Deliverable

14.3 Estimating the value of safety: methods and results for six European countries

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Contents

Deliverable description

Work Package 14 aims to develop a standardised framework for estimating the cost-effectiveness of the COMPARE system and related methods and tools, including the value of safety. This third deliverable corresponds to the third objective of the Work Package: to develop and apply a methodology to value safety (provided through rapid identification of pathogens through COMPARE) in several countries.

Early warning systems for infectious diseases and foodborne outbreaks are designed with the aim to increase the safety of citizens. As a first step to determine whether investing in such a system is worth the cost, this study used contingent valuation to estimate people's willingness to pay (WTP) for an early warning system. The contingent valuation experiment was administered using online questionnaires in February to March 2018 to cross-sectional, representative samples in the UK, Denmark, Germany, Hungary, Italy, and the Netherlands with a total sample size of 3,140. Mean WTP per month for an early warning system was €22.7 (median €9.3) per household per month. Pooled regression results indicate that overall, WTP valuations increased with household income and awareness of the risk of outbreaks, while WTP decreased with age and being female. The results suggest that there is a quantifiable monetary value for safety in the context of an early warning system for infectious diseases and foodborne outbreaks.

1. Introduction

In any country, increasing the health safety of the population is an important policy goal. Recent infectious outbreaks of, for example, Ebola, SARS, bird flu and Salmonella emphasise that this cannot always be realised by countries separately. In particular, such infectious outbreaks could be countered more rapidly by having an international, integrated early warning system for infectious diseases that helps to contain and mitigate outbreaks. As a first step towards such a system, the European Union has funded the interdisciplinary research network COMPARE (*http://www.compare-europe.eu/*), which conducts research ranging from topics on fundamental biological questions to organisational and legal issues related to such a possible warning system on a European level.

No matter what the design of such a system might look like in the future, establishing and maintaining it would entail considerable costs. These costs would ultimately be paid by the citizens of the European Union. All possible benefits of such an integrated early warning system must be considered to determine whether this would be money well spent. The relevant benefits could include assets such as a reduction in disease burden or the mitigation of economic consequences of infectious diseases and foodborne outbreaks, which can be considerable, for companies, countries and individuals. For instance, the economic impact of the Ebola crisis in 2014-2015 on Sierra Leone, Guinea and Liberia was estimated at $2.8 billion [1].

However, reliable evidence and estimates of the benefits of such an early warning system is lacking and difficult to obtain, especially in the case of multinational approaches. Our study aims to provide a first indication of the potential value of such a system to the European society. First, we develop a reliable and reproducible approach to estimate the perceived value of an early warning system which has the aim to improve health safety. Second, we apply this approach in several EU countries to facilitate interpretations and assess implications of our results on a European level.

This paper summarises our efforts to accomplish these goals and is divided into four sections. First, we briefly present findings from a previous literature review surrounding the methods that have been applied in similar contexts. The following section will report on the administration, design and analysis of our experiment. We will conclude the paper with a summary of the primary results and a discussion of the limitations and implications of our analysis.

2. Background

The introduction of a warning system as suggested by the COMPARE network would not be necessary if infectious diseases were not a significant factor in the Global (or European) Burden of Disease. The first paper from the Burden of Communicable Diseases in Europe (BCoDE) project found an average disease burden in Germany alone of 33,116 DALYs per year for influenza and 19,115 DALYs per year for Salmonella [2]. Hepatitis B and measles were also included as infectious diseases relevant to the BCoDE. Given the substantial effects that communicable or infectious diseases have on a single country, some of the benefits of a Europe-wide warning system are clear, as this burden of disease could be significantly reduced. However, as mentioned above, there are less tangible benefits, which include an increase of health safety, and the valuation of this concept is less straightforward than calculating DALYs.

It is not only the field of health research where the valuation of safety-affecting interventions is relevant. For example, the fields of both environmental and transportation research look at interventions that impact (usually for the better) the safety of recipients. Perry-Duxbury et al. (submitted manuscript, 2018) conducted a literature review in which they examined the methodologies of empirical research valuing safety from all relevant fields, including environment, transportation and health. Of the 33 papers reviewed 22 were found to use the contingent valuation method to value safety-affecting interventions. The four papers in the field of health that have empirically valued interventions that increase health safety all used a form of stated preference methodology. The aim of these papers was to estimate the value of reducing mortality risks [3], preventing child maltreatment deaths [4], reducing sexual risk [5] and vaccinations in pandemic outbreaks [6]. The first three papers used the contingent valuation method (WTP), while the last paper used the discrete choice evaluation method.

In their literature review of safety valuation methodology, which focused on empirical research from all fields including health, Perry-Duxbury et al. (submitted manuscript, 2018) find that in contingent valuation studies, having a higher income was always associated with a higher WTP, while a higher level of education was only associated with a higher WTP in 6 of the 9 papers that included education. Age and gender both had strong correlations with WTP. However, these correlations were positive in some of the literature and negative in the rest. The literature review also finds various results regarding individuals and their relationship with risk. For example, individuals that have been directly or indirectly exposed to the outcome measured are associated with reporting a higher WTP. Higher WTP was also the case if individuals had a higher level of perceived risk, were more knowledgeable or concerned about the issue, or were more concerned than others about the outcome. Finally, study design elements also affect WTP. Additionally, higher baseline risk is associated with a higher WTP. Both using higher costs and giving individuals more information lead to dichotomous results regarding the level of WTP, however, both elements of study design are significant in the papers that investigate them.

3. Methods

3.1 Survey administration

To estimate the WTP for an early warning system for infectious diseases and foodborne outbreaks in Europe, we conducted contingent valuation experiments utilising general population samples from six European countries. Sampling and administration of the WTP questionnaire were conducted by a professional sampling agency from February to March 2018 using an online survey format. The sampling agency recruited participants from an existing pool of households that are familiar with the survey format. The survey was administered to citizens aged between 18 and 65. Individuals aged 65 and above were not included for two reasons: First, recruiting elderly respondents from online panels is notoriously challenging in some of the included countries. Second, we wanted to limit our population to the (income) taxpayers. Samples were aimed to be representative regarding age, gender and level of education with a sample size of around 500 individuals per country. Participants were able to respond to the questionnaire on a computer or other mobile devices. They did not receive a personal financial reward for engaging in the experiment but could choose a charity which would receive a small donation after completing the survey.

