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Willingness to Pay for Mortality Risk Reduction from Air Quality Improvement: Evidence from Urban Bangladesh

Minhaj Mahmud[*], Yasuyuki Sawada[†], and Eiji Yamada[‡]

Abstract

This paper reports on the first attempt to measure the value of statistical life (VSL) in the context of mortality risk from air pollution in urban Bangladesh, using the contingent valuation (CV) method. The CV survey was conducted in 2013 in Dhaka and Chittagong, the two most densely populated cities in the country. We asked individuals willingness to pay (WTP) for mortality risk reduction from air quality improvement program and found that willingness to pay is correlated with the socio-economic characteristics, health status, and risk perception of the respondents, consistently with existing studies. The bootstrapped mean of VSL is ranged from 17,480-22,463 USD in purchasing power parity terms, which is equivalent to 9.78-12.57 times of GDP per capita of Bangladesh. Considering our study setting, the results we obtained may be regarded as a lower bound of VSL estimates in the context of environmental risk reductions in Bangladesh.

Keywords: value of statistical life, willingness to pay, contingent valuation, air pollution, Bangladesh

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1. Introduction

Bangladesh is one of the most densely populated countries in the world, and has been observing rapid urbanisation in recent decades. From 1996 to 2016, Bangladesh's urban population has grown by 113%, from 27 million to 57 million, while total population add 34% during the same period. The urbanisation rate reached to 35% in 2016 from 22% in 1996[1]. The country's largest cities, such as Dhaka and Chittagong, are extremely heavily populated. For example, Dhaka city is a one of the densest cities in the world having 14.5 million people in its Statistical Metropolitan Area with population density reaching about 130 thousand per square kilometre in some part of the city.[2]

Rapid urbanization in such an overly populated country often creates serious health related risks from various sources. According to Landrigan et al. (2017), 9 million people died from environmental pollution across the world, thus 1 in 6 deaths is caused by pollution worldwide. People of Bangladesh, especially those living in urban areas are increasingly exposed to such risks. The latest Environmental Performance Index published by Yale University ranked Bangladesh as the 8th worst among 180 countries. In terms of air pollution, the country is ranked as the worst in the world (180th).[3] Recent World Health Organization data reveal that the air quality in Dhaka reaches a yearly average of 90 $\mu g/m^3$ of PM2.5, which is 9 times as high as the WHO's safety standard level.[4] Obviously, there is an urgent need for strong public interventions to control current severe air pollution.

Quantifying the welfare cost of air pollution is a crucial step in motivating policy-makers to appropriately prioritize environmental control. While it is not necessarily easy to obtain reliable estimate for the welfare loss from fatalities (or morbidity) due to air pollution,

[1] https://data.worldbank.org/indicator/SP.POP.TOTL?end=2016&locations=BD&start=1995
[2] http://www.citypopulation.de/php/bangladesh-dhaka.php
[3] http://epi.yale.edu/country/bangladesh
[4] http://breathelife2030.org/city-data-page/?city=110

among a few popular methods, the contingent valuation (CV) method, which employs hypothetical scenarios and asks the respondents' willingness-to-pay (WTP) for a risk reduction scheme, remains a popular approach for quantifying the benefits from such risk reduction.[5] In the context of mortality risk, an individual's WTP for mortality risk reduction can be converted to the value of a statistical life (VSL) by dividing the stated WTP by the magnitude of risk reduction in question (see Hammitt and Graham, 1999).

CV studies on fatal risk reduction has been mainly conducted in developed countries.[6] Environmental hazards including ambient pollution are among the popular scenarios of the cause of death in existing studies in developed countries, among others, such as traffic accidents and diseases (OECD, 2012). However, in developing countries regardless of the cause of fatal risk, fewer studies have been conducted for measuring the WTP for mortality risk reduction using the contingent valuation method (e.g. Mahmud, 2009). CV studies on mortality risk caused by environmental pollution is especially limited in the context of developing countries. China is the most studied country in the developing world, with relatively large number of published researches (e.g. Wang and Mullahy, 2006; Hammitt and Zhou, 2006; Guo et al., 2007).[7] Other

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5 There is a emerging literature that exploits exogenous shocks to assess the cost of air pollution or benefit of reducing air pollution. For example, Chang et al. (2016) use an exogenous fluctuation in PM2.5 monitoring records to estimate the impact of air pollution on worker's productivity. They find that the benefit of reducing pollution is sizeable; the decline of PM2.5 concentration happened during 1999 and 2008 resulted in generating nearly 20 billion USD in benefit. Reviewing the recent evidence on the negative impact of air pollution on labour market performance and human capital accumulation, Zivin and Neidell (2018) argue the importance of a huge economy-wide benefit of clean air that reduces less-severe health hazards to normal and healthy people.

6 A few reviews and meta-analysis papers have been published on contingent valuation for pollution related mortality risk, such as OECD (2012), Kochi et al. (2006), Desaigues et al. (2011), Dekker et al. (2011), and World Bank and Institute for Health Metrics and Evaluation (2016), which rely on studies conducted in developed countries. On VSL studies including those using revealed preference approach, there are several meta-analysis papers, such as Robinson (2017); Masterman and Viscusi (2018); Narain and Sall (2016); Viscusi and Masterman (2017a,b); Lindhjem et al. (2011); Hoffmann et al. (2017); Viscusi (2017), that discuss the extension of the scope to the context of developing countries.

7 More studies are found for China regarding WTP for air quality improved policies, as summarised in Wang and Zhang (2009). However, in those studies, life saving scenario is not explicit and the VSL is not reported (except for Wang and Mullahy (2006); Guo et al. (2007)). Wang and Zhang (2009) conducted survey in April 2006 in 5 urban districts in Ji' nan city, China. Their scenario was an improvement in the city's air quality from Class III status (at the time of survey) to Class II in the Chinese standard. There was no life-saving implication in the scenario and they obtained 100 Chinese

countries include India (Bhattacharya et al., 2007), Turkey (Tekesin and Ara, 2014), Thailand (Vassanadumrongdee and Matsuoka, 2005; Gibson et al., 2007), Mongolia (Hoffmann et al., 2012), and Brazil (Arigoni Ortiz et al., 2009). Consequently, estimates of VSL in emerging and developing countries is scarce. In Table 1, we summarize the findings from the above mentioned studies.[8]

There exists a handful of studies focusing on VSL in the context of Bangladesh using different methodological approaches. One approach is using the benefit transfer method, by extrapolating the estimates obtained from meta-analysis of surveys conducted in developed countries. For example, Miller (2000) suggests that a Bangladeshi VSL lies in the range between USD30, 000 and USD1, 000, 000, or 131 - 2,762 times of per capita GDP. Robinson et al. (2017)'s benefit transfer estimate for Bangladesh is 142,709 USD (in 2015 international dollar), based on the international research using stated preference method. Viscusi and Masterman (2017b) instead provides a benefit transfer estimate from the revealed preference studies in the U.S. that gives 205,000 USD.

Apart from benefit transfer examples, Mahmud (2009) is the first and only example of CV studies focusing on VSL using field survey in rural Bangladesh. However, the scenario used was reductions in mortality risk by a vaccination program that would reduce the respondents' mortality risk either by 25% or 50%. His estimates of mean VSL for rural Bangladeshis rages from 103,074 Taka to 168,905 Taka (from 3.55 times to 5.82 times of GDP per capita).[9]

In the context of willingness to pay for environmental improvement (which is not necessarily linked to mortality), only one published study, to our knowledge, is Khan et al.

