one interviews</li> <li>- 8 magic wand and 9 matching interviews conducted</li> </ul>	<ul style="list-style-type: none"> <li>- Piloted both magic wand and matching questions</li> <li>- Magic wand questions elicited WTP (10 year) for 1, and 12 months in poor and normal health (individual/household)</li> </ul>	<ul style="list-style-type: none"> <li>- One to one interviews work well</li> <li>- Matching results might lead to inconsistent results compared to magic wand?</li> <li>- Appropriateness of asking WTP over 10 yr period?</li> <li>- Computerised interviews could benefit</li> </ul>	<ul style="list-style-type: none"> <li>- Steering Group discussions and Expert Group recommend investigating the relationship between magic wand and matching questions</li> <li>- Agreed that it is necessary to look at payment period for WTP</li> <li>- Agreed to try to computerize interviews</li> </ul>
Pilot 4 (cognitive testing)	<ul style="list-style-type: none"> <li>- 5 rounds of cognitive testing over Jan-April 2002</li> <li>- Conducted by research team and NatCen</li> </ul>	<ul style="list-style-type: none"> <li>- Recommendation to focus on magic wand questions</li> <li>- Revised questionnaire-direct WTP questions</li> <li>- WTP elicited over life time rather than 10 yr period at household level.</li> </ul>	<ul style="list-style-type: none"> <li>- Cognitive testing improves wording and structure of questionnaire</li> <li>- After 3 rounds of testing, research team recommends eliciting WTP for all 4 benefits together</li> </ul>	<ul style="list-style-type: none"> <li>- Fourth and fifth rounds of testing use format that elicits WTP for all 4 health benefits together and then WTP for each individually</li> <li>- this approach provides much better sensitivity of WTP to the health impact of concern.</li> </ul>

Summary of questionnaire formats during pilot phase

Pilot 1	Pilot 2	Pilot 3	Pilot 4
<p>Q1 – details of household members, names, age, relationship to respondent</p> <p>Q2 – attitudes to air pollution and its health effects</p> <p>Q3 – ranking of different health effects of air pollution</p> <p>Q4 – Area A vs Area B questions for mortality</p> <p>(i) certain gains in life expectancy (chronic mortality)</p> <p>(ii) uncertain gains in life expectancy (chronic mortality)</p> <p>(iii) gains in life expectancy when elderly and in poor health (acute mortality)</p> <p>Q5- Q6 Morbidity questions – ranking of illness episodes and magic wand (WTP) questions. Episodes of illness included:</p> <ul style="list-style-type: none"> <li>- 3 days confined to bed</li> <li>- hospital admission</li> </ul> <p>Q7- Q10 Background information – income, occupation, health problems</p>	<p><b>Magic wand questionnaire</b></p> <p>Q1 – ranking possible health hazards</p> <p>Q2 – priorities for risk reduction (car accidents, smoking, air pollution)</p> <p>Q3 Rankings for avoiding episodes of illness related to air pollution</p> <p>Q4 WTP to avoid illness episodes (eye irritation, days breathing difficulties)</p> <p>Q5 Ranking of gains in life expectancy in poor/normal health</p> <p>Q6 WTP for gains [1, 6, 12 months] in life expectancy in poor/normal health</p> <p>Q7 Household details</p> <p>Q8 WTP for gains in life expectancy for household</p> <p>Q9 Background questions</p> <p><b>Matching questionnaire</b></p> <p>‘Magic wand’ questions replaced with series of matching questions looking at trade offs of air pollution, car accident and smoking deaths</p>	<p><b>Magic wand questionnaire</b></p> <p>Q1 and Q2 – ranking possible health hazards to population/self</p> <p>Q3 Rankings for avoiding episodes of illness related to air pollution</p> <p>Q4 WTP to avoid illness episodes (days breathing difficulties, hospital admission)</p> <p>Q5 Ranking of gains in life expectancy in poor/normal health</p> <p>Q6 WTP for gains [1, 12 months] in life expectancy in poor/normal health</p> <p>Q7 WTP for RHA after age 65+</p> <p>Q8 Household details</p> <p>Q9 WTP for gains [1 month] in life expectancy for household</p> <p>Q10 Background questions</p> <p><b>Matching questionnaire</b></p> <p>‘Magic wand’ questions replaced with matching questions on trade offs with air pollution deaths/illness and car accidents</p>	<p><b>Direct WTP questionnaire</b></p> <p>Q1 Identify household members</p> <p>Q2 Identify health problems suffered by household</p> <p>Q3 Identify threats to own health from range of public health risks including air pollution</p> <p>Q4-Q8 Air pollution in area of living and risks of household to air pollution through existing or likely future health problems</p> <p>Q9 – Q12 Benefit to household from reducing air pollution in terms of each of 4 health effects (chronic and acute mortality, breathing difficulties and hospital admission)</p> <p>Q13 Household Budget question</p> <p>Q14 –Q16 WTP for all 4 benefits together</p> <p>Q17-Q19 WTP for 4 benefits individually</p>

## Pilot 1 – January – February 2000

The objective of this first pilot phase is to test the basic feasibility of just some of the types of questions that might – or might not – be used in the main study.

The main concern *at this stage* is not to focus on the complexities and uncertainties surrounding the epidemiology and/or toxicology of air pollution. Rather, our approach here has been to present members of the public with simplified and somewhat stylised information in order to test whether certain basic question formats are viable. If (some of) these question formats work well with relatively uncomplicated scenarios, a future task will be to elaborate upon the scenarios. On the other hand, if we have reason to believe that particular question formats are not viable even when they entail relatively simple scenarios, we can hold out little hope that they will deliver useful results when combined with more complex and difficult information.

Thus the particular scenarios used in this first phase of piloting were chosen principally in order to help us judge the viability of the question formats.

The pilot work in January and February 2000 involved two series of groups. Seven groups were convened in the week beginning January 24<sup>th</sup>. In the light of the experience gained, the research team modified the questionnaire and protocol before conducting another eight groups during the week beginning 21<sup>st</sup> February.

This first pilot explored the use of 'Area X vs Area Y' questions for alternative scenarios for gains in life expectancy. For these questions the basic idea was to ask respondents to suppose that they had to move to another area, and to offer them a choice between two areas which differed only in terms of the health effects of air pollution and the cost of living. The main aim was to see if it was feasible to elicit directly people's willingness to pay for reductions for themselves and other household members in (the risks of) both chronic and acute effects of air pollution, and to test for sensitivity to the magnitudes of the reductions. 'Magic wand' questions were also piloted to consider two temporary 'episodes' of illness attributed to air pollution. Respondents were asked first to rank the episodes and then asked willingness to pay to avoid such episodes.

Overall, a number of positive points emerged. The handout appeared to be broadly accessible and provided a good basis for discussion and the questions that followed. The various health impact descriptions were intelligible to most respondents and the ranking of these impacts was usually handled without great difficulty. The card-sorting procedure was generally well understood; and when asked to value the certainty of the avoidance of a 'episode' of illness, most respondents appeared willing and able to answer.

However, in other respects the questions addressing the possible short and long term effects on life expectancy proved more problematic. In the January groups, it seemed that respondents were insufficiently sensitive to the difference between the scenario involving the certainty of a year of life expectancy for everyone in the household and the scenario involving changes in the risks of those over 65 and already in poor health having death brought forward by a month. Modifications of the procedure prior to the February groups met with mixed success in tackling this problem. Many respondents struggled with the information about the various Areas, and the attention they paid to the risk-grids appeared to be at the expense of the life expectancy tables. As a result, we observed an uncomfortably large number of anomalies in the ranking exercise, and the *per capita* values for an extra year of (average quality) life expectancy generated by the certainty scenario were very much lower than the *per capita* values for an extra "statistical" year of (lower quality) life expectancy. While it is again arguable that budget constraints may have played *some* part in depressing these values, it seems likely that the major part of the discrepancy is due to the problems respondents had absorbing the information and picturing the true extent of the benefits being presented to them.