We conducted the experiment in Denmark, Germany, Hungary, Italy, the Netherlands, and the UK. The reasoning behind the country selection was to cover a variety of cultural perspectives relevant to the valuation of safety and public intervention. The latter was assessed by applying the three most relevant dimensions of Hofstede's cultural dimensions theory in this context: individualism vs collectivism, masculinity, and uncertainty avoidance [7]. The included countries furthermore constitute a reasonable mix of different levels of social and economic development in Europe. The questionnaire, which was initially developed in English, was translated into Danish, German, Hungarian, Italian, and Dutch by professional translators and checked for consistency by native speakers. Monetary values and payment scales were converted from GBP into DKK, EUR and HUF using the mean exchange rate from February 2018. In the case of Hungary, this was additionally adjusted by purchasing power. Payment scales were rounded to natural integer values in all survey versions to prevent peculiar payment options. The payment scale of the UK survey can be found in appendix B. Quality checks were conducted to ensure the homogeneity and consistency of the different survey versions across countries and languages.

3.2 Pre-testing of survey

Before the launch of the survey, the questionnaire was tested in the COMPARE study group (n=22) and a representative sample in the UK (n=134) in January 2018. Besides testing the payment scale, the goal was to establish whether the questionnaire itself and the contingent valuation experiment are feasible, whether respondents can understand all questions, and whether the survey length is appropriate. Overall, results indicated that the questionnaire is practicable, the CV exercise was found rational, and the chosen WTP elicitation approach worked. However, some participants complained about the length of the survey and others did not understand a survey module about social value orientation. We, therefore, eliminated this part of the survey.

The distributions of WTP valuations in the pilot raised questions about the appropriateness of the payment scale. To test the scale, we rolled out the main survey in the UK alongside two other survey versions (n=500 each) in which only the payment scales were altered. The results presented here, and the survey versions used in the remaining countries, are based on the questionnaire that provided the most internally valid WTP valuations.

3.3 Survey design

The general design of the WTP experiment followed the structure of an existing survey, which was designed to elicit the WTP for a QALY [8]. After a brief introduction to the topic at hand and the purpose and design of the questionnaire, respondents had to state their age and gender before describing their current health using the EQ-5D-5L. The questions about age and gender were positioned at the beginning of the survey to familiarise respondents with the general functioning of the survey without placing a high cognitive burden to answer the questions.

The following part of the questionnaire started with a "warm-up" WTP exercise, where participants had to state their WTP for a pair of shoes. This elicitation task was included to familiarise respondents with the procedure and to test whether the chosen approach results in reasonable estimates for a common market good. After a short (re-)introduction of the actual purpose of the study, respondents started with the central WTP task: valuing safety. A two-step procedure using a payment scale and an open-ended question was applied to elicit individuals' WTP for safety. Reasoning behind, and appropriateness of this approach was outlined elsewhere [8]–[10]. In short, we believe it provides precise and direct maximum WTP valuations.

It was outlined to respondents that establishing and maintaining an international integrated warning system, which could contain and mitigate infectious disease and foodborne outbreaks, naming Ebola, SARS, bird flu and Salmonella as examples, is not without costs. Participants then should imagine that the funding would take place through taxation, paid by all eligible people (aged 18 and above) in their respective country through monthly instalments starting from now on. Using a payment scale ordered from low to high (0, 1, 2, 3, 4, 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 100, 120, 150, 200, more), respondents were asked to indicate the amounts they would definitely be willing to pay per month for having this integrated warning system. This payment scale was adjusted for DKK and HUF. Individuals who chose the 'more' option on the payment scale subsequently had to indicate a value higher than 200 in an open-ended question. Individuals who chose 0 as their maximum WTP had to select one of the following options to specify their reasoning using one of the following options: "Not worth it", "Unable to pay", "Government task", or formulate another reason. Individuals who chose normal values on the payment scale afterwards had to mark the amounts they would definitely not be willing to pay per month on the same payment scale, excluding the maximum WTP values from the preceding step. The thereby generated WTP interval was used in the second step of the chosen approach. Here, respondents were faced with an open-ended question where they had to indicate an exact € amount within this interval that is closest to the maximum that they would be willing to pay per month. These elicited € amounts then constitute the WTP for an early warning system for infectious diseases. Throughout the two steps, participants were reminded to keep their ability to pay in mind (their net monthly household income) before indicating any interval or specific value to prevent ex-ante mitigation [11]. The corresponding survey questions can be found in appendix B.

The questionnaire continued with different WTP valuation scenarios (three scenarios per individual) involving various degrees of risk reduction and disease severity, which will not be discussed in this paper. Subsequently, respondents had to provide further socio-demographic information as well as assess their current quality of life. Furthermore, they were asked about whether they or their family were at one point exposed to an emerging infectious disease or outbreak before, and about their general awareness and concerns related to emerging infectious diseases and foodborne outbreaks. A short-form questionnaire of the health-risk attitude scale (HRAS) concluded that section.

The survey ended with a module asking respondents whether they have contents insurance, the size of the corresponding yearly premiums and how they would value the described early warning system in comparison to their contents insurance. This module was included for two reasons. First, purchasing such forms of insurance, with contents insurance being the most common one, to some part reveals the risk preferences of respondents. Second, asking for the premium and the relative value of early warning system and contents insurance serves as a validity check of the stated WTP. This check was central in the decision about which of the three different payment scales tested before the main study was the most appropriate one.

3.4 Data analysis

Before analysing the data, we converted all monetary values from Danish, UK, and Hungarian respondents into their respective € values using the average exchange rates during the month of sampling. In the next step, cross-country data validity and comparability were assessed by exploratory, descriptive analysis. We then calculated crude mean, median and range of WTP valuations as well as the proportions of and reasons for zero WTP answers.

Linear regression analysis was conducted on the WTP valuations from all six countries to examine which factors influenced the WTP and whether the found effects are in line with theoretical considerations as well as previous empirical findings of WTP determinants. The latter is summarised in section 2. The regression analysis functions as a validity check for our experimental design and WTP results by testing if respondents' WTP in fact is estimated to be influenced by factors, which are expected determinants of WTP. We also explored the suitability of Tobit or Two-part-models for the regression analysis but using root mean squared error and mean absolute error as performance criteria revealed that OLS provides the best model fit. Calculations were conducted using the pooled total sample, subsets of the sample excluding certain outliers, and country level samples. Descriptive analysis and regression analyses were performed using STATA 15.0 (Stata Corp. 2018. Stata Statistical Software: Release 15. College Station, TX: Stata Corp LP).