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yuan of WTP to this pollution reduction problem (with 49.3% zero-WTP).

8 See also Figure A2 and Table C1 in Robinson et al. (2017) for the list of studies on VSL in developing countries (not limited to environmental context).

9 As noted in the study, however, the purpose was rather methodological than providing a policy relevant VSL, in that the study test the effectiveness of training on probability and risk on individuals WTP for risk reduction and the offered risk reduction was rather large resulting in much smaller VSL estimate compared to other international studies.

(2014) that estimates WTP of Bangladeshi households for arsenic safe drinking water, by applying a double discrete choice value elicitation approach. On average, households are willing to pay about 5 percent of their disposable household income for getting access to arsenic safe drinking water.[10]

To our knowledge, there is no study eliciting WTP for fatal risk reduction from air pollution in the context of Bangladesh. To bridge this gap, we conducted a CV survey to elicit individuals WTP for a reduction of mortality risk from air pollution in Dhaka and Chittagong, the two largest cities in Bangladesh.[11] Ten sampling clusters were chosen from two cities (seven from Dhaka and three from Chittagong), and a total of 1,000 household heads were randomly selected for a face-to-face interview. A hypothetical scenario on reducing mortality risk from air pollution was explained and their willingness-to-pay was obtained using open-ended questions. We prefer open-ended questions to closed-ended ones because they provide more information, and are less prone to overestimation (see Mahmud, 2009). We obtained 994 valid answers for the WTP questions which were used in regression analyses to reveal the relationships between WTP and respondents' attributes such as age, income, education, health condition, and perception of pollution risks to their health. The measured WTP are associated with individual characteristics in similar ways as in past studies. Based on the regression analysis, we employed bootstrap resampling to estimate the mean and median WTP as well as those confidence intervals. The mean VSL is ranged from 17,480 to 22,463 USD in PPP, which is equivalent to 9.78-12.57 times GDP per capita in the same year.

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[10] Their purpose is to measure WTP for practical alternatives to reduce risk of arsenic exposure, and mortality risk reduction is not directly taken into the scope of study.

[11] These large cities severely suffer from environmental pollutions, mainly due to the emissions from vehicles. For example, according to Bangladesh Statistical Pocket Book 2007 published by the Bangladesh Bureau of Statistics, it is estimated that air pollution causes 15,000 premature deaths in Dhaka per year, implying that 125 people out of 10,000 die from air pollution in Dhaka every year.

Our study may be subject to several types of bias. The first concern is scope bias as we do not explicitly test for the sensitivity of stated values to the magnitude of risk reduction assumed. Given that the magnitude of risk reduction we set (5 in 10,000) is relatively larger than what is used in the existing international examples, VSL in our case is likely to be underestimated. Furthermore, in our hypothetical scenario, fatal risk originates from "environmental" source and it is reduced by a "public" intervention by the government. As revealed by OECD (2012), "environmental" and "public" provisions in the risk scenario significantly reduce the stated VSLs. Therefore, our scenario is by construction leaned towards having lowered estimates for the VSL. Taking this background into account, we argue that the estimate should be carefully interpreted as a potential "lower bound" of VSL in the context of environmental risk reduction in Bangladesh.

The remaining part of this paper is structured as follows. In Section 2, we introduce the study design including the details of data collection and description of data. Section 3 explains the empirical strategies to estimate the determinants of WTP then describes the results, followed by the estimation of the average and confidence interval of the mean and median VSL by using sample bootstrapping. In Section 4, we discuss the validity of our estimates. The final section concludes the paper.

2. Study Design

This study benefits from a household survey conducted by the JICA Research Institute in the selected areas in Dhaka and Chittagong, from June 6 to July 17 in 2013.[12] Total 11 enumerators trained by ERG conducted face-to-face interview by visiting the house of each respondents randomly sampled as described below. The main purpose of the survey was to collect the data on people's stated preferences for hypothetical risk reduction programs implemented by the

[12] The survey was implemented by the Economic Research Group (ERG) based in Dhaka.

Table 1: Existing Studies on VSL in Developing Countries

Authors	Cities/Survey Year/Sample Size	Mortality Risk Context	Implied VSL	Ratio of VSL to Annual Income
Wang and Mullahy (2006)	Chongqing (China) / March 1998 / 500 residents (482 valid ans.)	5/100,000 reduction of mortality risk by air pollution	286,000 CNY (102,509 USD in PPP)	80 times
Hammitt and Zhou (2006)	Beijing, Anqing, rural Anqing (China) / July 1999 / 3,700 adults	Mortality risk reduction by air pollution from 70/10,000 to 10/10,000 or 20/10,000 (Double-bounded, dichotomous-choice)	4,220 USD (Lowest estimated median for Anqing) to 16,900 USD (Highest estimated median for Beijing)	2.5 times (Anqing), 6.3 times (Beijing)
Bhattacharya et al. (2007)	Delhi (India) / Oct-Dec 2005 / 1,200 adults	Multiple scenarios in the context of traffic accident risk: Risk reduction ranging from 4/100,000 to 30/100,000.	1.3 million Rupees (150,000 USD in PPP) for the most exposed respondents	9.6 times
Tekesin and Ara (2014)	4 cities in Turkey in June-July 2012/ 1,248 adults	Discrete choice experiment across 4 fatal risks (lung cancer, other cancers, respiratory diseases, and traffic accident): Risk reduction ranging from 1/10,000 to 8/10,000, per year.	0.74 mil TL (0.49 mil USL in PPP)	39 times
Mahmud (2009)	30 villages in rural Bangladesh in 2003. 780 household heads	reductions in mortality risk by a vaccination program: Reduction of risk either by 25% or 50%.	103,074 Taka to 168,905 Taka	From 3.55 times to 5.82 times
Vassanadumrongdee and Matsuoka (2005)	Bangkok (Thailand)	Mortality risks from air pollution and traffic accidents	0.74-1.32 mil. USD (Air Pollution) 0.87-1.48 mil. USD (Traffic)	314 times (for lower estimate for air pollution)
Gibson et al. (2007)	Rural villages in Thailand / Sept 2003 /	Comparison of two scenario villages with different mortality risks from landmine explosion (comparing risk of 4/10,000 and 2/10,000 per year)	0.25 mil. USD	397 times
Hoffmann et al. (2012)	Ulaanbaatar (Mongolia) / Winter 2010 / 629 people aged over 40 years old.	5/10,000 and 10/10,000 mortality risk reduction by policies to mitigate air pollution (various scenarios for checking scope validity are included)	0.50 mil USD for latent (cancer) risk 0.57 mil. USD for contemporaneous (resp. Disease) risk	257 times and 293 times, respectively
Arigoni Ortiz et al. (2009)	Sao Paulo (Brazil) / March 2003 / 283 literate employees in middle or higher social class	5/1,000 mortality risk reduction from air pollution over 10 years	0.77 mil. USD (median estimate), 1.31 mil. USD (mean estimate)	258 times (for median estimate)

Note: Annual income used in the last column is the average income of survey respondents.

government. The total number of surveyed households was 1,000, with 700 from Dhaka and 300 from Chittagong.

2.1 Questionnaires

Stated preferences for mortality risk reductions were elicited through the two sections in the survey questionnaire. The first section conducted a choice experiments among multiple risk reduction programmes that were hypothetically designed to reduce mortality caused by several type of risks (namely, traffic accidents, air pollution, water pollution, and maternity). In the second part, the respondents were asked their willingness to pay for a government scheme to reduce air pollution in Dhaka (or Chittagong) that will reduce the risk of dying from air pollution. The program was framed as a government intervention to control vehicle maintenance to reduce pollutant emission from motorized vehicles, which can reduce the mortality rate in each city from 125 per 10,000 persons to 120 per 10,000.[13] In this paper, we analyze the second part of the stated preference survey focusing on WTP for mortality risk reduction from air pollution.