*In the light of these results, we could not recommend using questions in this form to try to obtain direct monetary valuations for reducing the health effects of air pollution.*

## Pilot 2 – July 2000

### Magic wand questionnaire

Piloting of the “magic wand” (MW) contingent valuation questions was carried out in York and Newcastle on a focus group basis, producing a total of 32 useable completed questionnaires. The main findings of the magic wand piloting were as follows:

- The mean and median willingness to pay responses for the non-fatal illness episodes are plausible and consistent with what theory and common sense would predict.
- Generally speaking, respondents found the “chances of death” handout explanation of gains in life expectancy helpful in understanding the concept.
- The relative magnitudes of the willingness to pay responses for each of the three gains in life expectancy also appear to be in line with the predictions of theory and common sense.
- Given that the normal health WTP responses are an increasing and strictly concave function of the length of gain in life expectancy, these results provide clear evidence of the impact of binding budget constraints.
- Finally, comparison of the mean and median responses for an additional six months or year in normal health with the corresponding figures for poor health indicate that the latter are in the region of one fifth of the former. Overall, then, the findings of the magic wand piloting are generally very encouraging and strongly suggest that such questions would be workable in a Main Study.

### Matching questionnaire

Piloting of the matching questions was carried out in Newcastle and Norwich, again on a focus group basis, producing a total of 33 useable completed questionnaires.

The main matching questions concerned acute air pollution vs smoking; acute air pollution vs car driver/passenger deaths; smoking vs car driver/passenger deaths and acute vs chronic air pollution. As in the case of the magic wand piloting, two versions of the matching questionnaire were administered. In the first of these the matching question tables were symmetrical about a middle row in which the choice was between preventing the loss of 1000 life years by cause A vs preventing the loss of 1000 life years by cause B, though the number of deaths prevented was also specified in brackets. Respondents were first asked to make a choice in relation to this middle row and then to complete the relevant part of the rest of the table. In the second version the middle row of the table involved a choice in which the number of deaths prevented was the same in the two options (100). In this version the number of life years gained was also specified in brackets.

The main findings of the matching questions piloting were as follows:

- **Saving a life year in poor health/saving a life year in normal health**  
*An encouraging result. The mean relativity of 0.3 implies that a life year saved in poor health is worth approximately one third (or approximately one fifth if three respondents who value a year in poor health higher than a year in normal health are omitted) of a life year saved in normal health. This is gratifyingly close to the same acute/chronic relativity derived from the corresponding magic wand questions, namely the valuation question regarding the worth of one year (or six months) of life expectancy in normal health and one year (or six months) of life expectancy in poor health.*
- **Saving a life year from air pollution/saving a life year from car accidents**  
A potentially anomalous result. Let us take the life year saved in normal health by preventing car accidents as a reasonable approximation to a life year saved in normal health by reducing the chronic effects of Air Pollution. Then, *prima facie*, the relativity of 0.92 for saving a life year in poor health versus saving a life year in normal health seems high.

However, it is conceivable that respondents would not take this view because of additional factors such as involuntariness and lack of control associated with air pollution. Thus, when faced with a question matching a life year saved in normal health from reducing air pollution (chronic effects) with a life year saved in normal health from car accidents, then they may offer a relativity in the region of 3. If they did state that one air pollution year is worth 3 car accident years, then the relativity of 0.92 would be plausible: multiplying the acute/chronic relativity of 0.3 by 3 gives 0.9. Given past experience, though, we feel that a relativity of such magnitude is unlikely. Replicating both results (0.2-0.3 for acute vs chronic and 0.92 for acute vs car accident) in a Main Study would clearly raise problems in terms of identifying the appropriate values for policy making.

- **Saving 100 deaths from air pollution/saving 100 deaths from car accidents**  
A worrying result in that preventing 100 air pollution deaths appears to be worth 0.2 of preventing 100 car accident deaths. Note that one air pollution death prevented is one life year in poor health saved while, on average, one car accident death prevented saves 40 life years in normal health. The relativity of 0.2 therefore implies that one life year in poor health (air pollution) is worth eight life years in normal health (car accident) since  $0.2 \times 40 = 8$ . This is clearly implausible. Further work could establish whether the result was simply an artifact of the particular table (i.e. starting point, layout etc) or whether there is a fundamental problem with this type of matching question.

### Implementation of procedures

*Even though the second stage pilot groups involved only 4 respondents (except on a couple of occasions when there were 5) and were conducted by experienced moderators thoroughly familiar with the concepts and the materials, some groups were demanding and/or time-consuming to run. On several occasions some key items of data were lost, either as a result of refusals, or else due to misunderstandings by respondents. The research team have considerable concerns about the advisability/feasibility of the main study being conducted in larger groups. A further concern, more apparent in the magic wand groups than in the matching groups (but present in the latter to some degree) was the non-independence of individual respondents' answers.*

The research team takes the view that the third phase of piloting should use one-to-one interviews rather than groups to administer both the magic wand and the matching questionnaires.

## Pilot 3 – November 2000

The second phase of piloting suggested that both the Magic Wand and Matching procedures were viable; but that it would almost certainly be better to conduct the main survey on a one-to-one in-home interview basis, ideally computer aided. The main purpose of this third phase of piloting was to undertake a limited number of individual interviews to establish whether such a procedure was indeed viable.

### Magic wand questionnaire

**A total of 8 interviews were conducted in Newcastle during November 2000.**

The main findings were as follows:

- The mean and median one-off willingness to pay responses for the non-fatal illness episodes and lesser severity non-fatal road injuries are broadly plausible, if on the somewhat modest side.
- In the case of monthly willingness to pay over the coming ten years for various gains in life expectancy and the avoidance of one respiratory hospital admission, the responses are again broadly plausible and in the main similar to those from pilot 2, the notable exceptions being (a) willingness to pay for a one month gain in life expectancy in normal health for all household members where the mean response was almost double the pilot 2 figure (though the medians were very much closer together) and (b) willingness to pay for a one year gain in life expectancy in poor health where the mean response was roughly half the pilot 2 figure. However, in connection with the latter finding it will be recalled that, in contrast to pilot 2, pilot 3 respondents were presented with a show card giving a summary of the typical health state and lifestyle restrictions of someone in poor health with heart or lung disease. Thus, it may well be the case that the condition described on this show card was regarded as being markedly worse than had been assumed to be the case by many pilot 2 respondents, who were not provided with an explicit description of "poor health". If this were so, then the substantially lower willingness to pay for an additional year in poor health observed in this pilot would be entirely plausible.
- More specifically, the mean ten-year total responses were as follows (again, where relevant, pilot 2 means are shown in brackets):

One month in normal health	£1357.50	(£1497.93)
One year in normal health	£7387.50	(£7600.00)
One year in poor health	£ 678.75	(£1378.00)
Avoidance of hospital admission	£1380.00	
One month normal health for household	£8177.14	(£4868.15)

- As far as the interviews themselves were concerned, if anything these went even more smoothly than the magic wand focus group sessions in pilot 2. In particular, the one-to-one interview format facilitated the explanation of points concerning which the respondent required clarification.
- Other factors that tended to require explanation/emphasis were the fact that willingness to pay responses were being sought not as the thin end of a taxation increase wedge but rather as a means of gauging strength of preference with a view to informing public sector decisions concerning the expenditure of pre-determined, pre-existing budgets in various areas. Some respondents also sought reassurance that they were interpreting the payment vehicle correctly (i.e. one-off vs monthly payment over ten years). It also turned out to be very important to stress that WTP responses must take account of what the respondent could afford and in this respect the monthly expenditure budget handout proved to be extremely useful.

The most significant outstanding question that needs to be addressed before the main study questionnaire is finalised concerns the monthly payment over a forthcoming period. While the questionnaire asked about a monthly payment over the next ten years and respondents seemed to experience no particular difficulty in understanding and responding to the question, several uncertainties exist concerning the appropriateness of the question in this precise format. For example why ten years? Why not, say, twenty years for those who are below the age of 45? Or the remainder of working life? But if the latter what do we do about those who have retired? What about inflation and discounting?