4 Results

The total number of completed surveys from the six chosen European countries was 3,140. On average, it took respondents 18.9 minutes (SD 11.2) to complete the questionnaire. The six samples are well balanced regarding age, gender and education in their respective countries for the aimed subset of individuals aged between 18 and 65. Descriptive statistics of the respondents per country are shown in Table 2. The average monthly household income ranges from 1,152 in Hungary to 6,029 in Denmark. Employment status and educational attainment naturally varies between countries. The sub-samples also differ considerably in the rate of past exposure to infectious diseases and foodborne outbreaks (9% in the UK vs. 64% in Hungary) as well as the importance of religion in daily life (from 2.54 in Denmark to 3.7 in Italy on a 7-point scale) and subjective well-being as measured by the SWLS (from 16.29 in the Netherlands to 21.39 in Hungary).

Table 2: Descriptive statistics

	UK	Denmark	Germany	Hungary	Italy	Netherlands	Total
Monthly household income in EUR	3,339	6,417	3,076	1,214	2,495	2,715	3,214
	(2,974)	(9,004)	(1,919)	(1,149)	(1,662)	(1,632)	(4,372)
Age	42.06	40.99	43.08	41.76	41.65	43.52	42.18
	(13.65)	(14.55)	(13.35)	(13.23)	(13.94)	(14.91)	(13.97)
Female	0.50	0.49	0.52	0.51	0.52	0.49	0.51
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
No finished secondary education	0.02	0.08	0.02	0.03	0.02	0.03	0.03
	(0.15)	(0.28)	(0.15)	(0.16)	(0.12)	(0.16)	(0.18)
Finished high school (or similar)	0.50	0.54	0.65	0.55	0.60	0.59	0.57
	(0.50)	(0.50)	(0.48)	(0.50)	(0.49)	(0.49)	(0.50)
Finished tertiary education	0.48	0.38	0.33	0.42	0.39	0.38	0.40
	(0.50)	(0.49)	(0.47)	(0.49)	(0.49)	(0.49)	(0.49)
Married	0.60	0.52	0.58	0.62	0.57	0.57	0.58
	(0.49)	(0.50)	(0.49)	(0.49)	(0.50)	(0.49)	(0.49)
Employed	0.56	0.49	0.58	0.66	0.44	0.52	0.54
	(0.50)	(0.50)	(0.49)	(0.48)	(0.50)	(0.50)	(0.50)
Self-employed	0.09	0.06	0.10	0.08	0.19	0.08	0.10
	(0.29)	(0.24)	(0.30)	(0.27)	(0.39)	(0.27)	(0.30)
Unemployed	0.06	0.08	0.04	0.04	0.10	0.06	0.06
	(0.24)	(0.27)	(0.21)	(0.19)	(0.29)	(0.24)	(0.24)
Homemaker	0.11	0.03	0.07	0.04	0.09	0.06	0.07
	(0.31)	(0.16)	(0.26)	(0.19)	(0.29)	(0.24)	(0.25)
Student	0.06	0.17	0.08	0.07	0.10	0.11	0.10
	(0.23)	(0.37)	(0.27)	(0.25)	(0.30)	(0.31)	(0.30)
Retired	0.08	0.13	0.12	0.10	0.08	0.06	0.09
	(0.27)	(0.33)	(0.32)	(0.30)	(0.27)	(0.23)	(0.29)
Unable to work	0.05	0.05	0.01	0.02	0.00	0.11	0.04
	(0.21)	(0.22)	(0.12)	(0.15)	(0.06)	(0.31)	(0.20)
EQ5D-5L (unweighted sum score)	86.76	83.86	85.41	88.99	87.50	88.94	86.91
	(18.05)	(17.99)	(16.98)	(14.49)	(14.64)	(14.14)	(16.24)
Awareness of outbreaks	52.89	50.91	51.64	52.68	55.15	49.95	52.21
	(8.06)	(7.79)	(8.51)	(8.21)	(8.04)	(8.26)	(8.31)
No past exposure	0.90	0.67	0.72	0.38	0.87	0.69	0.71
	(0.30)	(0.47)	(0.45)	(0.49)	(0.33)	(0.46)	(0.45)
Family past exposure	0.06	0.18	0.13	0.17	0.05	0.11	0.11
	(0.23)	(0.38)	(0.34)	(0.37)	(0.22)	(0.31)	(0.32)
Personal past exposure	0.06	0.21	0.18	0.48	0.09	0.23	0.20
	(0.23)	(0.41)	(0.38)	(0.50)	(0.28)	(0.42)	(0.40)
HRAS-SF	29.32	27.17	28.87	28.68	30.10	28.83	28.84
	(5.99)	(5.55)	(5.92)	(4.89)	(5.32)	(5.88)	(5.68)
Observations	553	514	522	504	523	524	3,140

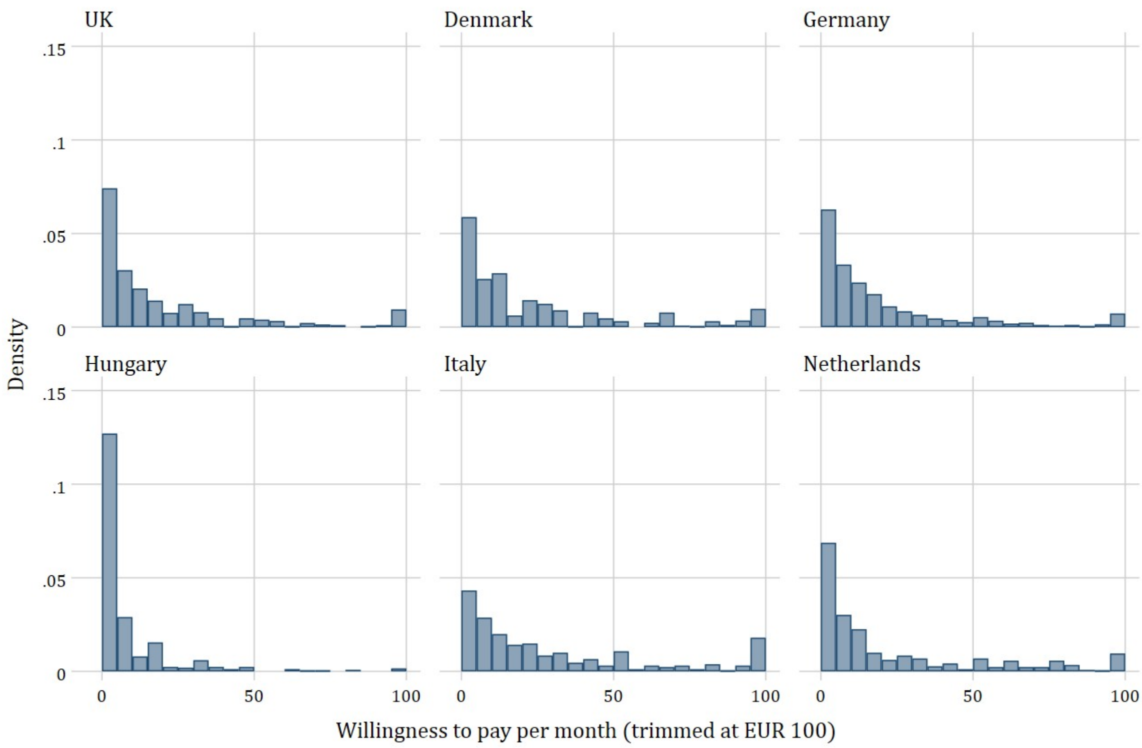
Notes: Standard deviation in brackets; Monthly household income was only available for 2,772 respondents; awareness of outbreaks scored from 12 to 84 (12 question with 7 levels); HRAS scored from 6 to 42 (6 questions with 7 levels); sum score of EQ5D-5L rescaled from 1 to 100.

