Willingness to pay to avoid health risks from road-traffic-related air pollution and noise across five countries

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HIGHLIGHTS

• WTP to avoid air pollution and noise effects substantially varied by country.
• Risk perceptions and environmental concerns affected WTP estimates.
• Perception and concern differences affected between-country differences in WTP.
• Air pollution WTP is higher than for noise if only qualitative information is given.
• WTP to avoid severe annoyance was higher than for 1/2 year change in life expectancy.

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ABSTRACT

We conducted a multi-country study to estimate the perceived economic values of traffic-related air pollution and noise health risks within the framework of a large European project. We used contingent valuation as a method to assess the willingness-to-pay (WTP) for both types of pollutants simultaneously. We asked respondents how much they would be willing to pay annually to avoid certain health risks from specific pollutants. Three sets of vignettes with different levels of information were provided prior to the WTP questions. These vignettes described qualitative general health risks, a quantitative single health risk related to a pollutant, and a quantitative scenario of combined health risks related to a pollutant. The mean WTP estimates to avoid road-traffic air pollution effects for the three vignettes were: €130 per person per year (pp/y) for general health risks, €80 pp/y for a half year shorter in life expectancy, and €330 pp/y to a 50% decrease in road-traffic air pollution. Their medians were €60 pp/y, €10 pp/y and €50 pp/y, respectively. The mean WTP estimates to avoid road-traffic noise effects for the three vignettes were: €90 pp/y for general health risks, €100 pp/y for a 13% increase in severe annoyance, and €320 pp/y for a combined-risk scenario related to an increase of a noise level from 50 dB to 65 dB. Their medians were €20 pp/y, €20 pp/y and €50 pp/y, respectively. Risk perceptions and attitudes as well as environmental and pollutant concerns significantly affected WTP estimates. The observed differences in crude WTP estimates between countries changed considerably when perception-related variables were included in the WTP regression models. For this reason, great care should be taken when performing benefit transfer from studies in one country to another.

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1. Introduction

The health risks of traffic-related air pollution (e.g., increased risks of heart attacks, the exacerbation of asthma among children, and reductions in life expectancy/LE) and noise (e.g., noise annoyance, sleep disturbance, hypertension, cardiovascular risks, and poorer school performance) have been extensively documented by a numerous epidemiological studies (Brunkreuf and Holgate, 2002; Hoek et al., 2002; World Health Organization, 2012, 2013; Basner et al., 2014). These health and wellbeing risks generate substantial costs for society (El-Fadel and Massoud, 2000; Kan and Chen, 2004; Zhang et al., 2007; Pascal et al., 2013) that are external to a large extent because they are not reflected in the market price of transportation or accounted for in the allocation of economic resources (Levy et al., 2010). It is increasingly recognised by the European Ministerial Conferences on Environment and Health and WHO that in order to effectively and efficiently manage environmental quality, it is necessary to take into account all costs and
benefits of alternative policy scenarios for use in rational planning procedures (Randall, 1986) and to develop ways to make them more transparent (World Health Organization, 2000). The assessment of willingness-to-pay (WTP) is a common approach to evaluate individual preferences and the prices of non-market goods such as environmental quality (Hoenenagel, 1994; U.S. Environmental Protection Agency, 2011).

Economic values of road-traffic-related air pollution and noise are often assessed using different instruments. The risks of air pollution are predominantly evaluated in terms of stated willingness-to-pay/WTP using contingent valuation (CV) approaches, whereas many noise studies assess revealed WTP, using hedonic price approaches (Navrud et al., 2006; Desaigues et al., 2011). The differences in the WTP estimation methodologies applied to air pollution and noise hamper the joint use and comparison of outcome data, particularly because the risks of these pollutants differ in nature and severity. Therefore, we simultaneously assessed the WTP for the risks of traffic-related air pollution and noise on health using one instrument and approach. We conducted this assessment within the EU-funded project, “Integrated Assessment of Health Risks from Environmental Stressors in Europe” (Briggs, 2008; Integrated Assessment of Health Risks of Environmental Stressors in Europe (INTARESE), 2009; Integrated Assessment of Health Risks of Environmental Stressors in Europe (INTARESE), 2012).

Our research questions were: i) How much are people willing to pay to avoid health risks from road-traffic-related air pollution and noise? ii) Which determinants were associated with the WTP for these health risks? and iii) What are the differences in WTP values across countries?