The enumerators explained to the respondents that the annual death caused by air pollution in Dhaka counts 15,000, and that this number means that 125 people out of 10,000 dies from air pollution per year given the population of Dhaka (12 million). Then, we gave a hypothetical policy scenario that could reduce the mortality risk from 125/10,000 to 120/10,000, though government intervention to control vehicle pollutant emission. The WTP is directly measured through the following two questions:

Q1: "If you are told that the death risk in Dhaka due to air pollution can be reduced by a government initiative from 125 out of 10000 to 120, would you then spend for it?"

Q2: (For the respondent who answered "yes" to Q1) "What is the maximum amount which you would be willing to pay annually to decrease your yearly death risk from 125 out of 10000 to 120?"

For the respondent who answers "No" to the first question, the enumerator asks why he or she does not want to pay for the program.[14]

Before the respondents stated their preference on risk reduction programs, they were asked to answer around 70 questions on their socio-economic characteristics and preferences,

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[13] The government of Bangladesh has already carried out reforms in the auto-rickshaw (three-wheeler) sector in Dhaka to reduce air pollutant emissions. In 2003, it forced the owners to replace petrol engines to CNG (compressed natural gas) engines. This transformation was well implemented and Bangladeshi citizens are quite aware of that success.

[14] Note that the magnitude of mortality risk reduction was a change of 0.05 percentage points. This is ten times larger than the scenario used by Wang and Mullahy (2006) for Chongqing, China, but much smaller than Mahmud (2009) used for rural Bangladesh.

such as; household demographics, income and expenditure, asset holdings, incidence of death and sickness, victimization experiences from accidents and other misfortunes, health conditions (current condition as well as chronic disease history), smoking behaviour, and perception about the health risk caused by environmental pollution of their residential areas. Just before they entered the stated preference part, we provided training on the concept of probability and risk reduction, followed by a test for ensuring the respondents' understanding. The language of implementation was Bangla and the questionnaire was field tested and revised to facilitate understanding before the survey was conducted. To motivate their responses, a small gift was offered to the respondents.[15] The questionnaire is provided in the Appendix.

2.2 Sampling Design

We conducted a stratified-cluster sampling for the two largest cities in Bangladesh, Dhaka and Chittagong. Each city had three strata, based on the situation in surface water pollution level. Out of six strata, two strata in Dhaka had three sampling clusters in each.

Therefore, the total number of clusters was ten. 100 households were selected at random from each stratum, to construct the 1,000 sample households.

2.2.1 Selection of Strata and Clusters

As we focused only on major urban areas where people are more exposed to environmental risks compared to rural areas, the selection of survey clusters in Dhaka and Chittagong was based on actual level of environmental pollution to understand urban dwellers' preferences for risk reduction. At the time the survey was conducted, there was no information available for the spatial variation of air pollution within these cities. However, for water pollution, geographically

[15] The Gift is worth of 100 Taka either in cash or equivalent in kind, depending on the respondent's choice. 75% received cash, 20% received a gift, 1.5% were indifferent, and 1.5% declined to accept cash or a gift

detailed information was available both for Dhaka and Chittagong. For Dhaka, World Bank (2006) identified water pollution level in different areas in Dhaka based on Biochemical oxygen demand (BOD). BOD is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period. BOD exceeding 6 *mg/l* implies that the water is polluted and not acceptable as pure drinking water. Depending on the level of BOD, the areas were categorized as Red, Orange, Yellow and Blue.

The regions marked as Red represent the areas that have the most polluted water sources in Dhaka. The Red regions denote the presence of BOD, 500% beyond the standard (6 *mg/l*). Areas near the Buri ganga river, including Fatulla, Kutubpur, Shyampur, Sutrapur, Kotwali, Lalbag, Kamrangirchar, Hazaribag, Adabar, Gabtali; areas near Tongi bridge, including Machimpur, Abdullapur, Tongi bazar, Natun Bazar, Rajabari, and areas near the Balu river, including Kayetpara, Balurpar, Baburjayga, Tejgaon, Kahelpara, Sarulia, Kanchpur, Siddhirganj, Sona mia bazaar are marked as Red. Out of these areas, three, Kamrangirchar, Tongi bazar, and Hazaribag, were randomly selected for the survey. This is our first sampling stratum and we refer this as "Dhaka-Most Polluted" stratum in what follows. From this stratum, three sampling clusters were randomly selected, giving 300 respondents in total.

The Orange regions represent mildly polluted areas attached to water bodies and correspond to 200-500% beyond the standard level of BOD. Areas near the Turag river including Shah Ali, Solahati, Mhimaghar, Diabari, Nalbhog; areas near the Sitalakhya river, including Sombaria bazar, Nabigonj bazar, Dankunda bazar, Hajiganj, Nabinagar, Kashipur, Baktabali bazar, Bhabaniganj; other areas near the Sitalakhya river including Noapara bazar, Rupsi bazar, Purbagaon, Chhatian, Ulaba, and Kayetpara; and areas near the Balu river including Gobindapur, Talia, Rayer dia bazar, Palashia, Bhaturia, and Purbachal are marked as Orange. Three of these regions, Shah Ali, Diabari and Nabinagar were ran- domly selected for the survey. We label this stratum with three clusters (300 respondents) as "Dhaka-Medium Polluted" stratum.

The yellow regions correspond to less polluted water bodies containing 100-200% BOD beyond the standard BOD level. This region was skipped due to the fact that pollution variation is captured in Red and Orange regions. The blue regions have the least polluted water sources within the BOD standard which are acceptable as sources of drinking water after conventional treatment. Maniknagar is randomly chosen from the Blue stratum. This stratum is a singleton cluster.

For Chittagong, the selection of the sampling cluster is based on the information provided by a previous study of surface water quality in Chittagong (Zuthi et al., 2009). Chittagong Water Supply and Sewerage Authority (CWASA) has divided its water supply network into four routes. Zuthi et al. (2009) conducted an assessment of the water quality in all the four routes. All the water samples collected from the different routes of CWASA distribution had BOD5 concentrations greater than the permissible value of 0.20 parts per million (ppm). Among the four routes, the Route 2 was found to be most severely polluted with average BOD5 level of 5.2 ppm. From the Route 2, Shershah Colony is randomely selected for our survey cluster.

Route 1 was the second most severely polluted water route in Chittagong. The BOD5 concentration level was 3.6 ppm. From this route, Garibullah Shah Majar Road area was randomly selected for the survey. The Route 4 was the least polluted among the four routes, and an area consisting of Riazuddin Bazar and Enayet Bazar was randomly chosen from this route.

In summary, we set six strata based on city and water pollution levels, with three strata in each city corresponding to the most-polluted, medium-polluted, and the least-polluted sections of the city. We draw ten sampling clusters from these strata. For the first two strata, Dhaka-Most Polluted and Dhaka-Medium Polluted, we have three clusters in each stratum. However, the remaining four, we have only one cluster in each stratum, making these “singleton” strata.

Both World Bank (2006) and Zuthi et al. (2009) cover only the areas nearby water route such as river, canal, and lakes. Since the random selection of clusters are made from the list of areas found in these two environmental studies, our cluster sampling frame does not correspond to either administrative or statistical area in Dhaka and Chittagong. In addition, the areas are not strictly defined, which means that the basic information necessary to construct a sampling frame such as area size, boundary, and population were missing. Therefore, our sample only roughly represents the urban and suburban population living nearby surface water, and it is impossible to put sampling weights to produce strict representativeness.