The advantage of the above-described two-step procedure to elicit individuals' WTP lies in providing point estimates for all 3,140 survey respondents. These individual point estimates can be aggregated and compared without the need for rescaling or imputing of data. The crude mean stated monthly household WTP for an integrated early warning system for infectious diseases and foodborne outbreaks using data from all six countries was €22.7 (median €9.3). The standard deviation of €41.4 exemplifies a large heterogeneity in WTP. Table 3 presents the corresponding values for all six countries and Figure 1 the distribution of WTP values. For aesthetic reasons, values over €100 are shown as €100 in Figure 1.

Table 3: Willingness-to-pay per month in EUR

	Mean	SD	Median	Min	Max	N
UK	23.4	46.7	8.0	0.0	569.6	553
Denmark	26.9	41.7	13.4	0.0	461.0	514
Germany	20.3	31.2	10.0	0.0	250.0	522
Hungary	8.6	16.1	3.2	0.0	144.2	504
Italy	32.1	56.2	15.0	0.0	1000.0	523
Netherlands	24.6	40.1	10.0	0.0	467.0	524
Total	22.7	41.4	9.3	0.0	1000.0	3,140

Figure 1: Distribution of WTP values per country



The mean WTP is heavily driven by a few very high values which go up to €1,000. The proportion of values above €100 ranges from 0.6% in Hungary to 8.41% in Italy. Some of these outliers might represent the real WTP of respondents with very high incomes. However, for 4.4% of respondents, where income data were available, the WTP per month exceeds 5% of their monthly household income (on average €62.7). At what threshold these values become unrealistic is certainly up for debate, but it shows that some valuations hardly reflect the real WTP. Excluding these observations, the mean WTP decreases from €22.7 to €19.1. The elicited values for the lower interval of the first stage of the WTP exercise ('How much would you definitely be willing to pay?') have a mean of €6.2 and a standard deviation of €5.9 (details are listed in appendix C).

There is also considerable heterogeneity in the proportion of respondents with a WTP of zero within countries: Italy at the lower end with 7.27% and the Netherlands at the upper end with 18.13%. Table 4 presents the share of zero values per country as well as the reasoning behind the zero valuations. Almost a quarter of respondents from Hungary stated a WTP of zero. In Italy it was only 7.3%. Most respondents chose the pre-specified option "Government task" (57.3%) and only to a lesser extent the options "Not worth it" (17.2%) and "Unable to pay" (15.3%) to justify a WTP of zero, but again with considerable differences between countries. We tested whether the characteristics of the respondents with a WTP of zero differed from their counterparts and found that respondents with a positive WTP were on average more aware of the dangers of outbreaks for infectious diseases (p = 0.0071) and had been exposed to said diseases in the past at a higher rate (p = 0.0423).

The results of the additional questions about contents insurance revealed that 68.9% of households retain such type of insurance. The stated mean monthly payments for the contents insurance was €18.6 (SD 39.4) in the subset of 865 respondents (40% of insurance holders) providing that information. The mean monthly WTP in that group was €24.7 (SD 44.7). Almost half of respondents (45.9%) indicated that the perceived value of the warning system is equal to the value of the contents insurance, while 27.9% indicated a higher value.

Table 4: Percentage of responses with WTP of zero

	Zero resp.	**Reasoning**			
	(total)	Not worth it	Unable to pay	Gov't task	Other
UK	12.8	25.4	15.5	50.7	8.5
Denmark	11.9	23.0	19.7	49.2	8.2
Germany	15.7	20.7	15.9	54.9	8.5
Hungary	23.2	7.7	12.0	71.8	8.5
Italy	7.3	21.1	15.8	47.4	15.8
Netherlands	18.1	14.7	15.8	55.8	13.7
Total	14.8	17.2	15.3	57.3	10.1

Table 5 column (1) lists the results of an OLS regression with the elicited WTP values as dependent variables using the pooled data from all six countries. To account for the correlation of errors within countries, we used clusterrobust standard errors at the country level in the regression models. The number of observations dropped from 3,140 to 2,772 compared with the descriptive analysis as many respondents did not provide an estimate of their household income. For 739 of these 2,772 observations, merely the income intervals (e.g. €2,000-3,000) were available. We imputed the country-specific means of these intervals as point estimates for household income to use these observations in the regressions.

As expected, income had a highly significant and positive effect on the WTP. Age and being female significantly reduced the WTP, while the positive coefficient on age-squared hints at a non-linear relationship between age and WTP. Education did not affect WTP. These conclusions were stable across model specifications step-wise including further socioeconomic variables (martial and employment status), infectious disease relevant variables (health status, awareness of outbreaks and past exposure) and risk attitude (see appendix D). Adding country dummies to the model slightly diminished the effect of income. Compared with the UK, which WTP valuations were closest to the overall mean (€23.4 and €22.7), all country dummy variables except the Denmark dummy variable are significant (see appendix D). This means that even after controlling for socioeconomic characteristics, especially income, the WTP significantly differs between countries. We also ran a regression including Hofstede's cultural dimensions masculinity, individualism, and uncertainty avoidance, as well as trust in public institutions from the European Social Survey [12] on country level, instead of the country dummies. The most striking result is the considerable impact of a higher level of trust in public institutions on WTP.