The determinants of interest were i) demographic and socioeconomic factors including those cited in the economics literature such as household income, gender and education (Thompson, 1986; Robinson, 1993; O’Brien and Viramontes, 1994; Blumschein and Johannesson, 1998; Diener et al., 1998; Ready et al., 2004; Van Doorslaer et al., 2006); ii) factors identified in the public health literature, i.e. the severity of health risks, familiarity with the risks, and current health status (Fischer et al., 1991; Blumschein and Johannesson, 1998; Van Doorslaer et al., 2006; Lloyd et al., 2008); and iii) factors identified in the social sciences literature (i.e. aspect of risk perception, such as familiarity and level of awareness of the risks, level of concern regarding environmental health risks, and perceived level of exposure) which are based on respondents point of view and are, therefore, subjective in nature. This latter set of determinants is not typically included in WTP studies of environmental health risks; however, these factors are considered important in the social sciences for obtaining value preferences (Fischhoff and Furby, 1988; Johnson and Sovic, 1995; El-Fadel and Massoud, 2000). Therefore, we considered them to be of potential interest given their relationships to the perception and acceptability of risks. We drafted four hypotheses based on the (social sciences) literature, to guide our statistical analyses:

- People who are well aware of the health effects of road-traffic air pollution and noise have a higher WTP.
- People who report to be very concerned about the environment in general, and/or very concerned about the effects of air pollution and/or noise specifically, have higher WTP.
- People who report to be very annoyed by road-traffic air pollution or noise provide higher WTP.
- People who report to be highly sensitive towards the effects of air pollution and/or noise, and/or have difficulty relaxing in polluted or noisy places, provide higher WTP.

2. Materials and methods

A web-based questionnaire survey was carried out in December 2010 in the United Kingdom (UK), Finland (FI), Germany (GE), the Netherlands (NL) and Spain (SP).

2.1. Study population

An external survey agency (Blauw Research, ISO9001&ISO20252 certified) recruited respondents through their existing population panels in the five countries. Panelists were invited to participate through the regular panel procedures (e-mail) and received a personal login code and password to fill in the web-based questionnaire. By weighting on age, sex and education, the sampling was representative for the population of the specified countries, aged 18 to 64 years old. We aimed at 2000 respondents per country.

2.2. The questionnaire: determinants of interests

The questionnaire consisted of the three main groups of questions, reflecting our determinants of interest. These are: i) demographical and social-economic factors, recognised in the economics literature and others, i.e. household income, gender, education, ii) factors from the public health domain i.e. familiarity with the (severe) health effects, current health status, and iii) factors from the social sciences domain, i.e. familiarity, attitude and perception of risks, level of awareness, level of concern of environmental health effects, perceived level of exposure. Where possible, we followed widely applied and standardised questions and scales. We made two versions of the questionnaire to limit size and cognitive burden to the respondents; one version is focusing on road traffic-related air pollution and the other on road traffic-related noise. Questionnaires on air pollution or noise were randomly assigned to respondents, i.e. respondents were provided with either WTP questions on air pollution or noise. First questions on general WTP were followed by a series of questions on the health gain in specific effects of air pollution or noise related to a specific pollutant reduction. See Appendix B for the wording of these questions.

Before addressing the WTP questions, respondents received questions on their perceived health. This was based on the standardised and validated Health Survey RAND-36 (Hays et al., 1993) to obtain general health score. In this part, respondent’s concern regarding the specific pollutant was also addressed. In the second part of the questionnaire, a brief description of the health effects related to road traffic air pollution and noise was provided. We only presented main health effects for which authoritative reviews indicate sufficient scientific evidence related to the pollutants. The third part of the questionnaire assessed social–demographic information such as age, gender, education, household net income per month, and respondent’s level of environmental concerns.

Three vignettes were used for the brief descriptions in the second part of the questionnaire. The first was a generic qualitative description of the health effects for which there is sufficient evidence in the literature. This addresses the “naïve” understanding of respondents of the health effects. For air pollution, these were risk for hospital admission for cardiovascular- and respiratory diseases, reduction of life expectancy, and risk for doctor-diagnosed asthma in young children. For noise effects, these were risks for heart attacks, severe sleep disturbance, severe annoyance, and poorer reading performance in children. We also assessed whether respondents were aware of these health effects. The second vignette was a quantitative description of a single specific health effect, in line with other recent WTP studies on air pollution and noise (Bue Bjorn, 2004; Wang and Mullaly, 2006; Riethmüller et al., 2008; Li et al., 2009; Desaigues et al., 2011). This addressed the current scientific practice of pollution emissions by 2030 that was related to half a year gain in average life expectancy. For air pollution, it explained that a 50% decrease in the air pollution emissions by 2030 was related to half a year gain in average life expectancy. For road traffic noise, an increase from 50 dB to 65 dB meant an increase of
13% to become severely annoyed by noise according to the exposure–response relation (Miedema and Oudshoorn, 2001).

The third vignette was a quantitative description of a scenario of combined effects that would happen simultaneously if a certain policy (50% change in air pollution levels, and 50 to 65 dB change in noise levels) would be implemented (a more policy-oriented approach). A set of quantitative changes in risk for the health effects was described in the general description. The wording of these three vignettes is provided in Appendix A.