2.2.2 Random Selection of Respondents

From each of the selected clusters in Dhaka and Chittagong, 100 households were drawn randomly. As explained above, we did not have the documentation of sampling frame such as total population in each area. In practice, randomization was carried out by a "random walk" of enumerators, starting from a randomly chosen house and selecting the next household at a fixed X-th interval. Depending on the approximate total number of households in these areas, the randomization criteria such as choosing every 3rd or 5th or 7th or X-th household was selected on the spot. In the case of rejection, the enumerator was asked to move to the next household and follow the randomization accordingly.

Basically, the interval X set by enumerators for their random visits of household was larger for the areas with more households. This implies that the probability of being selected for a sample was smaller (i.e. weight should be high) for the populated area. This sampling method roughly ensures that the total area is equally covered within each cluster. However, we unfortunately do not have sufficient information on the population of our sampling clusters. Furthermore, we cannot identify in which cluster the enumerator chose which skip rule (i.e. the interval X) for selection of households. Under such condition, it is impossible to calculate the sampling weight to recover the national or city-level representativeness, and our estimate may therefore be biased from the population statistics at the national level or city level.

2.3 Description of the Data

Table 2 summarizes basic statistics of the variables used in the analysis. Out of total 1,000 respondents, 271 answered "No" to Q1, the question whether they have a willingness to pay for the hypothetical government program to reduce mortality caused by air pollution either in Dhaka or Chittagong (framed depending on the place of survey). However, among the 729 who said "yes" to Q1, there are 16 respondents who failed to appropriately answer Q2 which asked them to specify the amount they would be willing to pay. Out of those 16, 10 are revealed to have been miscoded as "yes" for Q1 despite the true answer was "no". The remaining 6 respondents seem to have answered "yes", but that was not successfully recorded to Q2. Thus, by dropping these 6 unsuccessful observations, the number of observations appropriate for analysing the WTP became 994. The number of respondents who said they were willing to pay (Q1) and specified the amount (Q2) was 713 out of 994 (71.7 %). The mean value of log WTP is 5.465, corresponding to 236.3 Taka by taking exponential.

The average log per capita expenditure was 8.384 (its exponential value is 4376.5 Taka).[16] This is equivalent to 168.6 USD in PPP of 2011 price, 50 % higher than the national average of 112.2 USD according to the PovcalNet of the World Bank. This is reasonable because we only sample from the urban population. The mean log age is 3.51 (its exponential is 33.4). About 61% of respondents were male. More than 60% of respondents completed at least primary school and were literate. Among them, 22.1% had tertiary or higher degrees.

The main monetary cost item associated with the damage from air pollution is medical care. Therefore, the level of household's medical expenditure might be related to its willingness to pay for pollution reduction measures. The average share of medical care in total monthly expenditure was 8.7 percent. As many as 29.0% regularly or sometimes smoked.

[16] In terms of income earned, 64% falls in the middle-income class with their earnings being greater than 10,000 Taka but less than 30,000 Taka monthly. More than a quarter of sample households earned incomes greater than 30,000 Taka. Since income data is collected only by asking in which income bracket the respondent's household falls, we use monthly expenditure per capita as a proxy for the household' monetary earning in what follows.

We also collected respondents' perceptions regarding a few urban health risk factors, such as water quality and air quality. For water quality, the average score on the health risk they perceived from the neighbourhood water was 2.03, almost around the second lowest ranking where the score is scaled from 1= very low risk to 5 = very high risk, and 2 is put a description as "some risk". Regarding air quality, perceived risk on health is higher than that for water with the average score was 2.39, which is in between "some risk" and "moderate risk". The perception of own health condition as well as disease experiences were also recorded. The average self-reported health score was 3.4, lying in between "fair" and "good". A bit surprisingly, many has had suffered from chronic diseases; 57.4% answered that they experienced undesirable health conditions such as asthma, respiratory disease, bronchitis, chronic cough, diabetes, heart disease, of high or low blood pressure.

Since air pollution mitigation policy to reduce fatal risk is basically a public policy with strong externality, social capital of individual citizen might be relevant in determining whether and how much he or she wants to contribute. For the proxy of social capital, we adopted a popular GSS Trust question by asking respondents' degree of agreement with the statement "Most people can be trusted", which measures the level of interpersonal trust.[17] The score is scaled from 1 = "strongly disagree" to 6 = "strongly agree". The average score was 3.59, which means that people are almost neutral about this statement.

Column (6) of Table 2 shows the design effect for each variable, which is the ratio of the variance when our complex sampling design is taken into account, to the variance assuming simple random sampling. Design effect varies across variables, ranging from 0.17 to 13.52. In general, design effects gets larger as intra-cluster correlation grows. While there are several variables for which our sampling design outperform random sampling, it should be noted that variables which

[17] The detail of this variable is explained in Mahmud and Sawada (2018).

is likely to be geographically correlated tend to have large design effect, such as expenditure, highway travel frequency, and perception to health risk by environmental hazards.

Table 2: Descriptive Statistics

VARIABLES	VARIABLES Description	(1) N	(2) mean	(3) sd	(4) min	(5) max	(6) DEFF
Dependent variables							
Yes	Have Positive Willingness to Pay	1,000	0.713	0.453	0	1	2.28
l_WTP	Willingness to Pay (log)	713	5.465	1.589	1.609	10.60	0.50
Explanatory Variables							
l_pc_exp	Per capita expenditure (log)	995	8.384	0.550	6.695	10.36	3.98
l_Age	Age (log)	991	3.513	0.318	2.890	4.369	0.55
Male	Male	1,000	0.609	0.488	0	1	2.15
l_HHsize	Household Size (log)	998	1.500	0.397	0	3.611	0.93
Nchild	Number of Children under 5	999	0.514	0.682	0	4	0.36
mededuc	Medium Education Attainment	1,000	0.386	0.487	0	1	1.95
higheduc	High Education Attainment	996	0.221	0.415	0	1	0.40
Trust	Most people can be trusted (6 scales; 6 = strongly agree)	997	3.587	1.577	1	6	2.73
lifesat	Degree of life satisfaction (10 grads; 10=very satisfied)	999	7.388	2.146	0	10	1.13
religious	degree of religiousness	1,000	0.639	0.481	0	1	0.96
toilet_share	sharing toilet with other HH	1,000	0.495	0.500	0	1	2.20
mob_adult	mobile per head	997	0.585	0.334	0	3	1.64
TV	Having TV	1,000	0.853	0.354	0	1	1.56
agLand	Havig agricultural land	1,000	0.326	0.469	0	1	0.58
l_highwayFreq	highway travel frequency (times per year, log)	999	2.279	1.862	0	5.481	5.21
meanTransp	having means of transportation	1,000	0.197	0.398	0	1	1.15
medishare	Medical expenditure share	997	0.0868	0.114	0	0.775	0.61
smoking	Smoking (Regularly or Sometimes)	1,000	0.291	0.454	0	1	1.98
health1	Self-reported Health (5 grades; 5=very healthy)	996	3.405	0.782	1	5	0.63
health2	Health Condition (Chronic Disease)	1,000	0.574	0.495	0	1	1.16
AfDW	Affected by Drinking Water	1,000	0.187	0.390	0	1	0.57
AfResp	Affected by Resp. Disease	1,000	0.189	0.392	0	1	0.63
victAcc	victimized by traffic accidents (self/hh/friends)	1,000	0.293	0.455	0	1	0.21
witnessAcc	witnessed traffic accidents last year	1,000	0.354	0.478	0	1	1.11
sickold	Sick elderly in hh	1,000	0.232	0.422	0	1	0.41
lostchild	having lost child	1,000	0.196	0.397	0	1	1.84
matdeath	any maternal death in HH	1,000	0.237	0.425	0	1	0.49
misfortune	victimised by misfortune (theft, disaster, etc.)	1,000	0.259	0.438	0	1	0.64
pRwater	Perceived Health Risk from Neighbourhood Water Quality	995	2.033	1.228	1	5	13.52
pRair	Perceived Health Risk from Neighbourhood Air Quality	996	2.387	1.296	1	5	4.98
pRroad	Perceived Risk of Road Safety	991	2.886	1.371	1	5	3.82
diff_choice	Feeling difficult to answer (Fatigue)	1,000	0.469	0.499	0	1	2.07
negative	negatie feeling to the interview	1,000	0.266	0.442	0	1	0.19
rec_cash	Prefer cash	1,000	0.751	0.433	0	1	0.54
rec_gift	Prefer gift	1,000	0.192	0.394	0	1	0.17
suv_dur	survey duration (minutes)	1,000	120.0	11.27	87	151	0.55