To get some feel for how a change of format might affect responses, in the last four interviews, having asked the question about a monthly payment over the next ten years, respondents were asked if their answers would have been different if the monthly payment had remained as a fixed proportion of their overall monthly expenditure or income (so as to take account of inflation) and were to apply over the remainder of working life. Perhaps not surprisingly, responses were mixed. This is clearly an area that requires more work.

### Matching questionnaire

**A total of 9 interviews were conducted in Newcastle during November 2000.**

We focus here on the questions concerned with extensions of life:

- An extra year in normal health as a result of reducing chronic effects is weighted much more highly than an extra year in poor health gained from reducing acute effects: 1 extra normal health year is equivalent to an average of 2.7 (median of 7.5) extra years in poor health. (The ratio from the magic wand questions means was 1:11)
- 1 extra year in normal health as a result of reducing chronic effects is weighted somewhat higher than an extra year in normal health gained from reducing car accidents, with the air pollution year being equivalent to an average of 1.3 (median of 2) extra car accident years.
- 1 extra year in normal health as a result of reducing car accidents is worth an average of 1.6 (median of 1.5) extra years in poor health gained from reducing acute effects.

It may be thought surprising that poor health is not discounted more against normal health, given the description shown to respondents and the ages of those who would benefit. However, what emerged clearly from even this small sample of respondents is that many do not consider only the numbers of years gained but also the numbers of people benefiting.

This meant that in the question when both options offered the same number of extra years, 1,000 individuals stood to get some benefit from reducing bad air days while only 100 stood to benefit from reducing chronic effects. And although 7 out of 9 respondents still favoured the years of normal health in that choice, several were reluctant to accept a much bigger imbalance in the numbers of people benefiting.

The same desire by some respondents to put at least some weight on the numbers of people benefiting irrespective of the magnitude of the benefit may also go a long way towards explaining why each extra year of normal health from reducing the chronic effects of air pollution received greater weight than each extra year resulting from reductions in road accidents: that is, when both options offered 1,000 extra years in normal health, the fact that only 25 individuals stood to benefit from the roads option compared with 100 who stood to benefit from the air pollution option clearly tipped the balance towards air pollution for many respondents.

In a number of respects, both magic wand and matching procedures worked as well as, or even better than, the research team had hoped. Compared with the group format, there was a general feeling that the key issues were being communicated effectively to respondents, that there was less confusion and misunderstanding, that such misunderstandings as did occur could more easily be identified and clarified, and that respondents' answers constituted as reasonable a reflection of their values and preferences as could be expected from a 45 minute interview about a moderately complex set of issues.

Both magic wand and matching interviews would be made easier, and allow more sophisticated design features, if they were computerised. This would help to standardise the way in which different interviewers operated, while also making it easy to customise procedures (e.g. to give respondents the life expectancy information pertinent to someone of their particular age and gender) and automatically randomise certain features (e.g. the starting points of different questions).

*Discussions in the Steering Group and Expert Group following the third pilot led to the recommendation to investigate the relationship between matching questions and magic wand questions. This arose because of concerns that the two procedures appeared inconsistent. As a result, a paper was produced by the study team "Magic wand/matching question think piece". This paper concluded the magic wand questions were more directly relevant for the purposes of use in cost benefit analysis although matching questions could have an important supportive role. The pilots that followed therefore focus on the magic wand questions. These pilots were undertaken by the research team in conjunction with NatCen [National Centre for Social Research] who were contracted to carry out the main survey.*

### **Pilot 4 – cognitive testing (January to April 2002)**

*Within pilot 4, the questionnaire has involved considerable redrafting based, initially, on suggested improvements from within the research team and NatCen and, secondly, on 5 rounds of cognitive testing.*

*Cognitive testing methods, derived from social and cognitive psychology, enable the exploration of the processes by which respondents answer survey questions, and the factors that influence the answers they provide. Cognitive interviews can highlight where respondents misunderstand questions or key concepts, do not know or cannot recall the needed information from memory, use an inappropriate strategy for making a judgment, or prefer to hide certain information or provide a socially desirable answer. Pre-testing questions in their questionnaire context aims to establish whether:*

- respondents can understand the question concept or task,
- they do so in a consistent way, and in a way the researcher intended.

There are two main cognitive testing techniques – ‘think aloud’ interviewing and retrospective probing. The former requires respondents to talk about the processes through which they arrive at their answers as they are being interviewed. The latter involves detailed questioning once the interview is completed. Since the current interview is likely to involve a learning curve in respondents’ understanding of the task in hand, which would in turn be likely to affect retrospective feedback, concurrent think aloud cognitive testing was used in this development work.

*The first two rounds of testing within pilot 4 involved about 20 respondents in total, reflecting a cross-section of the general population on factors such as gender, age, social class, educational attainment and ethnic group. The interviews were carried out by members of the research team, in pairs, as well as by a NatCen field interviewer, who is fully trained and experienced in cognitive testing methods.*

### **Wording**

The wording of the questionnaire has been modified radically, both before and as a result of the cognitive testing. The vocabulary used has been simplified as far as possible, in order to be accessible to the population as a whole. The original version was thought to include an excessive amount of detailed information for respondents to process. Much of this detail was cut prior to the first round of cognitive testing. Nevertheless, it was still felt after the first round that respondents were unable to take in all of the information, and so further cuts were made. The aim has been to explain, as clearly as possible, the necessary tasks as well as the various issues for the respondent to bear in mind, without exceeding their likely threshold of concentration and understanding.

## Structure

The structure of the interview has been changed significantly since the original version. Initial discussions between the research team and NatCen highlighted the fact that the questions jumped between those relating to the respondent alone, and those relating to the respondent's household. This was felt to be potentially confusing, and an attempt was made to simplify the question ordering.

## Mode

The questionnaire was originally intended to be carried out as a Paper and pen Personal Interview (PAPI). However, during discussions of the aims and methodology of the survey, the possibility of converting the questionnaire into Computer Assisted Personal Interview (CAPI) was raised. The main reason for this was to facilitate the randomisation of respondents into the different experimental sub-groups. All versions of the interview would be embedded within the CAPI programme, ruling out potential errors and also the need for interviewers to carry around multiple versions of a paper document.

In addition to this fundamental advantage, there are a number of other benefits of CAPI which further justify a change of mode. These are outlined below:

- **Routeing** – a CAPI programme allows for different routes through the interview.
- **Text fills** – this is related to the previous point. It is possible to have different versions of the same question, depending on the sub-group of respondents concerned.
- **Data quality** – editing rules can be incorporated into the CAPI programme to check internal consistency and ranges.
- **Calculation** – one of the major issues to resolve in the design of the questionnaire has been to give respondents an idea of how much their WTP answers would total over the remainder of their life. For the main fieldwork these calculations will be incorporated into the CAPI programme, meaning that the total value is automatically calculated and presented to the interviewer on their lap-top screen.
- **Timing** – the survey data from a CAPI interview are transmitted on a regular basis from interviewers. There is no need, of course, for data to be keyed. This, along with the fact that editing rules within the programme reduce the need for data cleaning, mean that the data processing is considerably quicker than for a PAPI survey.

## Proposed changes following 3rd round of cognitive testing

Following the 3rd round of cognitive testing, the project team became concerned about the difficulties people were having with some of the concepts and questions. In particular, when asked how much they were willing to pay for each of the 4 health benefits, many respondents were giving similar amounts for each, and seemed to be thinking more about what they could afford and less about the actual value of each health benefit to them. Moreover, there was considerable concern that the sum of the 4 individual responses would be far greater than the amount they actually would be willing or able to pay in total for all 4 benefits together. However,

## Annex 1

since many policies to reduce air pollution would, if successful, deliver some bundle of the various benefits rather than any one on its own, we need to try to ensure that the total values are not grossly overstated. In the light of these concerns, an alternative questionnaire design was explored. The revised questionnaire format set out to value each of the benefits as part of a bundle rather than on a separate, stand-alone basis.