Respondents were provided with the option “I don’t know” as an answer to the questions about WTP amounts to avoid giving an irrelevant answer or for the sake of going to the next questions. If respondents answered €0 on the WTP general questions, follow-up questions were asked about their motive for the zero response. Options for these follow-up questions were: i) costs should be included in transportation prices; ii) government should pay all costs to reduce air pollution; iii) effects of air pollution from road traffic are negligible; (iv) principally against putting amount of money on health; and v) other reasons. Options i), ii), and iv) of these follow-up questions, combined with the WTP of €0, were used to identify a protest vote (PV), an answer indicating that respondents did not accept the concept of WTP.

The questionnaire was first pre-tested on length and comprehensibility by colleagues and by professionals from the survey agency. Then, the questionnaire was translated into the languages of participating countries. Subsequently, the translations were checked by native speakers on translation and comprehensibility (project members of the INTARESE project). Finally, the questionnaire was pre-tested in 10% of the samples in the main study. At the end of the questionnaire, respondents could provide their feedback. The pre-test indicated that a) many respondents volunteered that this was an important topic to address, and b) many respondents indicated that the WTP questions were difficult to answer. These observations have strengthened us in our view that respondents should be given an option to give a “don’t know”-answer to the WTP questions.

2.3. Payment vehicle

The manner in which the payment of the WTP amount is made, including the timing and duration of the payment, is known as the payment vehicle. This study applied an out-of-pocket voluntary payment vehicle. We asked respondents their annual contribution for the rest of their lives. For example: “A 50% decrease in air pollution emissions by 2030 will increase life expectancy by 6 months. What is the maximum amount of money you would be willing to pay (annually, for the rest of your life) to gain 6 months of life expectancy? The maximum amount of money I am willing to pay is... € or £ per year”. The conversion from Pounds to Euros was based on 2010 exchange rate. Respondents were reminded to take their annual household net income into account prior to answering the WTP question what they as a person would be willing to pay.

2.4. Data analyses

After data cleaning, recoding and explorative descriptive analyses, we applied a 1.5% cut-off point for WTP values as default, to avoid unrealistically high values for WTP. This cut-off is similar to values reported in the literature; this roughly corresponds to a cut-off based on expendable income of €3000 per person/month (Desaigues et al., 2011). Thus, all reported means and medians are trimmed. In addition, we excluded ‘Protest votes’ and ‘Don’t know’ responses. For the UK, we converted the values of the national currency into Euros. WTP values are presented in € per person per year (€ pp/p). To analyse the determinants of the WTP estimates, we constructed two multivariate linear regression (basic and extended) models for the three WTP estimate levels: generic, specific risk, and combined risk scenarios. The basic model consisted of variables that have been frequently identified as significant in the literature (i.e., age, gender, years of education, country, income and health score). To the basic model, we added perception-related variables to construct the extended model. This extended model consisted of awareness of the increased health risks associated with road-traffic-related air pollution/noise, their environmental concern, severe concern regarding the health risks of air pollution/noise, annoyance due to air pollutants/noise, constant freight traffic, sensitivity to road-traffic air pollution/noise, difficulty relaxing in a location with air pollution/noise, confidence in the government to reduce road-traffic air pollution/noise, and opinions concerning policy attempts to reduce road-traffic air pollution/noise and improve the wellbeing of residents. The extended models were used to test our hypotheses presented in the Introduction, about the role of risk perception aspects.

The 11-point scale for the level of annoyance was dichotomised into “very annoyed” or “not annoyed”; scores of 8–10 were categorised as “very annoyed”, following the ISO convention (ISO/TS 15666:2003). This was also the case for annoyance by air pollution, and the level of concern by noise and air pollution. The 5-point scale for the perception-related variables was converted into smaller “agree, neutral, or disagree” or “yes or no” scales. The 3-point awareness scale was converted into a “yes or no” scale in which those who selected “very much aware” were categorised as “yes”. Since the percentages were rounded in this study, summing percentages (%) may not add up to 100%. All of our analyses were performed with IBM Statistics SPSS Version 19.

3. Results

There were 10,464 responders participating in the web-survey. Respondents in the air pollution module (N = 5243) and those in the noise module (N = 5251) came from similar socio-demographic backgrounds in terms of age, sex, net household income, financial position, and years of education. According to the follow-up questions to €0 responses, approximately 10% of the participants were unwilling to provide monetary values (i.e., a “protest response”). The primary reasons provided for registering a protest response to the WTP question regarding reduced air pollution were (i) these costs should be included in transportation prices (30%); (ii) the government should pay all costs to reduce air pollution (30%); and (iii) principally opposition to assigning a monetary value to health (20%). With regard to noise, these figures were (i) 26%, (ii) 33%, and (iii) 20%, respectively. Approximately 50% answered, “I don’t know”; these don’t know responses are described in greater detail elsewhere. After excluding respondents who provided ‘Protest votes’ and ‘Don’t know’ responses and applying the 1.5% cut-off point for WTP values, 2458 respondents in the air pollution module and 2426 respondents in the noise module remained. Table 1 describes the prevalence of the health-, environmental-, attitude-, and perception-related factors per country.