Mesurement units are in the parentheses of the second column. Variables without measurement units are binary variables. DEFF refers to the design effect: the variance when taking the sampling design into account divided by the variance when simple random sampling is assumed.

3. Estimting Determinants of WTP

Using the data presented in the preceding section, we first estimate the determinants of WTP consisting of the determinants of probability to agree to pay for pollution reduction policy and the determinants to the amount of WTP conditional on having any willingness. We employ the commonly used "Two-part model" estimation. This approach (Duan et al., 1983; Wang and Mullahy, 2006; Hammitt and Zhou, 2006) is used to separately estimate (i) the probability of "yes" to the question of whether the respondent has a willingness to pay, and (ii) the amount of WTP conditional on positive WTP. The first part, we estimate the following equation by Probit.

$$\text{Prob}(\text{WTP} > 0) = f_1(x_1\beta_1) \qquad (1)$$

In (1), X_1 summarizes the vector of determinants. The second step is the estimation of WTP amount conditional on $WTP > 0$. Our estimation equation is the OLS as below:

$$\ln(\text{WTP}|\text{WTP} > 0) = f_2(x_2\beta_2) \qquad (2)$$

The vector of determinates, X_2 can be different from X_1. In the following analysis, we use a common variable set, $X = X_1 = X_2$.[18]

As explained above, our sampling is stratified and clustered. Therefore, estimation should respect the complexity of the sampling design. Since the sampling weight attached to each cluster is not recoverable, we compare the results across different sub-samples, to grasp potential bias from unweighted aggregation. Furthermore, another technical difficulty arises

[18] As a robustness check, we estimate the "Type-II Tobit" specification so that we can verify whether the endogenous selection to answer the second part of the questionnaire (the amount) matters for the results. The estimation Results were very similar to the Two-Part model results presented in the paper, and are therefore not shown in this text for the sake of space.

from the small number of clusters, where we have only three clusters in two strata in Dhaka, and remaining six strata are singleton with only one cluster. As pointed out by Cameron and Miller (2015), when the number of cluster is very few (below 30), standard bias correction methods for the standard errors, such as White heteroskedasticity robust variance-covariance matrix estimator, cannot always mitigate the over-rejection problem. For the estimation of standard errors, we use the “wild cluster bootstrap” procedures according to the recommendation in Cameron and Miller (2015). More specifically, “score wild bootstrap” by Kline and Santos (2012) is used for the probit estimation, and “wild bootstrap procedure” of six-point version proposed by Webb (2014) is used for the linear estimation of WTP amount.[19]

3.1 Regression Results

Table 3 and Table 4 summarise the results of estimating equation (1) and equation (2), across different sub-samples. Each column corresponds to a sub-sample we analyse. The standard errors or p-values are not shown for the sake of space, while the star indicates the level of significance calculated using wild cluster bootstrap methods as explained above. Column (1) is for all the sample when ignoring the strata and treating the clusters as 10 independently and randomly chosen ones. Column (2) restricts the analyses to the seven clusters from Dhaka, ignoring the strata within them. Column (3) is the same for Chittagong. Two strata in Dhaka, Dhaka-Most Polluted and Dhaka-Medium Polluted, have three clusters in each, enabling us to use the wild bootstrap methods. The results for the Dhaka-Most Polluted stratum are shown in Column (4), and those for the Dhaka- Medium Polluted stratum are in Column (5).

In general, we find a consistent pattern of estimates on expenditure, age, and educational attainment. These three variables are the basic ones which are usually included in the existing studies in other countries. The signs of our estimates are in line with those past studies; positive

[19] In estimation, we benefit from a STATA command “boottest” (Roodman et al., 2018) for bootstrapping.

coefficient on the expenditure, negative on age, and positive for the educational attainment. The significance of the coefficients varies across the sub-sample.

We included some unique variables and examine their relationship with the respondent's WTP. The first set of variables are related to the respondents' attitude towards life and social relationship, measured as trust, life satisfaction, and religiousness. Trust is negatively associated with the probability of having a willingness to pay as in Table 3. Its coefficients are significant when estimated overall the samples as in column (1), only for Dhaka (column (2)), and for Chittagong (column (3)) in Table 3. For the amount of WTP conditional on having any willingness to pay, trust does not show consistent results across different sub-samples. Life satisfaction seems to have positive relationship both in the selection and level equations, while results are not conclusive because they are insignificant for most of the sub-samples.

Variables related to the respondents' asset holding are also included, namely, the number of mobile phones per adult, possession of TV, agricultural land, and means of transport such as motorbike and car. Asset holding is in general related positively to WTP. Especially, in the level equation estimates shown in Table 4, number of mobile phones and possession of means of transport consistently and positively significant across different sub-sample specifications. This implies that the asset variables can improve the model's explanatory power, while these asset holding variable are correlated with income variables alone.

We asked the respondents' frequency of using highway. This is the log of the number of travels the respondent has made during past one year. Interestingly, this variable consistently has a positive coefficient for both the selection equation and the level equation, with significance for multiple cases. Potentially, this might happen because the variable is capturing the respondent's type of job or wealth which cannot be fully captured by the expenditure and asset variables.

Since mortality risk from air pollution is closely related with health, we examine the association between WTP and a series of health related variables, including health related activities such as medica expenditure share and smoking, self-reported health status, and objective health status as the incidence of chronic illness and air/water-borne diseases. There is no outstanding variable with a strong relationship to WTP, either in the selection or in the level equation.

We include variable related to the respondents' experience on misfortunes so that we can capture the potential impact of such experiences on WTP through affecting theirrisk preferences. In general, none of the variables is very distinct in explaining the relationship both in the selection and level equations. Being a victim of an accident is positively (but insignificantly) related to the probability of having positive WTP in the selection equation. Contrarily, having a sick elder member in household is consistently negatively related.

Regarding the respondents' risk perception on the residential environment, high perception of water and air pollution may be positively related to the amount of WTP conditional on having any willingness to pay.

These three sets of variables, related to health, misfortunes, or environment, can capture the respondents' perception on probability of dying which is positively associated with the VSL in theory, as described in Hammitt (2017). The results indicate that the first two category of variables does not seem to strongly support this hypothesis, while it could apply to the third category which is directly related to environmental pollution, the issues the mortality risk in the survey is framed.