In the version of the 11<sup>th</sup> April (4th round), the design attempted to build values up incrementally. Having told respondents that they would, in due course, be asked for a value for all four benefits together, the 11<sup>th</sup> April version started by asking for the value of one benefit (preventing occasional days of breathing discomfort) then added a 2<sup>nd</sup> (preventing a respiratory hospital admission) then a 3<sup>rd</sup> (preventing deaths brought forward) and finally the 4<sup>th</sup> (general extension of life expectancy). Although this approach worked much better in terms of getting respondents to discriminate more between the benefits, there appeared still to be a tendency to overstate WTP for the 1st benefit valued, while relatively understating the value of the 4<sup>th</sup> benefit presented. An alternative procedure is to start by obtaining a value for all 4 benefits, and then progressively separate out the individual components. A 5<sup>th</sup> round of testing indicated that this alternative procedure was feasible.

# Main survey final questionnaire

## QUES 1-2.

Initial questions collecting info about household members' names, ages, etc. and any existing health problems.

## QUES 3

SHOWCARD B. "Thinking just about yourself personally, I would like you to tell me which are the three biggest threats to **your health**. First, which one of the things on this card is the biggest threat to your health?" READ OUT TEXT IN BOLD ON SHOWCARD B.

### QUES 3a

"And which is the second biggest threat?":

### QUES 3b

"And which is the third biggest threat?":

## Explan1

"From now on I want us to focus on one particular thing that might damage our health and possibly shorten our lives. That thing is **air pollution** caused by smoke, fumes and chemicals in the air.

I have some cards which show various ways that air pollution might affect people's health, and I would like to ask you some questions about these effects." READ OUT FROM SHOWCARD C1 AND THEN GIVE TO RESPONDENT.

"**Faster Ageing**. Some chemicals in the air may cause wear and tear on our bodies, so that people living in areas with more pollution may age faster and die younger than people in low pollution areas. Some experts think that the average person in Britain might lose about a month of life in this way. Others think the average loss of life might be as much as a year."

## QUES 4

"Compared with other areas of Britain, do you think that air pollution in your area is about average, worse than average, or better than average?":

AA: About average;

WA: Worse than average;

BA: Better than average.

## Intro1

**TAKE BACK SHOWCARD C1 THEN READ OUT FROM SHOWCARD C2 AND THEN GIVE TO RESPONDENT.**

**“Death Brought Forward when Elderly and in Poor Health.** On a few days every year, air pollution reaches unusually high levels. For some people in their 70's and 80's with existing heart or lung disease, the unusually high level of pollution on a bad air day can put so much extra stress on their breathing that their heart fails and they cannot be revived. Often these people are not expected to live very much longer anyway, but a bad air day can bring their death forward. If the bad air day had not occurred, they could have lived a few weeks or months longer, although this time would have been spent in their existing poor state of health.”

## QUES 5

“Have any of your relatives ever suffered from heart or lung disease when they were elderly?”

Y:Yes

N:No

If Yes, go to QUES 5a

## QUES 5a

Code all that apply:

Partner,  
Parent,  
Child,  
Other

## Intro2

**TAKE BACK SHOWCARD C2 THEN READ OUT FROM SHOWCARD C3 AND THEN GIVE TO RESPONDENT.**

**“Hospital Admission.** Another possible effect of bad air days is that some people need hospital treatment. The people affected in this way are mostly in their 70's and 80's with some kind of lung disease, although some of those affected may be younger people with asthma or other chest conditions. The unusually high pollution can cause them to suffer an attack of coughing, wheezing, chest pains and struggling for breath which becomes so bad that they need to be admitted to hospital. They may have to stay in hospital for anything from a day or two, up to a couple of weeks, followed by a period of time resting at home.”

## QUES 6

"Have you {or any named member of household} ever needed to be admitted to hospital because of breathing difficulties?"

Y:Yes

N:No

If Yes, go to QUES 6a

## QUES 6a

Code all that apply:

Self,  
Partner,  
Parent,  
Child,  
Other

## Intro3

**TAKE BACK SHOWCARD C3 THEN READ OUT FROM SHOWCARD C4 AND THEN GIVE TO RESPONDENT.**

**"Breathing Discomfort on 2 or 3 Days Every Year.** For people of all ages who have asthma or various other allergies or chest conditions, bad air days can bring on a cough and a feeling of discomfort in the chest. If they do any heavy work or vigorous activity they may wheeze or feel breathless. As soon as the bad air day is over, they return to normal health. But, on average, they are likely to suffer 2 or 3 days of breathing discomfort every year throughout their lives."

## QUES 8

"Have you {or any named member of household} ever suffered occasional days of breathing discomfort of the kind described on this card?"

Y:Yes

N:No

If Yes, go to QUES 8a

## QUES 8a

Code all that apply:

Self,  
Partner,  
Parent,  
Child,  
Other

### Intro4

TAKE BACK SHOWCARD C4.

### Explan2

"If we want to tackle the health problems on the cards you've just seen, we would have to reduce air pollution. That would mean reducing the fumes and chemicals from traffic and factories, and using cleaner fuels. I'd like you to look at four cards showing the ways in which reducing air pollution might benefit some people's health. For each one in turn, I will ask you to think about how much benefit, if any, you {and all named members of household} would get from it." INTERVIEWER: USE THE APPROPRIATE COLOUR E SHOWCARDS.

## QUES 9

"So, let's start with this card." READ OUT SHOWCARD E-D AND HAND TO RESPONDENT.

"**AVOIDING 2 OR 3 DAYS OF BREATHING DISCOMFORT EVERY YEAR**. This would be most likely to benefit people with asthma or various other allergies or chest conditions for whom bad air days can bring on coughing and wheezing. By reducing the number of bad air days, such people would avoid 2 or 3 days of breathing discomfort like this **every year** from now on. I'd like to know how much benefit, if any, you think you/your household might get from this, either now or in the future."

### QUES 9a

SHOWCARD F. "First, can I ask you: how unpleasant do you think it would be to experience this kind of breathing discomfort for 2 or 3 days every year? Please take your answer from the top half of this card.":

- A "not at all unpleasant",
- B "a little unpleasant",
- C "quite unpleasant",
- D "very unpleasant"

### QUES9 b

SHOWCARD F. "Second, can I ask you: how likely or unlikely do you think it is that you {or any named member of household} will experience such days of breathing discomfort in the future? Please take your answer from the bottom half of this card.":

- A "very unlikely",
- B "quite unlikely",
- C "quite likely",
- D "very likely",
- E "Can't say"

### QUES 9c

SHOWCARD G. "So, if it were possible to reduce the bad air days that cause some people 2 or 3 days breathing discomfort every year, how much benefit would that be to you/your household? Please take your answer from this card.":

- A "No benefit at all",
- B "A very small benefit",
- C "A small benefit",
- D "Quite a big benefit",
- E "A very big benefit"

### QUES 10

"Now, let's look at this card." READ OUT SHOWCARD E-H AND HAND TO RESPONDENT.  
"AVOIDING AN ADMISSION TO HOSPITAL WITH BREATHING DIFFICULTIES. This would be most likely to benefit people in their 70's and 80's who have some kind of lung disease, or younger people with asthma or other chest conditions. By reducing the number of bad air days, such people would be less likely to develop attacks of breathing difficulties which require admission to hospital. Again, I'd like to know how much benefit, if any, you think you/your household might get from this one, either now or in the future."