Several noteworthy differences between countries were observed regarding the perception and attitude indices. For example, compared with respondents from other countries, the Dutch were the least concerned with the environment in general as well as air pollution and noise specifically and the least annoyed at home by road-traffic air pollution and noise. Moreover, they had the lowest perceived sensitivity to pollutants, the least difficulty relaxing in polluted location, and agreed significantly more often with the statement that the government had done its best to reduce air and noise pollutants. The citizens of other countries exhibited specific differences relative to the Dutch. Finnish respondents stated that they had the busiest freight traffic near dwellings (between two and four times greater than the Dutch). Spaniards had the greatest environmental concern (nearly three times higher) and were more concerned about road-traffic-related air pollution and noise (nearly five to seven times greater). Moreover, they perceived themselves as more sensitive to air pollution and noise risks (nearly three times higher), felt the most annoyed by road-traffic-related air pollution and noise, and found their lives would be severely affected by traffic noise (nearly three to ten times greater).
pollution and noise (approximately ten times higher), and experienced the greatest difficulty relaxing in polluted or noisy locations.

3.1. WTP across different vignettes

Figs. 1 and 2 show the boxplots of WTP estimates for air pollution and noise by countries respectively. Noticeable differences were observed regarding the WTP estimates across pollutants and countries. Table 2 presents the mean and median WTP estimates.

WTP for the general risks of air pollution was higher than for noise, WTP to avoid specified effect for noise (severe annoyance) was higher than for air pollution (life expectancy), and WTP for the combined scenarios was similar for both pollutants. The country that provided the highest and the lowest WTP estimates for air pollution risks differed for each vignette. For noise, Finland had the highest WTP estimates for all three vignettes, while the Netherlands provided the lowest (except for the specific effect).

3.2. Air pollution: determinants of general, LE, and combined scenario WTP estimates

The results of the WTP regression analysis for road-traffic-related air pollution risks are presented in Table 3. This table shows the regression coefficients that are expressed as percentage in change in WTP value. We estimated WTP changes using the basic and extended models for general risks, a specific effect (6 month reduction in LE), and a scenario of combined risks. For example, 25- to 34-year-old respondents had 47% lower WTP estimates in the general basic model and in the general extended model, whereas the WTP estimates for the same age group were

Table 1

Health-, environment-, attitude-, and perception-related factors regarding road-traffic-related air pollution and noise by country. The numbers indicate the percentage of people who responded positively, except perceived general health scores (ranging from 0 to 100).

<table>
<thead>
<tr>
<th></th>
<th>NL</th>
<th>UK</th>
<th>DE</th>
<th>ES</th>
<th>FI</th>
<th>Pooled data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness of health risks</td>
<td>69</td>
<td>24</td>
<td>67</td>
<td>28</td>
<td>58</td>
<td>46</td>
</tr>
<tr>
<td>Environmental concern</td>
<td>68</td>
<td>32</td>
<td>32</td>
<td>29</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>EC: low</td>
<td>38</td>
<td>43</td>
<td>32</td>
<td>28</td>
<td>29</td>
<td>11</td>
</tr>
<tr>
<td>EC: medium</td>
<td>38</td>
<td>34</td>
<td>32</td>
<td>34</td>
<td>33</td>
<td>23</td>
</tr>
<tr>
<td>EC: high</td>
<td>24</td>
<td>24</td>
<td>36</td>
<td>38</td>
<td>38</td>
<td>66</td>
</tr>
<tr>
<td>Air pollution/noise concern</td>
<td>8</td>
<td>6</td>
<td>21</td>
<td>17</td>
<td>27</td>
<td>24</td>
</tr>
<tr>
<td>Annoyance at home due to road-traffic air pollution/noise</td>
<td>3</td>
<td>3</td>
<td>15</td>
<td>12</td>
<td>13</td>
<td>12</td>
</tr>
</tbody>
</table>

* The numbers consist of all respondents minus the number of protest votes and “I don’t know” responses, and after applying a cut-off point of 1.5% for WTP values.
29% lower for the LE basic model and 31% lower for the LE extended model as well as 58% lower for the scenario basic model and 63% lower for the scenario extended model.

As shown in Table 3, most of the significant variables in the basic model remained associated with WTP estimates in the extended model. The additional variables included in the extended models (that significantly affected all three WTP estimates levels) were environmental concerns, annoyance at home by road-traffic air pollution (except for the general extended model), respondent sensitivity to air pollutants (except for the LE extended model), respondent ability to relax in polluted locations, and the government’s attempts to reduce pollutants (except for the LE extended model with a “neutral” answer). Factors that did not significantly influence the WTP estimates were respondent awareness of health risks, air pollution concern and respondent belief that policies to reduce pollutants were intended to improve wellbeing.