Table 3: Selection Equation Estimates (Probit)

Dependent Variable = Yes

VARIABLES	(1) All	(2) Dhaka	(3) Chittagong	(4) S1	(5) S2
l_pc_exp	0.258 *	0.175	0.464	0.217	0.255
l_Age	-0.409 **	-0.201	-0.922 **	-0.147	-0.0278
Male	0.307 ***	0.317 ***	0.188	0.167	0.389 *
l_HHsize	0.127	0.0580	0.294	0.272	0.133
Nchild	0.0184	0.00331	0.0570	-0.0369	0.167
mededuc	0.318 ***	0.238 ***	0.515 *	0.232	0.354
higheduc	0.193	0.153	0.215	0.337	-0.0498
Trust	-0.0772 ***	-0.0476 *	-0.183	-0.0386	-0.0654
lifesat	0.0467 **	0.0415	0.0459	0.0268	0.122
religious	0.0476	-0.0268	-0.00503	-0.209	0.136
toilet_share	0.173	0.291 **	-0.140 *	0.267	0.363
mob_adult	0.114	0.296	-0.189	0.151	0.189
TV	0.0246	-0.0538	0.160 *	-0.185 *	0.110
agLand	0.124	0.294 **	-0.292	0.280	0.237
meanTransp	0.0144	0.188	-0.458 *	0.416	-0.0817
l_highwayFreq	0.0676 *	0.0648	0.0948	0.0907	-0.0234
medishare	0.373	-0.0324	1.283	0.201	-0.195
smoking	0.0324	0.0918	0.00706	0.145	0.187 *
health1	-0.0434	-0.0200	-0.0703	0.000156	-0.0798
health2	0.131	0.0878	0.377	0.393 *	-0.117
AfDW	-0.0146	0.0521	-0.300	-0.0322	-0.122
AfResp	-0.164	-0.160	-0.285	-0.168	-0.0585
victAcc	0.295	0.226	0.395	0.235	0.0313
witnessAcc	0.0226	-0.0579	0.250	-0.149	0.131 *
sickold	-0.309 *	-0.231	-0.518	-0.187	-0.889
lostchild	0.0565	0.152	-0.248	0.0430	0.198
matdeath	-0.0274	0.0714	-0.130	-0.153	-0.00299
misfortune	0.00941	0.0833	-0.207	-0.00538	0.375 *
pRwater	-0.0509	-0.0391	0.0116	-0.0267	0.134
pRair	-0.0683	-0.0984	0.116 *	0.0208	-0.301
pRroad	-0.0354	-0.0161	-0.0925	-0.0390	0.262
diff_choice	-0.0936	-0.202 *	0.275	-0.0767	-0.431 *
negative	-0.224 **	-0.317 **	-0.112	-0.478	-0.219
rec_cash	0.295	0.261	0.255	-0.400	0.837 *
rec_gift	0.527 *	0.510	0.684	-0.154	1.017 **
suv_dur	0.000978	0.00154	-0.00125	-0.000846	-0.00230
Constant	-1.042	-1.178	-0.568	-1.343	-3.116
Observations	957	672	285	289	287
Pseudo-R	0.113	0.130	0.209	0.103	0.238

Column (4) for the Dhaka-Most Polluted Stratum (S1) only
Column (5) for the Dhaka-Medium Polluted Stratum (S2) only
*** p<0.01, ** p<0.05, * p<0.1. S.E. is not shown for space
p-values are calculated using Score Wild Cluster Bootstrap

Table 4: Level Equation Estimates (OLS)

Dependent Variable = l_WTP

VARIABLES	(1) All	(2) Dhaka	(3) Chittagong	(4) S1	(5) S2
l_pc_exp	0.841 ***	0.568 **	1.443	0.458	0.675 *
l_Age	-0.0976	-0.0122	-0.00840	0.180	-0.511
Male	0.0404	-0.313 **	0.717	-0.438	-0.177
l_HHsize	0.750 ***	0.830 ***	0.734	0.606	1.033 *
Nchild	0.0342	0.143	-0.309	0.0449	0.168
mededuc	0.129	0.106	0.282	0.0401	0.124
higheduc	0.119	0.300	-0.195	0.540	0.228
Trust	0.0355	-0.00139	0.160	0.00608	0.0383
lifesat	0.0225	0.0127	-0.0572	-0.0439	0.0288
religious	-0.126	-0.252 *	0.219	-0.180	-0.413 *
toilet_share	-0.00915	0.00610	-0.0648	-0.273	0.184
mob_adult	0.342 **	0.492 *	0.169 *	0.603 *	0.388
TV	0.0630	0.00862	0.390	-0.397	0.304
agLand	0.0437	0.146	-0.352	-0.0435	0.221
meanTransp	0.312 **	0.352 ***	0.495 *	0.258	0.565 *
l_highwayFreq	0.0814	0.0911 *	0.0364	0.0639 *	0.104
medishare	-0.690	-0.140	-0.838	0.565	-0.427
smoking	0.466 **	0.494 ***	-0.0519	0.643	0.482
health1	0.256	0.284	0.426	0.183	0.335
health2	0.0663	0.0720	0.0911	-0.0574	0.420 *
AfDW	-0.00185	0.0157	-0.0557	0.266	-0.334
AfResp	0.00864	0.00619	-0.323	0.0290	0.0854
victAcc	0.0664	0.239	0.00177	-0.0853	0.532 *
witnessAcc	-0.278 *	-0.269	-0.540	0.280	-0.500 *
sickold	0.108	0.338 **	-0.248	0.0168	0.681 *
lostchild	-0.0785	-0.168	0.280	-0.489	-0.255
matdeath	-0.127	-0.0396	-0.309	-0.143	0.125
misfortune	-0.0793	-0.0396	0.00187	-0.403 *	0.226
pRwater	0.136 **	0.0723 *	0.296	0.0275	0.125
pRair	0.0341	0.0599 ***	-0.199 *	0.0811	0.0650 *
pRroad	-0.0206	-0.0237	0.0912	0.0449	-0.154
diff_choice	-0.0142	-0.104	0.479	-0.201	-0.0321
negative	-0.449 **	-0.427	-0.404	0.111	-0.801 *
rec_cash	0.218	0.293	2.054	0.190	0.110
rec_gift	0.249	0.165	2.458	-0.0605	0.176
suv_dur	-0.00317	-0.00329	-0.00270	-0.0124	0.0161 *
Constant	-4.168	-2.033	-12.71	1.061	-4.513
Observations	685	477	208	185	229
R-Squared	0.216	0.221	0.460	0.303	0.326
Adj R-Sq.	0.173	0.157	0.346	0.133	0.199

Column (4) for the Dhaka-Most Polluted Stratum (S1) only
Column (5) for the Dhaka-Medium Polluted Stratum (S2) only
*** $p<0.01$, ** $p<0.05$, * $p<0.1$. S.E. is not shown for space
p-values are calculated using Wild Cluster Bootstrap with Six-Points

3.2 Bootstrap Estimation of Mean (Median) WTP and VSL

Using the results of estimation of the selection and level equations in the previous section, we now calculate the mean and median of WTP and their confidence intervals using boot- strap resampling. The estimation results give the functional forms for the probability of "yes" for Q1, $\text{Prob}(y_1 = 1) = f_1(x_1'\beta_1)$, and the log of the WTP amount that is given as an answer to Q2, $\ln(y_2|y_1 = 1) = f_2(x_2'\beta_2)$. Using the obtained functional forms, we calculate the predicted value of WTP of individual i, $\hat{y}_{2i}$, conditional on observed x_{1i}' and x_{2i}':

$$\hat{y}_{2i} = f_1\left(x_{1i}'\hat{\beta}_1\right) \times \exp\left(f_2\left(x_{2i}'\hat{\beta}_2\right)\right) \qquad (3)$$

The individual predicted values calculated by (3) is used to construct the mean or median of WTP. Furthermore, we repeat the same procedure for the bootstrapped samples for 4,000 times to obtain the confidence intervals for the mean (median) estimates using the results of the previous section.