### QUES 10a

SHOWCARD H. "So, how unpleasant do you think it would be to experience such an admission to hospital? Please take your answer from the top half of this card.":

- A "not at all unpleasant",
- B "a little unpleasant",
- C "quite unpleasant",
- D "very unpleasant"

### QUES 10b

SHOWCARD H. "How likely or unlikely do you think it is that you {or any named member of household} will ever need to be admitted to hospital in the future because of breathing difficulties? Please take your answer from the bottom half of this card.":

- A "very unlikely",
- B "quite unlikely",
- C "quite likely",
- D "very likely",
- E "Can't say"

### QUES 10c

SHOWCARD I. "So, if it were possible to reduce the bad air days that cause some people to require an admission to hospital, how much benefit would that be to you/your household? Please take your answer from this card.":

- A "No benefit at all",
- B "A very small benefit",
- C "A small benefit",
- D "Quite a big benefit",
- E "A very big benefit"

### QUES 11

"Now let's look at this card." READ OUT SHOWCARD E-P AND HAND TO RESPONDENT.

"**{X=1/3/6} MONTHS MORE LIFE IN POOR HEALTH WHEN ELDERLY**. This would be most likely to benefit elderly people with heart or lung disease. By reducing the number of bad air days, such people could expect to live about X months longer, although this extra time would be spent in their existing poor state of health. Again, I'd like to know how much benefit, if any, you think you/your household might get from this one, either now or in the future.":

### QUES 11a

SHOWCARD J. "So, how desirable or undesirable do you think it would be to live X months longer in that poor state of health? Please take your answer from the top half of this card.":

- A "very undesirable",
- B "fairly undesirable",
- C "fairly desirable",
- D "very desirable"

### QUES 11b

SHOWCARD J. "How likely or unlikely do you think it is that you {or any named member of household} will suffer from heart or lung disease when you/they are elderly? Please take your answer from the bottom half of this card.":

- A "very unlikely",
- B "quite unlikely",
- C "quite likely",
- D "very likely",
- E "Can't say"

### QUES 11c

SHOWCARD K. "So, if it were possible to reduce the bad air days that might bring death forward by X months for elderly people in poor health, how much benefit would that be to you/your household?":

- A "No benefit at all",
- B "A very small benefit",
- C "A small benefit",
- D "Quite a big benefit",
- E "A very big benefit"

### QUES 12

"Now let's look at this card." READ OUT SHOWCARD E-N AND HAND TO RESPONDENT.

"**{X=1/3/6} MONTHS MORE LIFE IN NORMAL HEALTH.** By reducing the general level of air pollution that causes wear and tear and faster ageing, everyone could live longer. That would mean that you {and everyone else in your household} could expect to live about X months longer in your {their} normal state of health. Again, I'd like to know how much benefit, if any, you think you/your household might get from this one, either now or in the future":

### QUES 12a

SHOWCARD L. "So, how desirable or undesirable do you think it would be for you {and everyone else in your household} to live X months longer in your/their normal state of health? Please take your answer from the top half of this card.":

- A "very undesirable",
- B "fairly undesirable",
- C "fairly desirable",
- D "very desirable"

## QUES 12b

SHOWCARD L. "So, if it were possible to reduce the general level of air pollution so that you {and everyone else in your household} could expect to live about X months longer in your/their normal state of health, how much benefit would that be to you/your household. Please take your answer from the bottom half of this card.":

- A "No benefit at all",
- B "A very small benefit",
- C "A small benefit",
- D "Quite a big benefit",
- E "A very big benefit"

### Explan3

"To bring about these possible benefits (POINT TO 4 E-SHOWCARDS), it would be necessary to further reduce the fumes and chemicals from traffic and factories, and encourage people to use cleaner fuels. This would probably put up prices for all kinds of everyday goods and therefore increase your/your household's cost of living.":

### Explan3a

"In a moment, I'm going to ask you whether or not you/your household would be willing to pay anything at all in the form of higher prices for any of these benefits, and, if so, how much you think they are worth. We shall be asking a large number of people the same questions, and if everyone answers for themselves, we will get a good picture of the views of the population as a whole. So, we would like you to focus just on the benefits to you {and each member of household by name} and not to answer on behalf of anyone else.":

### Explan4

"Sometimes when we ask people these questions they tell us how much they would like to pay if they could afford to. It is important to us to know how much, if anything, you **really** believe you **would** pay, given what you/your household can afford and how much benefit you think you/your household would actually get from them.":

## QUES 13

SHOWCARD M. "To help you think about this I would like you to tell me which one of these statements best describes your/your household's situation as regards money.":

- A "We normally have enough money for anything we want",
- B "We have enough money, so long as we plan our spending carefully",
- C "We have enough money for basic things, but we can't afford anything unnecessary",
- D "Sometimes it is hard for us to afford even basic things we need"

### QUES 13Int

“Now, to help you think about how much benefit you/your household would get, I would like to recap some of your earlier answers.”:

### QUES 13a

INTERVIEWER: POINT TO E-D (AVOIDING 2 OR 3 DAYS...) “You said you thought it would be {whatever they said earlier} to experience this kind of discomfort. You also thought it {whatever they said earlier} that you/some member of your household will experience such days of breathing discomfort in the future. So overall, you thought that reducing the bad air days that cause some people 2 or 3 days of breathing discomfort every year would be {whatever they said earlier} to you/your household.” INTERVIEWER: SELECT APPROPRIATE WHITE LABEL AND PLACE ON E-D. “So I’m going to put this label on that card.” INTERVIEWER: IF RESPONDENT DOES NOT ASK TO CHANGE, RECORD 'Did Not Change' BELOW. BUT IF RESPONDENT ASKS TO CHANGE, RECORD NEW ASSESSMENT (2-6) BELOW AND CHANGE LABEL ON E-D ACCORDINGLY:

DNC “Did Not Change”,  
NBAA “No Benefit At All”,  
AVSB “A Very Small Benefit”,  
ASB “A Small Benefit”,  
QABB “Quite A Big Benefit”,  
AVBB “A Very Big Benefit”

### QUES 13b

INTERVIEWER: POINT TO E-H (AVOIDING HOSPITAL...). “You said you thought it would be {whatever they said earlier} to experience such an admission to hospital. You also thought {whatever they said earlier} that you/some member of your household will ever need to be admitted to hospital in the future because of breathing difficulties. So overall, you thought that reducing the bad air days that cause some people to require such an admission would be {whatever they said earlier} to you/your household.” INTERVIEWER: SELECT APPROPRIATE WHITE LABEL AND PLACE ON E-H. “So I’m going to put this label on that card.” INTERVIEWER: IF RESPONDENT DOES NOT ASK TO CHANGE, RECORD 'Did Not Change' BELOW. BUT IF RESPONDENT ASKS TO CHANGE, RECORD NEW ASSESSMENT (2-6) BELOW AND CHANGE LABEL ON E-H ACCORDINGLY:

DNC “Did Not Change”,  
NBAA “No Benefit At All”,  
AVSB “A Very Small Benefit”,  
ASB “A Small Benefit”,  
QABB “Quite A Big Benefit”,  
AVBB “A Very Big Benefit”

### QUES 13c

INTERVIEWER: POINT TO E-P (X MONTHS MORE LIFE IN POOR HEALTH WHEN ELDERLY). "You said you thought it would be {whatever they said earlier} to live X months longer in that poor state of health. You also thought {whatever they said earlier} that you/some member of your household will suffer from heart or lung disease when elderly. So overall, you thought that reducing the bad air days that might bring death forward by about X months for elderly people in poor health would be {whatever they said earlier} you/your household." INTERVIEWER: SELECT APPROPRIATE WHITE LABEL AND PLACE ON E-P. "So I'm going to put this label on that card." INTERVIEWER: IF RESPONDENT DOES NOT ASK TO CHANGE, RECORD 'Did Not Change' BELOW. BUT IF RESPONDENT ASKS TO CHANGE, RECORD NEW ASSESSMENT (2-6) BELOW AND CHANGE LABEL ON E-P ACCORDINGLY:

DNC "Did Not Change",  
NBAA "No Benefit At All",  
AVSB "A Very Small Benefit",  
ASB "A Small Benefit",  
QABB "Quite A Big Benefit",  
AVBB "A Very Big Benefit"