Overall, we observed that most perception-related variables significantly affected WTP estimates. The effect of country was substantial, as shown in Fig. 1 and the basic model. After adjusting the effect of perception-related variables, the effect estimates for country in the extended model changed considerably. This change was most pronounced in ES. The difference from ES to NL (baseline) was 115% higher WTP in the baseline model compared with the WTP decrease of 35% in the extended model, relative to baseline.

3.3. Noise: determinants of general, annoyance, and combined scenario WTP estimates

The results of the WTP regression analysis for road-traffic-related noise risks are presented in Table 4. Similar to Table 3, most of the significant variables in the basic model remained associated with the WTP scores in the extended model. Gender, education, and financial position did not significantly to substantially affect noise WTP estimates for specific effect (13% increased risk of severe annoyance) and the combined scenario in basic and extended models.

The variables included in the extended models that significantly affected all three WTP levels were environmental concerns, noise concerns (except for the scenario extended model), respondent sensitivity to noise (except for the combined annoyance model), respondent ability to relax in noisy locations, and the government’s attempts to reduce pollutants (except for the extended annoyance model).

Factors that did not significantly influence the WTP estimates were respondent awareness of health risks, annoyance at home by road-traffic noise (except for the general extended model), constant freight traffic near the dwelling, and the respondent disagreement or who were neutral with the statement that policies seeking to reduce pollutants are intended to improve wellbeing.

As with air pollution, we observed that most perception-related variables significantly influenced WTP estimates, and country played a smaller role in the extended model compared with the basic WTP model. This finding indicates that between-country differences in perceptions influence between-country differences in WTP outcomes.

3.4. Differences in variables that influenced WTP estimates of air pollution and noise

Based on the extended models, perception- and attitude-related variables significantly affected the WTP values for air pollution and noise. Environmental concerns, respondent sensitivity to pollutants, difficulty relaxing in polluted locations, and disagreement with the notion that pollution-reduction policies seek to improve wellbeing were the four variables that affected the WTP estimates for general risks, LE, and the combined-risk scenario. However, awareness of health risks did not significantly affect the estimate of either pollutant. Overall, we observed that country often significantly predicted pollution and noise estimates (as shown in the basic models), but this effect changed when
perception-related variables were taken into account (as seen in the extended models).

The general health score significantly predicted air pollution and noise WTP (except for the noise annoyance model). Other variables in the basic model and perception-related variables significantly influenced WTP scores to varying degrees. Country, environmental concern, and respondent ability to relax in polluted locations were the strongest predictors of the WTP estimates. However, household income had a more significant role concerning WTP for noise than WTP for air pollution.

4. Discussion

Our study investigated in five European countries the willingness-to-pay (WTP) to avoid the health effects associated with traffic-related air pollution and noise. This was done simultaneously for both pollutants using a single instrument: an open-ended web-based questionnaire. The general objectives were to assess and compare the monetary values of air pollution and noise health risks based on stated WTP by the respondents. Specific research questions addressed the respondent’s WTP to avoid the health risks from road-traffic related air pollution and noise, the determinants associated with the WTP for these health risks, and the differences in WTP values across countries. There were approximately 5000 respondents participating in each pollutant sections in the questionnaire, making our study larger than most other multi-country studies of environmental health effects. To our knowledge, there are no other multi-country studies of this scale reported in the open literature that simultaneously investigated the monetary value of air pollution and noise health effects using WTP with a single instrument and approach. In addition, we included perception- and attitude-related variables to study WTP.

4.1 Main findings

The WTP estimates to avoid health risks due to road-traffic-related air pollution and noise differed across all five countries. The mean WTP estimates for general air pollution risks, LE and the combined risk scenario were €130, €80 and €330 pp/y, respectively,
and the medians were €40, €10 and €50 pp/y, respectively. For noise risks, the mean WTP values were €90, €100 (severe annoyance) and €320 pp/y, respectively, with medians of €20, €20 and €40 pp/y, respectively. These values were obtained after 1.5% cut-off on WTP estimates. We compared the effects of alternative cut-offs on WTP estimates, i.e., of 1.5%, 3% and 5%, and also a cut-off based on expendable household income criterion of €3000 per month as used in New Energy Externalities Developments for Sustainability/NEEDS (2006). The distribution of WTP estimates on our study appeared to be not very sensitive to the application for different cut-off points. As expected, the application of a lower cut-off point for unrealistic high values leads to a lower mean and slightly lower median for WTP.

About 10% of the respondents were against valuing health risks in terms of monetary values (*"protest vote" or PV) and about half of the respondents opted for the "don't know" or DK response. The PV and DK respondents were excluded from the main findings reported in this study. With the higher proportion of DK responses than PV, we explored potential effect of DK on distribution of WTP values using weighting and imputation approaches. The results did not indicate substantial changes in the WTP estimates with differences of approximately 15% between un-weighted, weighted and imputed estimates (Istamto et al., 2014). Weighted and imputed data did not affect the results of the regression analyses either (results not shown).