The VSL is obtained by dividing WTP by the magnitude of risk reduction in the scenario (5/10,000). In order to construct confidence intervals for the mean (median) WTP, we use the bootstrap re-sampling method.[20] The estimation procedure is as follows: the bootstrap resampling is made at the cluster level. For each round of re-sampling, we estimate selection equation and level equation on the bootstrapped samples, and calculate the predicted WTP using (3) for each re-sampled observation. Mean (or median) WTP over this predicted WTP across bootstrapped observations are then calculated. This process is repeated for 4,000 times to obtain the bootstrapped average and confidence intervals for the mean WTP.

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[20] The procedure is similar to Wang and Mullahy (2006).

Table 5 summarises the estimation results, across different sub-samples. The average VSL in PPP USD ranges from 17,480 to 22,463. The average VSL is the smallest for the case of all the sample is used, and it is the largest for the strata 2 (Dhaka-Medium Polluted). The confidence interval is the narrowest for strata 2 with only 1,234 USD, while it becomes very large for the case of Chittagong (16,632 USD). To understand the large variability of the estimated VSLs, Table 7 show key descriptive statistics and predicted values of mean WTP and VSL of each of 10 clusters. Chittagon's wide confidence interval compared to other subgroup seems to be caused by the ShehShah cluster (Column (8) of Table 7) whose average amount of willingness to pay conditional on having any willingness to pay is very low (195.4 Taka) compared to other clusters. DEFF (Design Effect) of each mean estimate is also reported in the table. Here, DEFF is defined as the ratio of the variance of mean VSL by bootstrapping accounting for our complex sampling design, to the variance of mean VSL calculated when the bootstrapping is carried out by a simple random resampling from the pool of all 1,000 observations.

Table 6 shows the bootstrap estimation results of the median VSL. Compared with the mean VSL, there is no systematic relationship between the estimated average median VSL and the sample size. And the estimated values are all significantly smaller than those for mean VSL.

Bangladesh's nominal GDP per capita in 2013 was 46,322 Taka.[21] Therefore, the estimated mean VSL is about 9.78-12.57 times of GDP per capita (5.03-7.61 times for median VSL estimate). This is much higher than the estimate of mean VSL by Mahmud (2009) at between 3.55 times and 5.82 times GDP per capita at the time of survey.[22] However, in terms of a multiple of GDP per capita, our estimated VSL is much smaller than CV studies in other countries. For example, Wang and Mullahy (2006)'s result implies that the median VSL is 70.32

[21] https://data.worldbank.org/indicator/NY.GDP.PCAP.KN?locations=BD

[22] The survey was done in 2003 and nominal GDP per capita then was 29,010 Taka. His mean VSL estimates ranged from 103,074 Taka to 168,905 Taka, depending on different settings. However, the study deals with very large risk reduction and VSL is inversely proportional to the size of the risk reduction offered.

times average nominal income, calculated from WTP for reducing mortality risk from air pollution in Chongqing, China. Miller (2000) conducts a meta-analysis of 68 VSL studies in developed countries and found that stated VSL is typically about 120 times of GDP per capita. In Section 4, we will further discuss on the validity of our estimates and how we can position it among the international examples.

4. Discussion on the Validity of Results

CV method is a widely used methodology to evaluate the monetary value of goods whose market values cannot be observed directly. However, it has long been criticised for its reliability and practical usefulness for policy making. Hausman (2012) summarises the methodological limitations of contingent valuation method. He categorises the problems which are commonly observed in the existing contingent valuation studies into three; (i) Hypothetical bias, (ii) Discrepancy between willingness to pay (WTP) and willingness to accept (WTA), and (iii) Scope bias.

The first problem, the hypothetical bias, stems from the fact that the contingent valuation method relies on hypothetical questions about the non-market goods that are un-familiar to the people in their daily life. Since hypothetical questions may not always be associated with people's actual experience, a substantial discrepancy between what they say and what they do (if they actually face the situation) can emerge. Hausman (2012) reports hypothetical bias usually overestimates the true price of a non-market good. Viscusi and Masterman (2017b) assert that revealed preference studies using the Census of Fatal Occupational Injuries (CFOI) of the U.S. are relatively favourable because they are not subject to biases introduced by hypotheticals, instead of using stated preference results. In addition, they suggest that the best way to calculate a VSL for a country with insufficient data is to "transfer a base VSL from the United States calculated using the labor market estimates", by extrapolating the country's value from the US base value and the income elasticity of the VSL.

Table 5: Estimates of Mean VSL

	(1) Average	(2) Confidence Interval (5%)	(3) Confidence Interval (95%)
All sample (N=1,000, DEFF = 2.51)			
mean WTP (Taka)	226.6	198.0	256.5
VSL (Taka)	453,200	396,000	513,000
VSL (PPP USD)	17,480	15,274	19,786
Dhaka (N=700, DEFF=1.54)			
mean WTP (Taka)	248.5	225.3	274.7
VSL (Taka)	497,000	450,600	549,400
VSL (PPP USD)	19,169	17,380	21,190
Chittagong (N=300, DEFF=3.03)			
mean WTP (Taka)	271.2	164.2	379.8
VSL (Taka)	542,400	328,400	759,600
VSL (PPP USD)	20,920	12,666	29,298
Only Dhaka-Most Polluted Stratum (N=300, DEFF = 1.24)			
mean WTP (Taka)	260.2	228.1	291.8
VSL (Taka)	520,400	456,200	583,600
VSL (PPP USD)	20,072	17,596	22,509
Only Dhaka-Medium Polluted Stratum (N=300, DEFF = 0.36)			
mean WTP (Taka)	291.2	283.1	299.1
VSL (Taka)	582,400	566,200	598,200
VSL (PPP USD)	22,463	21,838	23,072

The conversion rate between US dollar and Bangladesh Taka, 1USD=78.2049 BDT, as of June 30, 2013 (Bangladesh Bank) is used for calculating US dollar values. The PPP conversion factor of Bangladesh Taka into international dollar (at 2011 price) was 1USD = 25.927BDT.
(See `https://data.worldbank.org/indicator/PA.NUS.PPP?locations=BD`).
DEFF refers to the design effect the variance when taking the sampling design into account divided by the variance when simple random sampling is assumed.