Coming back to Table 5, both awareness of outbreaks and the HRAS-SF seem to follow a U-shaped relationship with the dependent variable. In comparison with the first quartile, the middle two quartiles have negative coefficients, whereas the 4th quartile has a positive coefficient. However, this positive coefficient is only significant in the case of awareness of outbreaks. Past exposure, marital status or not being employed or married did not affect WTP.

To test whether our conclusions are also stable when excluding certain outliers, we ran three additional regressions, presented in columns (2) to (4) of Table 5. Model 2 excludes outliers, which are here defined as monthly WTP valuations larger than 5% of the monthly household income (n=122 or 4.4%). This 5% threshold was chosen as a trade-off between excluding unrealistic observations without losing too many observations. Model 3 excludes observations outside of the interval of 7.7 and 39.2 minutes survey completion time, the highest and lowest 5% percentiles. Model 4 combines both exclusion criteria. Excluding these outliers lead to a considerable improvement in model fit, as measured by RMSE, AIC and BIC. In general, the direction and size of the coefficients was reasonably stable across models. The coefficients of female and self-employed were not significant anymore, while health status as measured by the EQ5D-5L, age-squared and HRAS-SF became significant. The larger coefficient of income is a direct consequence of constructing the exclusion criteria as a ratio of WTP and income.

Table 6 presents the results of linear regressions on the country level using the country-specific samples applying the same exclusion criteria of model 4 in Table 5 (appendix E contains results without excluding outliers). As could have been expected, factors impacting WTP differ considerably between countries with some coefficients even switching signs. Household income is significant in all the six countries, whereas age significantly reduces WTP in three of the countries. Besides income, no explanatory variables are consistently significant across countries. A consistently positive coefficient can be found for being in the highest quartile of outbreak awareness, i.e., being very aware of the associated risks. Better health was associated with lower WTP throughout all countries. Alongside the differences in coefficients, the explanatory power of our model changes substantially between countries. The R-squared varies between 0.109 for the GER model and 0.252in the IT model. Differences in AIC/BIC and RMSE were even more substantial.

Table 5: Regression results full sample and without certain outliers

	(1) Full sample	(2) Outliers	(3) Int. length	(4) (2) and (3)
monthly household income (log)	7.286***	9.570***	6.725***	9.644***
	(1.248)	(0.504)	(1.241)	(0.487)
age	-1.594*	-1.091**	-1.464**	-1.030**
	(0.625)	(0.276)	(0.461)	(0.327)
age2	0.012	0.007**	0.011*	0.007*
	(0.008)	(0.003)	(0.005)	(0.003)
female	-4.820*	-3.548	-4.904*	-3.093
	(1.917)	(1.982)	(2.113)	(2.188)
finished tertiary education	1.130	2.690	0.643	1.622
	(2.474)	(1.808)	(2.303)	(1.833)
married	2.842	1.755	1.472	0.521
	(2.727)	(1.486)	(2.026)	(1.270)
self employed	6.380***	2.180	7.068***	2.896
	(1.284)	(2.054)	(1.230)	(2.596)
not employed	-0.020	-2.097	-1.210	-1.698
	(1.791)	(2.152)	(2.378)	(2.124)
EQ5D (unweighted sum score)	-0.150	-0.165**	-0.109	-0.147**
	(0.097)	(0.057)	(0.055)	(0.050)
awareness of outbreaks 2nd quartile	1.535	-0.043	2.223	-0.313
	(2.633)	(0.563)	(2.747)	(0.594)
awareness of outbreaks 3rd quartile	-1.018	-1.155	0.060	-0.657
	(1.896)	(1.687)	(1.941)	(1.876)
awareness of outbreaks 4th quartile	8.886*	5.941**	7.833**	5.964*
	(3.859)	(2.264)	(3.020)	(2.323)
no past exposure	-1.279	-2.710	-0.731	-1.863
	(3.212)	(2.664)	(2.929)	(2.460)
HRAS-SF 2nd quartile	-0.102	-0.219	1.034	0.255
HRAS-SF 3rd quartile	-0.599	-0.209	-1.773	-0.140
	(1.146)	(1.513)	(1.334)	(0.880)
HRAS-SF 4th quartile	3.516	4.036*	5.000**	4.451**
	(2.067)	(1.660)	(1.428)	(1.286)
Constant	20.519	-8.328	17.406	-13.586
	(23.320)	(11.065)	(18.865)	(8.622)
Observations	2,772	2,651	2,496	2,396
R^2	0.078	0.155	0.090	0.142
AIC	28,408	25,275	24,852	22,766
BIC	28,437	25,305	24,881	22,795
rmse	40.706	28.488	35.193	28.033

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Outliers defined as WTP over 5% of monthly income and top and bottom 5% of interview length;