In the regression analysis we used a basic model that consists of demographic, social-economic and health variables (age group, gender, education, country, financial position, household income, perceived general health score and awareness of health effects). We also developed an extended model that included variables known to affect risk perception and acceptability: sensitivity to pollutants, environmental concerns, and confidence in governmental actions to control pollution. We found that sensitivity to pollutants and environmental concern significantly influenced WTP estimates for all three vignettes: general risks, LE, and the combined scenario. Confidence in governmental efforts to control pollution significantly predicted WTP for air-pollution- and noise-related general risks and for the combined scenario. Sensitivity analyses on the use of aggregated versus and non-aggregated variables in the extended models showed that the outcomes of the regression analysis were

**Table 4**

<table>
<thead>
<tr>
<th>Noise</th>
<th>General basic</th>
<th>General extended</th>
<th>Single effect basic</th>
<th>Single effect extended</th>
<th>Scenario basic</th>
<th>Scenario extended</th>
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<td>Education expressed per 10 years</td>
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<td>81–90 years</td>
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<td>91–100 years</td>
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<td>Perceived general health score in 25-point intervals</td>
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<td>46–65</td>
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<td>66–85</td>
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<td>86–105</td>
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<tr>
<td>Awareness of health risks*</td>
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<td>12–18</td>
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<td>19–25</td>
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<td>26–32</td>
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<td>33–42</td>
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<td>EC: low</td>
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<td>EC: medium</td>
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<td>EC: high</td>
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<td>Noise concern*</td>
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<td>Annoyance at home by road-traffic noise*</td>
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<td>Constant traffic noise near dwelling*</td>
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<tr>
<td>Respondent sensitivity to noise*</td>
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<tr>
<td>Difficulty relaxing in noisy locations*</td>
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<td>Government attempts to reduce pollutants: agree</td>
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<td>Neutral</td>
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<td>Disagree</td>
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<td>Policies to reduce pollutants intended to improve wellbeing: agree</td>
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<td>Neutral</td>
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<td>Disagree</td>
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* A "yes"-answer by respondents.
generally robust against the scaling of the variables (results not shown).

Generally, the results were in support of several but not all of the hypotheses we derived from the social sciences literature. Overall, the data were in support of the hypotheses that WTP estimates were the highest for people who were environmentally concerned, sensitive to air pollution or noise and had difficulty to relax in polluted and noisy places. In addition, generally, those who expressed noise concern and who were severely annoyed at home by road-traffic air pollution were also willing to pay more. This was strongest in the regression analysis on the WTP questions with qualitative information on effects and less so for specific health endpoints. In contrast, the results did not support the hypotheses that people who were well aware of the health effects of road-traffic air pollution and noise, provided higher WTP estimates.

Our study shows that WTP to avoid general health risks from air pollution was higher than that for noise. Surprisingly, WTP to avoid specified effect for noise (severe annoyance) was higher than for air pollution (six months decrease in life expectancy). WTP for the combined scenarios was similar for both pollutants.

4.2. Methodological considerations and comparison to other multi-country studies

We used an open-ended/OE web-based questionnaire to assess the WTP. Alternative contingent valuation/CV approaches may have yielded somewhat different results. The debate about the best form to assess WTP for the valuation of the environmental related health effects is on-going and the choice of format (e.g. open-ended questions, payment cards, or discrete choice experiments) depends on the context and the research objectives (Carson et al., 1998; Diener et al., 1998; Bateman et al., 2008). The OE method is reported as stable over time (high test–retest rate) and is considered to be free of anchoring and range biases (Hoenenagel, 1994) compared to other methods such as the payment card or the dichotomous choice method (Ladenburg and Olsen, 2008; Lindhjem et al., 2010). Avoiding anchoring and range bias effects was important to our objective to simultaneously assess the WTP for a diversity of health effects of air pollution and noise that differ in degrees of severity to the individual, family, and population at large. Thus, the OE-approach was the method of choice in this study, given its favourable features in this respect.

Compared to other contingent valuation methods such as discrete choice experiment and payment card method, the OE questionnaire method is generally reported to yield lower (conservative) WTP values (Welsh and Poe, 1998; Klose, 1999; Bijlenga et al., 2011) and may have a better construct validity. A disadvantage of the OE question approach is that it does not provide a smooth distribution of WTP values, since respondents tend to report ‘rounded’ numbers of fives, tens or hundreds and not the intermediate values. This drawback, however, did not interfere with our objectives. The most recent comparable studies are those from the EU financed projects, NEEDS (New Energy Externalities Developments for Sustainability/NEEDS, 2006; Desaigues et al., 2011) and HEATCO (Navrud et al., 2006). These studies analysed the WTP estimates for health and well-being risks associated with air pollution and environmental noise, respectively.