### QUES 13d

INTERVIEWER: POINT TO E-N (X MONTHS MORE LIFE IN NORMAL HEALTH). "You said you thought it would be {whatever they said earlier} if you {and everyone else in your household} could live about X months longer in normal health as a result of reducing the general level of air pollution, and that this would be {whatever they said earlier} to you/your household." INTERVIEWER: SELECT APPROPRIATE WHITE LABEL AND PLACE ON E-N. "So I'm going to put this label on that card." INTERVIEWER: IF RESPONDENT DOES NOT ASK TO CHANGE, RECORD 'Did Not Change' BELOW. BUT IF RESPONDENT ASKS TO CHANGE, RECORD NEW ASSESSMENT (2-6) BELOW AND CHANGE LABEL ON E-N ACCORDINGLY:

DNC "Did Not Change",  
NBAA "No Benefit At All",  
AVSB "A Very Small Benefit",  
ASB "A Small Benefit",  
QABB "Quite A Big Benefit",  
AVBB "A Very Big Benefit"

### QUES 14

"So, if you {and each member of household by name} could get all four of these things (POINT TO FOUR E-SHOWCARDS) do you think it would be worth paying at least something in the form of higher prices each year, or do you think that none of these is worth paying anything at all for?":

W "Worth paying something" If answer is W, go to Explan5.  
NW "Not worth anything" If answer is NW, go to Ques 14a.

## QUES 14a

SHOWCARD N. "Which of the statements on this card best describes why you would not be prepared to pay anything for any of these?":

- A "These things are of no value to me (or anyone else in my household)",
- B "I (my household) cannot afford anything at all for these things",
- C "I (we) would rather spend our money on other things",
- D "The money should come from existing taxes",
- E "The costs should be paid by whoever causes the air pollution",
- F "I don't believe that reductions in air pollution will produce these results",
- G "Some other reason"

If Ques 14a has been answered, go straight to socio-economic questions.

## Explan5

"To help you decide the most you would be willing to pay in the form of higher prices to get them, I will ask you to sort some cards. LAY OUT TEMPLATE AND PICK UP MONEY CARDS. Each of these cards shows an amount in red that you might pay each year and, in blue, what that would work out at each month. I'm going to shuffle the cards so that they're in no particular order. Then I would like you to look at them one at a time and decide whether or not it would be worth paying that amount **every year for the rest of your life** for all four benefits. Each time I show you a card, I will give you an estimate of how much that would add up to over the rest of your life, based on the average for someone of your age and gender.":

## QUES 15 {1}

SHUFFLE MONEY CARDS AND TURN OVER THE TOP CARD. RECORD AMOUNT SHOWN ON THE TOP CARD PER YEAR:

- A "£1",
- B "£2.50",
- C "£5",
- D "£10",
- E "£25",
- F "£50",
- G "£100",
- H "£250",
- I "£500",
- J "£1000",
- K "£2500",
- L "£5000"

### QUES 16 {1}

“The first card is {whatever they turned over} per year. For someone of your age and gender, that would add up to a total of about {whatever it comes to} over the rest of your life. So, if it was going to cost you that amount for you/your household to get all four of these (POINT TO ALL FOUR CARDS), do you think you certainly **would** be willing to pay that, certainly **would not** be willing to pay that, or are you undecided?” INTERVIEWER: PLACE CARD IN APPROPRIATE SPACE ON THE TEMPLATE.

***THIS PROCEDURE IS REPEATED UNTIL ALL CARDS ARE SORTED***

### QUES 17

INTERVIEWER: WHEN ALL SORTED, RECORD HIGHEST **YEARLY** AMOUNT IN **WOULD** PAY PILE:

- A “£1”,
- B “£2.50”,
- C “£5”,
- D “£10”,
- E “£25”,
- F “£50”,
- G “£100”,
- H “£250”,
- I “£500”,
- J “£1000”,
- K “£2500”,
- L “£5000”

### QUES 17a

WHEN ALL SORTED, RECORD LOWEST **YEARLY** AMOUNT IN **WOULD NOT** PAY PILE.

INTERVIEWER: IF **NO** CARD IN WOULD NOT PAY PILE, ENTER '13':

- A “£1”,
- B “£2.50”,
- C “£5”,
- D “£10”,
- E “£25”,
- F “£50”,
- G “£100”,
- H “£250”,
- I “£500”,
- J “£1000”,
- K “£2500”,
- L “£5000”,
- 13 “WOULD NOT PAY PILE EMPTY”

## QUES 18

"The most you said you were certain about was {whatever they said earlier} each year. For a person of your age and gender, that would come to a total of about {whatever it comes to} over the rest of your life. Bearing in mind what you can afford, and how much benefit you think you/your household would get from these things, does that seem about right to you or is it too much or too little?":

- Y "About right" If Y, go to
- N "Too much/too little" If N, go to Ques 18a

## QUES 18a

"What do you think is the most you really would be prepared to pay for all four? It does not have to be an amount shown on any particular card." RECORD RESPONSE PER YEAR OR OVER LIFETIME.":

- PYear "Per Year"
- LTime "Lifetime"

## QUES 18b

"For a person of your age, that would come to {feed back implication of answer to Ques 18a}. Does that seem about right to you?":

**REPEATED UNTIL RESPONDENT IS SATISFIED**

## Explan6

"You've just said that you would be willing to pay {whatever they settled on} per year for all four of these (POINT TO ALL FOUR E-CARDS). Now I'd like to know how you would divide that amount between them.":

## QUES 19

"First, can you tell me which one of the four you think is worth the most to you/your household?":

- A "E-N",
- B "E-P",
- C "E-H",
- D "E-D"

### QUES 19a

"How much of the £{annual total amount} would you put towards that one?" RECORD AMOUNT THEN TURN E SHOWCARD FACE DOWN:

### QUES 20

"Now, can you tell me which one of the remaining three you think is the next most valuable to you/your household?":

RESPONDENT CHOOSES FROM REMAINING FACE UP E SHOWCARDS, AND THAT IS RECORDED.

### QUES 20a

"How much of the £{amount left after response to 19a subtracted from total} that is left would you put towards that one?" RECORD AMOUNT THEN TURN CARD FACE DOWN.

### QUES 21

"Now can you tell me which of the remaining two you think is the next most valuable to you/your household?":

RESPONDENT CHOOSES FROM REMAINING FACE UP E SHOWCARDS, AND THAT IS RECORDED.

### QUES 21a

"How much of the £{remainder} that is left would you put towards that one?" RECORD AMOUNT THEN TURN CARD FACE DOWN:

### QUES 22

INTERVIEWER: RECORD THE ONE THAT IS LEFT.

### QUES 22a

"Does that mean you would put £{whatever money is left} towards the one that is left?":

Yes

No If No, routed to redo exercise

**IF THE MONEY REMAINING RAN OUT BEFORE ALL E SHOWCARDS HAD BEEN TURNED OVER, THE INTERVIEWER CHECKED THAT THE RESPONDENT DID INDEED WANT TO SIGNIFY A ZERO VALUE TO THOSE CARDS STILL FACE UP. IF THEY DID, ZEROS WERE RECORDED. IF THEY DID NOT, THEY WERE ROUTED TO REDO THE EXERCISE.**

## QUES 23

INTERVIEWER: TURN ALL THE CARDS OVER AND POINT TO EACH AS YOU READ OUT THE AMOUNT. "So the total comes to {whatever they settled on}. That breaks down as follows:

X MONTHS MORE LIFE IN NORMAL HEALTH {insert amount assigned}

X MONTHS MORE LIFE IN POOR HEALTH WHEN ELDERLY {insert amount assigned} AVOIDING ADMISSION TO HOSPITAL WITH BREATHING DIFFICULTIES {insert amount assigned}

AVOIDING 2 OR 3 DAYS OF BREATHING DISCOMFORT EVERY YEAR {insert amount assigned}

"Does that seem about right, or do you want to change any of your answers?":