Table 6: Regression results per country without outliers

	(1) UK	(2) DK	(3) GER	(4) HUN	(5) IT	(6) NL
monthly household income (log)	7.184***	13.707***	7.003***	4.891***	9.882***	8.489***
	(2.128)	(4.477)	(2.172)	(1.549)	(2.265)	(2.589)
age	-1.461**	-1.466	-0.181	-1.058**	-1.801**	-0.464
	(0.681)	(0.890)	(0.648)	(0.467)	(0.833)	(0.643)
age2	0.011	0.008	-0.002	0.010**	0.016*	0.000
	(0.008)	(0.010)	(0.007)	(0.005)	(0.010)	(0.007)
female	-2.806	-11.226***	-6.173**	-0.752	0.145	0.464
	(2.767)	(3.217)	(2.642)	(1.078)	(3.179)	(2.877)
finished tertiary education	5.012**	11.384***	-0.097	0.431	0.675	-0.634
	(2.363)	(4.363)	(3.008)	(1.288)	(3.278)	(2.720)
married	6.122***	0.506	2.947	-1.755	3.545	-1.314
	(2.366)	(4.656)	(2.965)	(1.552)	(3.126)	(2.422)
self employed	-5.309	5.521	-1.726	-0.949	0.313	7.786
	(4.146)	(11.389)	(5.152)	(2.816)	(4.238)	(9.617)
not employed	-3.954	5.892	-3.845*	0.357	-7.541**	-7.797***
	(2.453)	(4.367)	(2.214)	(1.694)	(3.549)	(2.842)
EQ5D (unweighted sum score)	-0.066	-0.177	-0.060	-0.037	-0.429***	-0.053
	(0.058)	(0.162)	(0.073)	(0.049)	(0.134)	(0.097)
awareness of outbreaks 2nd quartile	2.205	-1.797	-1.927	-0.136	3.369	1.313
	(2.934)	(5.614)	(3.431)	(1.464)	(4.327)	(3.441)
awareness of outbreaks 3rd quartile	5.368*	-5.915	-3.082	1.875	-1.950	-1.052
	(3.110)	(5.491)	(3.224)	(1.466)	(4.001)	(3.210)
awareness of outbreaks 4th quartile	12.001***	1.290	0.779	4.096*	7.960*	8.111
	(4.249)	(6.139)	(4.135)	(2.234)	(4.352)	(5.127)
no past exposure	-4.127	-7.549**	-4.983	1.616	-18.451***	-2.667
	(4.856)	(3.606)	(3.149)	(1.381)	(5.551)	(2.919)
HRAS-SF 2nd quartile	-0.286	-1.277	5.002	-0.174	-4.952	-0.709
	(2.785)	(4.098)	(3.423)	(1.769)	(4.826)	(3.945)
HRAS-SF 3rd quartile	2.962	0.474	4.490	-0.539	-9.147**	-2.025
	(2.960)	(4.408)	(3.271)	(1.497)	(4.495)	(4.225)
HRAS-SF 4th quartile	4.813	10.836*	5.342	0.967	1.742	-2.246
	(3.682)	(5.911)	(3.590)	(1.845)	(5.063)	(3.651)
Observations	487	450	462	446	419	387
R^2	0.168	0.201	0.109	0.158	0.252	0.160
AIC	4,676	4,571	4,357	3,505	4,019	3,638
BIC	4,747	4,641	4,427	3,575	4,087	3,705
rmse	28.931	38.147	26.519	12.080	28.697	26.047

Notes: Standard errors in parentheses; ∗ p < 0.10, ∗∗ p < 0.05, ∗∗∗ p < 0.01; Outliers defined as WTP over 5% of monthly income and top and bottom 5% of interview length;

5 Discussion

To estimate the value of an early warning system for infectious diseases and foodborne outbreaks, we developed a two-step contingent valuation experiment. This experiment was administered to balanced samples from the UK, Denmark, Germany, Hungary, Italy, and the Netherlands. The results showed that the mean monthly WTP per household was €22.7 (median=€9.3) in the total sample of 3,140 European citizens. This value ranged from €8.6 (median=€3.2) in Hungary to €32.1 (median=€15) in Italy. Results of regressions indicated that WTP increased with income and awareness of outbreaks, while it decreased with age.

Our results indicate that individuals, in general, are willing to pay for an early warning system for infectious diseases aimed to increase (health) safety. However, the standard deviations around the mean WTP estimates are substantial, indicating either diverse, ill-formed or ill-behaved preferences. Not surprisingly, WTP also differed substantially between countries with Hungary at the lower end, mirroring its lower purchasing power. The mean monthly WTP values itself (total mean €22.7, median €9.3) seem to lie within a reasonable range comparable to that of a supplemental health insurance package. This presents a valid comparator to our hypothetical early warning system, as in the case of such types of insurance, individuals are not well informed about the actual risks and benefits.

Regression analysis showed that throughout countries and models, income is the most important determinant of the WTP values elicited in our experiment. Better health status, synonymous to lower risk of getting infected, is associated with lower WTP, while being very aware of outbreak risk increases WTP. These results are in line with what could have been expected beforehand. It is noteworthy though that on a disaggregated level, income is not significant for the UK model if outliers are not excluded (appendix E). This result either implies that respondents did not consider their household income in the valuation process in violation of the survey instructions and economic theory, or that a stable WTP, regardless of income, exists for some individuals. The latter could be explained by the rather small monthly contribution in comparison to household income, i.e., certain individuals would pay a contribution of €10 if they had a monthly income of €2000 or €4000 because they assume this small amount would not conflict with their regular consumption. If WTP outliers are excluded, the coefficient becomes significant (Table 6).

The included "warm-up" WTP exercise eliciting the WTP for the market good shoes provided reasonable results ranging between €61.0 in Hungary and €138.5 in Denmark. We, therefore, believe that the respondents had no difficulties in operating the mechanics of the WTP elicitation exercises. As for the phrasing of the question itself as an additional recurrent tax/contribution, we think that most respondents in the surveyed countries are familiar with similar types of payments, e.g., supplemental health insurance. We, therefore, believe that the setting of the question did not lead to much confusion among respondents.

Although the aspects mentioned above generate some confidence in the validity of our results, we must acknowledge several limitations inherent to our analysis and the contingent valuation approach, which could have influenced our WTP estimates. To address the elephant in the room, we are aware that individual WTP estimates are highly susceptible to the design and framing of the WTP exercise. The reported WTP estimates from this experiment are only one realisation of possible results depending on the design of the WTP experiment (see for example [13]). Already by adding to the question that respondents should also consider other similar contributions in their decision making, we might have introduced a possible anchor point for some individuals [14]. Even more problematic in contingent valuation experiments is the respondent's sensitivity to the chosen payment scale [15], [16]. It has also been reported that valuations are sensitive to framing the payment as a monthly or yearly instalment [17]. To reduce these potential biases in our study, we tested two additional versions of our survey, varying payment scale and frequency of payment, and chose the survey version which provided the internally most consistent results. Central to the decision about which payment scale to use in the analysis were the logical consistency of determinants of WTP values, as well as the responses to the questionnaire module about contents insurance (outlined in section 3.3). We furthermore believe, by asking respondents for a value they would definitely pay and a value they would definitely not pay before the actual valuation, that our WTP responses are less prone to midpoint bias and also less prone to scale sensitivity. The first step provides a broad interval of possible values, without delimiting the final valuation too much. The payment scale additionally did not limit the WTP to integer values, as respondents could specify decimals in the second stage. The previous two points are also the reason why we think that the measurement error due to rounding to the next natural unit after converting currencies is negligible. By including a ”more” option in the payment scale, we furthermore potentially decreased endpoint bias.