The NEEDS study sampled 1463 respondents across nine European countries and assessed WTP in LE associated with a reduction in air pollution using the payment card method. After removing the 11% of respondents who reported protest responses and applying a 1.5% cut-off point for the WTP estimates, the WTP for a 6-month average gain in LE was €384 pp/year for the rest of their lives. This estimate is about four times higher than the mean WTP observed in our study, for an average gain of 6 months in LE (€82 pp/year).

When we restrict the comparison to the countries included in both NEEDS and in our study (DE, ES and UK), the results were three to five times higher. These higher estimates are in line with the literature indicating that an open-ended CV method generally yields lower WTP values. Differences in payment vehicle may also contribute to differences. The NEEDS study provided information about an average gain in LE, while our study provided information on several other health effects which also included an average gain in LE. Similar to the NEEDS study, we found that higher WTP estimates were significantly associated with higher levels of income and education. The NEEDS study did not assess effects of several factors that were significant for the LE WTP in our study, such as environmental concerns, annoyance at home by road-traffic air pollution, respondent sensitivity to air pollutants, respondent ability to relax in polluted locations, and the government’s attempts to reduce pollutants.

To compare the road-traffic-related noise WTP estimates, we examined the results of the HEATCO study that investigated WTP estimates to avoid noise annoyance across six countries among 5500 respondents using the payment card method (Navrud et al., 2006). Respondents were selected based on ambient noise levels at home and were asked to state their personal WTP estimates over the next 5 years to eliminate this annoyance at home. Their study reported an overall mean WTP of €50 pp/y with a median of €0 pp/year, which was low compared to our mean WTP of €100 pp/year with a median of €20 pp/year. In addition, many respondents providing a zero WTP answer (66%), and those who were opposed to the valuation method (76%) were not accounted for when weighting the WTP estimates. A direct comparison between the HEATCO study and ours is also difficult due to the payment versus OE method differences and the non-stratified versus noise-level stratified sampling. A number of factors used to stratify noise-maps and which were considered to be important in the HEATCO study for the WTP estimate for severe noise annoyance such as “constant freight traffic” and “annoyance at home by road-traffic noise”, were not significant in our study. Having a higher income level and a university education in the HEATCO study positive affected WTP estimates. In our study, income and gender were strongly associated with the WTP estimates for noise but education was not.

5. Conclusions

Our study shows that perception- and attitude-related variables, i.e. environmental concern, sensitivity and the ability to relax in polluted places, significantly affect the WTP estimates for both types of pollutants. These variables explain to some degree the differences in WTP estimates between countries. This stresses that benefit transfer from studies in one country to another should be performed with great care. In addition, the type of information provided (vignettes) influenced the WTP estimates. Qualitative information indicated higher WTP estimate for air pollution than for noise. In contrast, and contrary to expectation, avoiding a half year shorter life expectancy due to air pollution was valued lower than a 13% increase in severe annoyance by noise. The more policy relevant scenario of combined effects showed little difference between pollutants.

Acknowledgements

The study was performed within the EU 6th Framework study INTARESE (coordinated by David Briggs) and the strategic research program of the Dutch National Institute for Public Health and the Environment (RIVM). We gratefully acknowledge the contribution of Erkki Kuusisto, Jouni Tuomisto, Kari Pesonen, Rainer Friedrich, Anna Sillero Larena, and Mark Nieuwenhuijsen for their help with the translations and their useful suggestions during the earlier versions of our survey. Alistair Hunt provided insightful and valuable comments and advised in various stages of the project. In addition, we also would like to thank our respondents for their invaluable contribution to this valuation study.
Appendix A

Information provided to respondents prior to the WTP questions.

<table>
<thead>
<tr>
<th>Information regarding air pollution risks</th>
<th>Information regarding noise risks</th>
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<tr>
<td>Air pollution from road traffic has many negative health risks according to several studies and authorities including the World Health Organization (WHO). Road-traffic air pollutants can cause childhood asthma as well as respiratory and cardiovascular diseases. All of these risks can shorten your life expectancy (i.e., the number of years you are expected to live).</td>
<td>Road-traffic noise poses many negative health and wellbeing risks according to several studies and authorities including the World Health Organization (WHO).</td>
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<td>Cardiovascular diseases are disorders of the heart and blood vessels. They can limit your daily activities and deteriorate your quality of life. Patients with respiratory diseases are often limited in their daily physical activities, feel tired and exhausted by coughing attacks, and experience shortness of breath and difficulty breathing. Life expectancy is the number of expected years of life remaining at a given age. If you were born today, then your life expectancy is approximately 80 years. On average, women live 6 years longer than men.</td>
<td>The most important noise risk is heart attack (myocardial infarction). Patients who have suffered heart attacks rely on lifelong medical care.</td>
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<td>Cardiovascular- and respiratory-related diseases and life expectancy are not only related to air pollution but also depend on personal factors such as age, gender, weight, lifestyle, and genetics. Therefore, eliminating air pollution will not necessarily eliminate any given disease.</td>
<td>Noise risks with regard to wellbeing include annoyance and sleep disturbance. Sleep disturbance includes having trouble falling asleep, occasionally waking up in the middle of the night, waking up earlier than usual, or some combination therein. Annoyance is the feeling of disgust, anger, discomfort, or dissatisfaction that occurs when a person’s thoughts, feelings, or activities are negatively affected by the environment. Research has also shown that noise decreases reading performance among children at school.</td>
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</table>