Chng "Want to change" ***IN WHICH CASE, THEY WERE ABLE TO CHANGE TO WHATEVER INDIVIDUAL VALUES AND PERHAPS NEW TOTAL THEY WISHED, AND THESE WERE RECORDED.***

Crct "About right"

## Tables of responses within the main (Phase 2) study

TABLE 1a: AGE, GENDER AND SOCIAL CLASS OF RESPONDENTS  
(compared with 2001 Census or with 1999-2000 Family Expenditure Survey)

Age	Males		Females	
	Defra % (n = 286)	Census %	Defra % (n = 379)	Census %
16 to 29	8.4	22.8	12.4	21.2
30 to 44	28.3	29.1	26.1	27.7
45 to 59	28.7	24.4	25.1	23.0
60 to 74	23.4	16.4	21.9	16.7
75+	11.2	7.2	14.5	11.5
Social Class	All			
	Defra %	FES %		
Professional	20.9	25.6		
Managerial/Technical	16.8	20.8		
Skilled Non Manual	14.8	15.4		
Skilled Manual	20.2	16.0		
Semi-skilled Manual	15.0	11.6		
Unskilled Manual	12.3	10.6		

## Tables of reponses within the main (Phase 2) study

**TABLE 1b: OTHER RESPONDENT CHARACTERISTICS**

Houshold Size	Number	Percentage
1 Person	219	32.9%
2 Person	272	40.9%
3 Person	82	12.3%
4+ Person	92	13.8%
Household Income (gross per annum)		
<£15,000	292	43.9%
£15-30,000	172	25.9%
£30-60,000	92	13.8%
£60,000+	50	7.5%
Declined to answer	59	8.9%
Qualification Level <i>(2 respondents declined to provide details of their qualifications)</i>		
Degree level of equivalent	109	16.4%
Teaching or nursing qualification	32	4.8%
'A' levels or equivalent	66	9.9%
GCSE grades A-C or equivalent	97	14.6%
GCSE grades D-F or equivalent	42	6.3%
Recognised trade apprenticeship	38	5.7%
Clerical or commercial qualification	29	4.4%
No formal qualifications	208	31.3%
Other	45	6.8%

## Annex 3

**TABLE 2: PERCENTAGE OF RESPONDENTS WHO CONSIDER AIR POLLUTION A THREAT**

	Number	Percentage
Consider air pollution the biggest threat to health	100	15.0%
Consider air pollution the second biggest threat to health	116	17.4%
Consider air pollution the third biggest threat to health	124	18.7%
Total who consider air pollution a threat	340	51.1%

**TABLE 3: RESPONDENTS WITH FIRST HAND EXPERIENCE OF HOSPITAL ADMISSIONS DUE TO BREATHING DIFFICULTIES**

Person admitted to hospital with Breathing Difficulties	Number	Percentage
Self	43	6.5%
Partner	10	1.5%
Parent	2	0.3%
Child	21	3.2%
Other	3	0.45%
Total	79	11.9%

**TABLE 4: RESPONDENTS WITH FIRST HAND EXPERIENCE OF OCCASIONAL DAYS OF BREATHING DISCOMFORT**

Person with Breathing Difficulties	Number	Percentage
Self	144	21.7%
Partner	51	7.7%
Parent	3	0.45%
Child	56	8.4%
Other	3	0.45%
Total	257	38.7%

## Tables of reponses within the main (Phase 2) study

**TABLE 5: RESPONSES TO QUESTIONS ABOUT THE UNPLEASANTNESS/ LIKELIHOOD OF SUFFERING FROM OCCASIONAL DAYS OF BREATHING DISCOMFORT**

How unpleasant do you think it would be to experience this kind of discomfort? (5 respondents declined to provide a rating)	Number	Percentage
Not at all unpleasant	21	3.2%
A little unpleasant	70	10.6%
Quite unpleasant	210	31.8%
Very unpleasant	359	54.4%
How likely or unlikely do you think it is that you or any member of your household will experience such days of breathing discomfort in the future? (5 respondents declined to provide a rating)		
Very unlikely	139	21.1%
Quite unlikely	177	26.8%
Quite likely	219	33.2%
Very likely	101	15.3%
Can't say	24	3.6%
If it were possible to reduce the bad air days that cause 2-3 days/ year of breathing discomfort, how much benefit would that be to your household? (3 respondents declined to provide a rating)		
No benefit at all	115	17.4%
A very small benefit	72	10.9%
A small benefit	156	23.6%
Quite a big benefit	197	29.8%
A very big benefit	122	18.4%

## Annex 3

**TABLE 6: RESPONSES TO QUESTIONS ABOUT THE UNPLEASANTNESS/ LIKELIHOOD OF BEING ADMITTED TO HOSPITAL WITH BREATHING DIFFICULTIES**

How unpleasant do you think it would be to experience such an admission to hospital? <i>(3 respondents declined to provide a rating)</i>	Number	Percentage
Not at all unpleasant	16	2.4%
A little unpleasant	52	7.9%
Quite unpleasant	196	29.6%
Very unpleasant	398	60.1%
How likely or unlikely do you think it is that you or any member of your household will ever need to be admitted to hospital in the future because of breathing difficulties? <i>(3 respondents declined to provide a rating)</i>		
Very unlikely	152	23.0%
Quite unlikely	235	35.5%
Quite likely	192	29.0%
Very likely	52	7.9%
Can't say	31	4.7%
If it were possible to reduce the bad air days that cause hospital admissions, how much benefit would that be to your household? <i>(4 respondents declined to provide a rating)</i>		
No benefit at all	108	16.3%
A very small benefit	89	13.5%
A small benefit	140	21.2%
Quite a big benefit	189	28.6%
A very big benefit	135	20.4%

## Tables of reponses within the main (Phase 2) study

**TABLE 7: RESPONSES TO QUESTIONS ABOUT THE DESIRABILITY/ LIKELIHOOD/ BENEFITS OF GAINING LIFE EXPECTANCY WHEN ELDERLY AND IN POOR HEALTH**

How desirable or undesirable do you think it would be to live longer in that poor state of health? <i>(14 respondents declined to provide a rating)</i>	Number	Percentage
Very undesirable	239	36.7%
Fairly undesirable	206	31.6%
Fairly desirable	112	17.2%
Very desirable	94	14.4%
How likely or unlikely do you think that it is that you or any other member of your household will suffer from heart or lung disease when elderly? <i>(4 respondents declined to provide a rating)</i>		
Very unlikely	86	13.0%
Quite unlikely	180	27.2%
Quite likely	247	37.4%
Very likely	85	12.9%
Can't say	63	9.5%
If it were possible to reduce bad air days that might bring death forward for elderly people in poor health, how much benefit would that be to your household? <i>(4 respondents declined to provide a rating)</i>		
No benefit at all	180	27.2%
A very small benefit	84	12.7%
A small benefit	139	21.0%
Quite a big benefit	156	23.6%
A very big benefit	102	15.4%

## Annex 3

**TABLE 8: RESPONSES TO QUESTIONS ABOUT THE DESIRABILITY/ BENEFITS OF GAINING LIFE EXPECTANCY IN NORMAL HEALTH**

How desirable or undesirable do you think it would be for you (and all other household members) to live longer in your (their) normal state of health? (6 respondents declined to provide a rating)	Number	Percentage
Very undesirable	42	6.4%
Fairly undesirable	18	2.7%
Fairly desirable	106	16.1%
Very desirable	493	74.8%
If it were possible to reduce the general level of air pollution so that you could expect to live longer in you normal state of health, how much benefit would that be to your household? (5 respondents declined to provide a rating)		
No benefit at all	24	3.6%
A very small benefit	25	3.8%
A small benefit	55	8.3%
Quite a big benefit	166	25.2%
A very big benefit	390	59.1%