An inherent limitation of WTP analysis, in general, is the hypothetical nature of the experiment. Whether respondents would pay the elicited amounts in a real-world manifestation of our setting is at least questionable. Research has shown that such hypothetical WTP questions lead to an overestimation of the actual WTP [18], which also has been demonstrated in the case of the contingent valuation method [19]. Furthermore, the actual unit of valuation, an integrated early warning system for infectious diseases and foodborne outbreaks, also is a hypothetical construct, as it is not in existence yet. The survey included a brief description of its general purpose (appendix A), but we did not provide any more detailed information on the actual functioning and effectiveness of such a system. We do not know about respondents' expectations concerning potential future (health) benefits through such a system. However, as mentioned earlier, individuals do face similar decisions, without knowledge of real risks or benefits, when choosing specific types of insurance packages. In both cases, they include perceived risks and benefits in their decision making. One further possible limitation of our study is the exclusion of individuals aged 65 and above. One could argue that the WTP would be higher in the excluded group as they are in general more vulnerable to infectious diseases. This hypothesis is partly confirmed in some of the regression models by a positive and significant, although very small, coefficient of age-squared.

6 Conclusion

We developed and administered an experiment to obtain the maximum willingness to pay for an early warning system for infectious diseases and foodborne outbreaks. Results from surveys in six European countries showed that in general, households would be willing to contribute to such a system through additional taxation. However, the validity of the size of our estimates is limited by the usual drawbacks of WTP experiments. Nevertheless, our study shows that European citizens see the value of such an early warning system and would not oppose public funding.

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APPENDIX

A Survey information

Figure 2: Information at the beginning of the survey

In any country, increasing the health safety of the population is an important policy goal. Recent infectious outbreaks of, for example, Ebola, SARS, bird flu and salmonella emphasize that this cannot always be realized by countries separately. In particular, such infectious outbreaks could be countered more rapidly by having an international, integrated warning system that helps contain (that is, control or restrain) and mitigate (that is, make something less severe or reduce its effects) outbreaks. Therefore, integrating national warning systems could help to improve the health safety of the population. In this survey we are interested in how you would value this development.

This survey consists of three parts and takes between 15 and 20 minutes to complete. The results will be used for scientific research and policy advice. Your responses will remain anonymous to the research team. Participation is voluntary and you may stop at any moment. In case you decide to stop before the end of the survey, all the information you have provided will be discarded. In this survey there are no right or wrong answers; we are interested in your opinion.

This study is part of a multi-country project. More information about the project can be found on the following website: http://www.compare-europe.eu/.

Do you understand the purpose of this study, are you willing to participate in this survey, and do you give us permission to use your anonymous answers for scientific research purposes?

Figure 3: Information on early warning system

Currently, warnings systems that help contain and mitigate infectious diseases and foodborne outbreaks (such as Ebola, SARS, bird flu, salmonella, etc.) are fragmented. For example, they focus on a specific type of disease or operate within a single country.

Imagine that the protection of people against viruses and bacteria could be improved by establishing an international, integrated warning system that connects and processes information collected by the separate systems. Such an integrated system would make it possible to identify new outbreaks and infections more rapidly, making it possible to intervene faster and prevent potentially harmful health consequences caused by viruses or bacteria in your country.

Establishing and maintaining such an international, integrated warning system is not without costs. Suppose the funding of the contribution of your country to this international system would take place through taxation, paid by all eligible people in your country (above 18 years of age). This taxation would be collected through monthly instalments.

B Two-step Willingness-to-pay approach

Figure 4: WTP question - lower interval

Suppose all eligible people in your country, including you, would have to pay this monthly instalment starting now. Please consider the amounts on the scale below, from left to right, and select the amounts you would definitely be willing to pay per month for having this integrated warning system. Please keep in mind your ability to pay (your net monthly household income) and think of other insurance premiums you currently pay.

£0	£1	£2	£3	£4	£5	£10	£15	£20	£25	£30	£40	£50	£60	£70	£80	£100	£120	£150	£200	more

Figure 5: WTP question - upper interval

Now consider the same amounts below, from right to left, and select the amounts you would definitely not be willing to pay per month for having this integrated warning system. This amount would then be a taxation paid by all eligible people in your country. Please keep in mind your ability to pay (your net monthly household income) and think of other insurance premiums you currently pay.

£2	£3	£4	£5	£10	£15	£20	£25	£30	£40	£50	£60	£70	£80	£100	£120	£150	£200	more

Figure 6: WTP question - open ended question

You have indicated that you would definitely pay € 1 per month and that you would definitely not pay € 10 per month for having an integrated early warning system. Please indicate in the box below the amount between € 1 and € 10 that is closest to the maximum that you would be willing to pay per month. This amount would then be a taxation paid by all eligible people in your country. Please keep in mind your ability to pay (your net monthly household income).

£ (Q2G:1) ....

Figure 7: WTP question - Zero WTP

You have indicated that the maximum amount you would be willing to pay to establish and maintain an integrated early warning system is € 0.

Please indicate below, the reason behind this preference.

- (Q2D:1) Having an international, integrated early warning system is not worth more than € 0 to me
- (Q2D:2) I am unable to pay more than € 0
- (Q2D:3) Government should pay for this
- (Q2D:4) Other reason, namely (please specify) ....

C First stage of WTP elicitation

“Definitely willing to pay” per month in EUR						
	Mean	SD	Median	Min	Max	N
UK	5.9	6.7	6	1	99	553
Denmark	6.5	5.8	6	1	99	514
Germany	6.0	3.9	6	1	20	522
Hungary	4.8	3.6	4	1	20	504
Italy	7.7	7.0	7	1	99	523
Netherlands	6.6	7.1	6	1	99	524
Total	6.2	5.9	6	1	99	3,140