Appendix B

B.1. WTP questions related to air pollution

Certain measures can be taken to reduce the current level of air pollution caused by road traffic. These measures require funding, of which the government will only cover a portion. Therefore, society must contribute the balance. We are interested in determining whether you would be willing to pay for cleaner air to avoid the negative health risks due to road traffic.

The amount of money you would be willing to pay for the following items would come from your own budget. This means reducing your daily consumption of goods, services, or savings.

B.1.1. General questions regarding road-traffic-related air pollution

Based on your monthly net income, your annual household income is €... (referred to respondents indicated household income...).

What is the maximum amount of money you would be willing to pay (annually, for the rest of your life) to avoid the risks associated with air pollution due to road traffic in your area?

The maximum amount of money I am willing to pay is... € or £ per year.

B.1.2. Regarding the specific health risks due to road-traffic-related air pollution

A 50% decrease in air pollution emissions by 2030 will increase life expectancy by 6 months.

What is the maximum amount of money you would be willing to pay (annually, for the rest of your life) to gain 6 months of life expectancy?

The maximum amount of money I am willing to pay is... € or £ per year.

B.1.3. The combined health risks of road-traffic-related air pollution

In this scenario, a reduction of 50% in air pollution from road traffic can gradually be achieved by 2030. After 2030, air pollution will be maintained at this lower level.

The reduction will lead to:

- a 6-month increase in life expectancy
- a reduction in your risk of hospital admission for cardiovascular diseases by 1 to 2 per 10,000 people per year
- a reduction in your risk of hospital admission for respiratory diseases by 1 to 2 per 10,000 people per year
- a reduction in the risk of doctor-diagnosed asthma in young children by 34 per 10,000 children per year.

These benefits occur simultaneously and should be considered a single consequence.

What is the maximum amount of money you would be willing to pay (annually, for the rest of your life) to benefit from this reduction?

The maximum amount of money I am willing to pay is... € or £ per year.

B.2. WTP questions related to noise

Certain measures can be taken to reduce the current level of road-traffic noise. These measures require funding, of which the government will only cover a portion. Therefore, society must contribute the balance. We are interested in determining whether you would be willing to pay for less road-traffic noise to avoid its associated negative health risks. The amount of money that you indicate you would be willing to pay in the following questions would come from your own budget. This funding would mean reducing your daily consumption of goods, services, or savings.

B.2.1. General questions regarding road-traffic-related noise

Based on your monthly net income, your annual household net income is... (referred to respondents indicated household income...).

What is the maximum amount of money you would be willing to pay (annually, for the rest of your life) to avoid the risks associated with road-traffic noise in your area?

The maximum amount of money I would be willing to pay is... € or £ per year.

B.2.2. The specific health risks of road-traffic-related noise

Imagine that a medium-sized road will be built 75 m from your home. Cars, scooters, trucks, and buses are allowed to drive on this road.

After this road is built, the annual noise level near your home will increase from 50 dB to 65 dB. This increase in noise level might affect your health and wellbeing.

The noise will increase your risk of being severely annoyed by 13% (13 per 100 people).

What is the maximum amount of money you would be willing to pay (annually, for the rest of your life) to avoid a 13% increased risk of becoming severely annoyed due to traffic noise?

The maximum amount of money I would be willing to pay is... € or £ per year.
B.2.3. The combined health risks of road-traffic-related noise

Imagine that a medium-sized road will be built 75 m from your home. Cars, scooters, trucks, and busses will be allowed on this road.

After this road is built, the annual noise level at your home will increase from 50 dB to 65 dB.

The scenario will lead to

- an increased risk of you becoming severely annoyed due to road traffic by 13%;
- an increased risk of you having severe sleep disturbances during the night by 6%;
- an increased risk of heart attack by 1 in 10,000 people per year; and
- an increased risk of poorer reading performance by school-age children by 1 in 100,000 children.

These risks will occur simultaneously and should be seen as inseparable.

What is the maximum amount of money you would be willing to pay (annually, for the rest of your life) to avoid the negative risks of this noise?

The maximum amount of money I am willing to pay is .... € or £ | per.

References


Integrated Assessment of Health Risks of Environmental Stressors in Europe (INTARESE). Integrated Assessment of Health Risks of Environmental Stressors in Europe; Project co-funded by the European Commission under the Sixth Framework Programme (2002–2006); 2012.