**TABLE 9: DISCRETIONARY INCOME**

Which one of these statements best describes your/your household's situation as regards money? (5 respondents declined to answer)	Number	Percentage
Normally have enough money for anything we want.	134	20.3%
We have enough money, so long as we plan our spending carefully.	335	50.8%
We have enough money for basic things, but we can't afford anything unnecessary.	140	21.2%
Sometimes it is hard for us to afford even the basic things we need.	51	7.7%

## Tables of reponses within the main (Phase 2) study

**TABLE 10: FREQUENCY OF, AND REASONS FOR, ZERO WILLINGNESS TO PAY RESPONSES**

Initial response to WTP question	Number	Percentage
Worth paying something	477*	71.7%
Not worth paying anything	184	27.7%
Declined to provide an answer	4	0.6%
<b>Total</b>	<b>665</b>	
<b>Reasons for not paying</b>		
These things are of no value to me (or anyone else in my household)	17	9.2%
I (my household) cannot afford anything at all for these things	23	12.5%
I (we) would rather spend our money on other things	6	3.3%
The money should come from existing taxes	50	27.2%
The costs should be paid by whoever causes the air pollution	70	38.0%
I don't believe that reductions in air pollution will produce these results	9	4.9%
Some other reason	9	4.9%
<b>Total</b>	<b>184</b>	

*\*6 of these respondents later declined to provide a positive WTP response, leaving a sample of 471 respondents who stated a positive WTP for the package of four benefits*

TABLE 11: T-TEST RESULTS SUMMARY

### WTP for increasing life expectancy in normal health versus poor health

**Null hypothesis:** amounts allocated to increases in life expectancy in normal health (N) are not significantly higher than the amounts allocated to increases of the same magnitude in poor health (P)

This null hypothesis can be rejected where T is found to be greater than 1.645 (\*\* $p < .05$ , one-tailed) or 1.282 (\* $p < .10$ , one-tailed)

No. Trimmed	1 month	3 months	6 months
Untrimmed	4.7272**	2.5375**	4.3751**
2	4.9317**	3.4717**	4.5951**
4	5.2199**	7.7428**	6.8955**
6	5.2572**	8.0788**	6.9139**

### WTP for avoiding admission to hospital versus avoiding days of breathing discomfort

**Null hypothesis:** amounts allocated to avoiding a respiratory hospital admission (H) are not significantly different from the amounts allocated to avoiding 2-3 days per year of breathing discomfort (D)

This null hypothesis can be rejected where T is found to be greater than 1.96 (\*\* $p < .05$ , two-tailed) or 1.645 (\* $p < .10$ , two tailed).

No. Trimmed	H vs. D (1 month version)	H vs. D (3 month version)	H vs. D (6 month version)
Untrimmed	0.0783	-0.3732	-0.5284
2	0.0348	0.5189	0.9359
4	-0.4290	0.6119	0.2165
6	-0.4527	0.9228	0.3319

TABLE 12: BIVARIATE CORRELATION MATRIX

Variables:

- **PERCAP:** Per capita income (i.e., total household income divided by the number of people in the household)
- **AGE:** The age of the respondent
- **GENDER:** Whether the respondent was male or female – coded as 1 for males and 2 for females.
- **HHSIZE:** The number of people in the household (S in the expressions above)
- **NUMMONTH:** The number of extra months of life expectancy gained per person in the household
- **NUMCHILD:** The number of children (under 16) in the household
- **EXPER:** This variable gives a sum of the number of “yes” responses to the three questions about whether any relative or member of their household had had experience of heart/ lung disease when elderly (Q5), respiratory hospital admission (Q6) or days of breathing discomfort (Q9).
- **IMPORT:** Whether the respondent has identified air pollution as one of the three biggest threats to their health (coded as 0 - not identified, 1-identified as 3<sup>rd</sup> biggest threat, 2-identified as 2<sup>nd</sup> biggest threat, 3-identified as 1<sup>st</sup> biggest threat).
- **STARTCARD:** The value on the first ‘shuffle’ card shown to those who said they would pay something and recorded some positive WTP. Of course, those who gave non-protest zero WTP responses were not presented with a first card and were recorded as ‘missing values’ for this variable. In order not to lose those respondents (and thereby run the risk of biasing the results by omitting 46 genuine zeros), we substituted the average start card value for those respondents.
- **LIKELY-P/H/D** - The rating the respondent gave to the questions which asked them to rate how likely or unlikely they thought it was that they or the named members of their household would suffer from heart or lung disease when elderly (LIKELY-P) or experience either days of breathing discomfort (LIKELY-D) or a respiratory hospital admission (LIKELY-H) in the future.

Table 12 (page 1 of 2)

	WTP-N	WTP-P	WTP-H	WTP-D	PERCAP	AGE	GENDER	HHSIZE	NUM MONTH	NUM CHILD	EXPER	IMPORT	START CARD
WTP-P r p (2-tailed) N	.120 .006 517												
WTP-H r p (2-tailed) N	.259 .000 517	.369 .000 517											
WTP-D r p (2-tailed) N	.429 .000 517	.149 .001 517	.378 .000 517										
PERCAP r p (2-tailed) N	.197 .000 487	.137 .002 487	.234 .000 487	.126 .005 487									
AGE r p (2-tailed) N	-.053 .227 517	-.005 .903 517	.022 .614 517	-.037 .405 517	-.025 .578 487								
GENDER r p (2-tailed) N	-.065 .143 517	.039 .375 517	-.016 .712 517	-.005 .911 517	-.116 .011 487	-.043 .333 517							
HHSIZE r p (2-tailed) N	.129 .003 517	.012 .778 517	.005 .916 517	.136 .002 517	-.223 .000 487	-.317 .000 517	.095 .031 517						
NUMMONTH r p (2-tailed) N	.065 .140 517	.001 .983 517	-.012 .787 517	.021 .626 517	.012 .789 487	.006 .899 517	.040 .367 517	.013 .767 517					

Tables of reponses within the main (Phase 2) study

Table 12 (page 2 of 2)

	WTP-N	WTP-P	WTP-H	WTP-D	PERCAP	AGE	GENDER	HHSIZE	NUM MONTH	NUM CHILD	EXPER	IMPORT	START CARD
NUMCHILD r p (2-tailed) N	.069 .115 517	-.005 .903 517	-.014 .748 517	.071 .105 517	-.227 .000 487	-.407 .000 517	.117 .008 517	.783 .000 517	.002 .957 517				
EXPER r p (2-tailed) N	.072 .106 511	-.043 .331 511	.042 .339 511	.092 .038 511	-.164 .000 481	-.043 .328 511	.103 .020 511	.173 .000 511	-.057 .198 511	.106 .017 511			
IMPORT r p (2-tailed) N	.015 .743 488	-.002 .969 488	-.019 .680 488	.035 .438 488	-.021 .651 463	.222 .000 488	-.028 .533 488	-.004 .934 488	-.037 .412 488	-.036 .432 488	.132 .004 482		
STARTCARD r p (2-tailed) N	.142 .001 517	.181 .000 517	.079 .073 517	.095 .031 517	-.014 .761 487	.010 .819 517	.029 .510 517	.024 .594 517	.075 .091 517	.021 .641 517	.038 .398 511	-.032 .480 488	
LIKELY-P r p (2-tailed) N		.018 .689 516			-.070 .125 486	-.069 .115 516	.040 .366 516	.068 .124 516	-.011 .808 516	.021 .640 516	.306 .000 510	.052 .250 487	.040 .368 516
LIKELY-H r p (2-tailed) N			.099 .025 517		-.106 .019 487	-.127 .004 517	-.025 .568 517	.092 .036 517	.025 .564 517	.027 .539 517	.290 .000 511	.019 .674 488	.005 .919 517
LIKELY-D r p (2-tailed) N				.131 .003 516	-.111 .014 486	-.167 .000 516	.078 .076 516	.165 .000 516	-.005 .912 516	.098 .026 516	.397 .000 510	.115 .011 487	.011 .805 516

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