D Regression results stepwise including regressors

	(1)	(2)	(3)	(4)	(5)	(6)
monthly household income (log)	7.479***	7.117***	7.290***	7.286***	5.942***	5.999***
	(1.019)	(1.450)	(1.257)	(1.248)	(1.009)	(1.011)
age	-1.551**	-1.682**	-1.630**	-1.594*	-1.550*	-1.555*
	(0.519)	(0.637)	(0.627)	(0.625)	(0.657)	(0.657)
age2	0.013	0.014	0.013	0.012	0.012	0.012
	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
female	-4.073*	-4.085*	-4.644**	-4.820*	-4.860**	-4.889**
	(1.913)	(1.906)	(1.772)	(1.917)	(1.807)	(1.812)
finished tertiary education	1.335	0.934	1.170	1.130	1.501	1.512
	(2.517)	(2.639)	(2.540)	(2.474)	(2.270)	(2.279)
married		3.309	2.892	2.842	3.408	3.372
		(3.075)	(2.764)	(2.727)	(2.164)	(2.166)
self employed		6.663***	6.488***	6.380***	3.889*	4.233*
		(1.540)	(1.317)	(1.284)	(1.866)	(1.832)
not employed		0.852	0.007	-0.020	-1.331	-1.105
		(2.305)	(1.791)	(1.791)	(1.526)	(1.516)
EQ5D (unweighted sum score)			-0.143	-0.150	-0.133	-0.132
			(0.098)	(0.097)	(0.098)	(0.098)
awareness of outbreaks 2nd quartile			1.650	1.535	1.801	1.904
			(2.586)	(2.633)	(2.604)	(2.583)
awareness of outbreaks 3rd quartile			-0.542	-1.018	-1.039	-0.712
			(1.797)	(1.896)	(2.069)	(1.996)
awareness of outbreaks 4th quartile			9.924**	8.886*	7.841**	8.289**
			(3.700)	(3.859)	(3.038)	(3.010)
no past exposure			-1.211	-1.279	-5.264**	-5.310**
			(3.196)	(3.212)	(1.971)	(1.986)
HRAS-SF 2nd quartile				-0.102	-0.450	-0.334
				(1.059)	(1.410)	(1.396)
HRAS-SF 3rd quartile				-0.599	-1.243	-1.276
				(1.146)	(1.322)	(1.316)
HRAS-SF 4th quartile				3.516	2.718	2.634

				(2.067)	(2.157)	(2.155)

Table 5 continued

Denmark					-1.650	
					(1.023)	
Germany					-2.945***	
					(0.322)	
Hungary					-11.223***	
					(1.273)	
Italy					9.566***	
					(0.486)	
Netherlands					3.559***	
					(0.273)	
masculinity						2.471***
						(0.267)
individualism						-1.083***
						(0.171)
Uncertainty avoidance						-0.757***
						(0.069)
trust in public institutions						12.148***
						(2.288)
Constant	7.597	10.844	20.269	20.519	32.516*	0.547
	(14.330)	(21.011)	(23.278)	(23.320)	(15.629)	(23.153)
Observations	2,772	2,772	2,772	2,772	2,772	2,772
R^2	0.059	0.062	0.076	0.078	0.097	0.096
AIC	28,465	28,456	28,412	28,408	28,350	28,354
BIC	28,495	28,485	28,442	28,437	28,380	28,383
rmse	41.047	41.000	40.715	40.706	40.324	40.343

UK as reference country; Hofstede's cultural dimension aggregated on country level; masculinity increasing from 0-110; individualism increasing from 0-91; uncertainty avoidance increasing from 0-112; trust in public institutions increasing from 0-10 as average from European Social Survey; Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$;

E Regression results all countries with outliers

	(1) UK	(2) DK	(3) GER	(4) HUN	(5) IT	(6) NL
monthly household income (log)	3.152	9.440**	3.897*	3.972**	7.235***	7.891*
	(3.018)	(4.068)	(2.256)	(1.608)	(2.401)	(4.397)
age	-2.049**	-1.635*	-1.211	-1.043**	-4.110**	0.385
	(0.995)	(0.931)	(0.806)	(0.506)	(1.631)	(0.938)
age2	0.017	0.009	0.008	0.009	0.045**	-0.013
	(0.012)	(0.011)	(0.009)	(0.006)	(0.021)	(0.011)
female	-2.515	-11.980***	-7.801***	-1.985	-0.345	-3.313
	(4.529)	(3.225)	(2.732)	(1.321)	(4.679)	(3.868)
finished tertiary education	1.153	12.495***	0.497	-0.256	-0.400	-6.083
	(4.638)	(4.514)	(3.217)	(1.569)	(4.108)	(4.661)
married	8.446**	1.404	3.172	-1.056	10.256**	-5.218
	(3.780)	(4.457)	(3.115)	(1.734)	(4.148)	(4.897)
self employed	6.510	5.258	2.016	0.779	1.382	14.189
	(13.500)	(11.514)	(5.875)	(3.504)	(4.503)	(10.089)
not employed	-5.344	4.560	-3.758	2.032	0.022	-2.373
	(4.401)	(4.172)	(2.477)	(2.037)	(5.481)	(6.728)
EQ5D (unweighted sum score)	0.066	-0.178	-0.036	-0.013	-0.641*	0.004
	(0.088)	(0.159)	(0.075)	(0.060)	(0.339)	(0.152)
awareness of outbreaks 2nd quartile	13.305*	-1.527	-1.723	2.530	2.396	-0.268
	(7.069)	(5.515)	(3.666)	(2.124)	(5.080)	(5.147)
awareness of outbreaks 3rd quartile	6.092	-4.620	-3.228	3.327*	1.165	-1.000
	(3.758)	(5.404)	(3.642)	(1.774)	(4.729)	(5.422)
awareness of outbreaks 4th quartile	14.781***	1.763	1.383	3.744	17.152***	11.779*
	(4.710)	(5.974)	(4.383)	(2.383)	(6.339)	(6.637)
no past exposure	-8.092	-7.856**	-3.452	1.129	-17.813***	-3.708
	(7.718)	(3.693)	(3.317)	(1.695)	(6.749)	(5.495)
HRAS-SF 2nd quartile	3.975	-0.280	2.462	-1.331	-5.687	0.236
	(7.989)	(4.018)	(3.785)	(2.118)	(5.335)	(6.247)
HRAS-SF 3rd quartile	-0.620	2.373	2.408	-1.441	-4.477	-3.869
	(4.687)	(4.438)	(3.699)	(2.143)	(7.870)	(5.606)
HRAS-SF 4th quartile	3.550	12.099**	4.666	1.982	-0.410	-2.889
	(5.702)	(5.958)	(3.910)	(2.592)	(6.279)	(5.903)
Observations	506	456	475	461	461	413
R^2	0.074	0.185	0.092	0.108	0.108	0.110
AIC	5,336	4,643	4,559	3,868	5,040	4,253
BIC	5,407	4,714	4,630	3,938	5,111	4,322
rmse	46.382	38.640	28.873	15.767	56.251	40.868

Notes: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$;