Table 6: Estimates of Median VSL

	(1) Average	(2) Confidence Interval (5%)	(3) Confidence Interval (95%)
All sample (N=1,000, DEFF=2.42)			
median WTP (Taka)	153.6	133.3	177.0
VSL (Taka)	307,200	266,600	354,000
VSL (PPP USD)	11,849	10,283	13,654
Dhaka (N=700, DEFF=2.09)			
median WTP (Taka)	176.2	161.1	197.6
VSL (Taka)	352,400	322,200	395,200
VSL (PPP USD)	13,592	12,427	15,243
Chittagong (N=300, DEFF=3.76)			
median WTP (Taka)	116.5	80.92	168.5
VSL (Taka)	233,000	161,840	337,000
VSL (PPP USD)	8,987	6,242	12,998
Only Dhaka-Most Polluted Stratum (N=300, DEFF=0.78)			
median WTP (Taka)	167.0	162.2	173.6
VSL (Taka)	334,000	324,400	347,200
VSL (PPP USD)	12,882	12,512	13,391
Only Dhaka-Medium Polluted Stratum (N=300, DEFF=0.37)			
median WTP (Taka)	162.3	151.2	171.1
VSL (Taka)	324,600	302,400	342,200
VSL (PPP USD)	12,520	11,664	13,199

The conversion rate between US dollar and Bangladesh Taka, 1USD=78.2049 BDT, as of June 30, 2013 (Bangladesh Bank) is used for calculating US dollar values. The PPP conversion factor of Bangladesh Taka into international dollar (at 2011 price) was 1USD = 25.927BDT.
(See `https://data.worldbank.org/indicator/PA.NUS.PPP?locations=BD`).
DEFF refers to the design effect the variance when taking the sampling design into account divided by the variance when simple random sampling is assumed.

Table 7: Descriptive Statistics and Predicted Value of WTP at Each Cluster

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				Dhaka					Chittagong	
		strata= 1			strata= 2		strata= 3	strata= 4	strata=5	strata= 6
VARIABLES	Hazaribag	Kamrangir	Tongi	Diabari	ShahAli	Nobinagar	Maniknagar	ShehShah	GoribullahShah	Riaz Uddin & Enayet
Have Positive Willingness to Pay	0.770	0.590	0.540	0.814	0.765	0.850	0.660	0.717	0.680	0.790
Amount of Willingness to Pay	816.6	835.7	574.4	764.1	1,216	741.1	953.0	195.4	1,099	1,045
Per Capita Expenditure (Taka/Month)	4,395	4,510	5,677	4,526	5,920	4,336	6,223	4,846	6,315	4,860
Age	36.65	35.15	35.56	34.43	36.86	34.17	34.37	34.60	34.90	36.18
Male	0.560	0.560	0.490	0.598	0.735	0.860	0.540	0.596	0.590	0.560
Household Size	5.410	4.710	4.939	4.443	4.546	4.610	4.720	5.202	5.300	4.950
Medium Education Attainment	0.420	0.340	0.450	0.320	0.367	0.550	0.380	0.354	0.340	0.340
High Education Attainment	0.140	0.153	0.180	0.124	0.235	0.130	0.340	0.354	0.398	0.160
Perceived Health Risk from Neighbourhood Air Quality	3.570	3.450	2.960	2.093	2.299	1.455	2.450	1.980	1.808	1.778
Predicted mean WTP	399.5	369.2	494.8	313.0	682.1	354.5	360.2	99.42	698.0	272.8
(Impllied VSL, PPP USD)	30,817	28,480	38,169	24,145	52,617	27,346	27,786	7,669	53,843	21,044

Despite this universal scepticism to the stated preference approach, global evidence does not always discourage the use of the method. By a parametric meta-regression analysis on the studies in the U.S, U.S. Environmental Protection Agency's Office of Policy (2016) revealed that there is no distinct differences in the estimated VSL between the revealed preference studies and the stated preference studies.[23] This is a counter-evidence to the common concern that the stated preference method is highly susceptible to hypothetical bias (which is often supposed to be a larger VSL estimate with the stated preference to the revealed preference).

We believe that our estimates are not significantly affected by the hypothetical bias. Firstly, while the argument by Hausman (2012) focuses mainly on the cases of goods which are distant from the need of fatal risk reduction, our scenario (fatal risk reduction) is more closely tied to their daily decision making. Studies using revealed preference methods support that the risk reduction is people's daily issue and that they are willing to trade off money to reduce this. For example, Viscusi and Aldy (2003) provide market evidence using revealed preference that shows that people are willing to spend money to reduce their mortality risk in their daily life. Since hypothetical questions work better for issues closely related to the daily life risk reduction that are common and familiar than for unfamiliar public goods provision, it is reasonable to assume that hypothetical bias is less of a concern in our case.

In addition, our questionnaire design helps respondents to think more realistically. In existing studies, it is common to ask about WTP first followed by questions related to their socio-economic characteristics of the respondents. In our case, we introduce respondents to various risks people face in their daily life in Bangladesh, train and elicit their understanding of risk concepts, their own risk perceptions. Also, we asked questions related to socio-economic situation including income and consumption expenditures, cultural background, record of

[23] See Table 9. of U.S. Environmental Protection Agency's Office of Policy (2016) for the detail. It argues that the stated preference studies are about 15 percent lower on average than those from the revealed preference studies, but this is not a statistically significant difference.

individual health problems, etc. After these questions, the WTP questions were asked in the final section of the questionnaire. This two-step structure encourages the respondents to consciously reflect their own socio-economic as well as physical status, and provides the respondent a very good setting in answering the valuation question more thoughtfully and credibly.[24]

The discrepancy between WTP and WTA is not a major concern in the context of fatal risk reduction, as in our case. First of all, NOAA panel report (Arrow et al., 1993) recommended WTP instead of WTA in the context of contingent valuation studies. In addition, WTP seems more appropriate regarding values for reducing mortality risk from air pollution, because the policy implications of WTA values are not obvious in the context of improving air quality.[25]

Scope bias challenges two assumptions of VSL: that respondents correctly understand the probability of death (e.g. the fatal risk of 1/1000 is ten times more dangerous than the risk of 1/10000), and the willingness to pay is approximately linear with respect to the risk reduction magnitude (which is called near-proportionality). In the literature of contingent valuation, a "scope test" with multiple questions of different risk reduction magnitude is often conducted to deal with this problem. Since we did not conduct a scope test with multiple questions of different risk reduction magnitudes, our estimates of VSL potentially suffer from this problem. However, while the lack of scope test could limit the reliability of our VSL estimate to some extent, we still believe our analysis delivers useful information because the survey respondents received enough training to understand the probability concept and the urban air pollution situation in Dhaka (Chittagong). We provided examples and tested the respondents on their understanding of probability, and they generally got high scores, as seen below. As Mahmud (2009) shows,

[24] As far as we know, there is no study examining the impact of the style of questionnaires, especially about when the WTP questions are asked during the survey.

[25] Due to this theoretical concern, most of the existing studies on mortality risk reduction have focused on WTP. Gibson et al. (2007) measured both WTP and WTA for landmines removal programs in Thailand, and it is the only previous case that compares the values from the two methods, to the best of our knowledge. They find no significant difference between the two methods. Given these, we find that our approach to use only WTP is appropriate.

facilitating respondents' better comprehension through training prior to the questioning WTP is crucial in the mitigation of scope bias.

4.1 Respondents' Understanding of Risk and Risk Reduction

In the following two subsections, we discuss the plausibility of our estimates from various perspectives. Firstly, as we argued above, one of the important prerequisites for conducting contingent valuation studies is the good understanding of the concept of risk and risk reduction held by the respondents. Given generally low education profile of respondents where about 40% of the respondents have only primary or lower-level education, we paid special attention in training and examining their ability to correctly answer risk and risk reduction problems.

Before introducing our hypothetical risk reduction scenario and asking about their willingness to pay for it, we explained the concepts of risk reduction in detail followed by an examination. The exam checks that respondents correctly compare the level of risk and the magnitude of risk reduction. The results are summarised in Table 8. Almost all the respondents understood the concept of risk and risk reduction correctly. 98.7% of the respondents answered correctly when they asked to compare the level of mortality risk between two roads. Furthermore, 99.1 % of them correctly chose the option among three hypothetical risk reductions. Out of total 1,000 respondents, 980 respondents (98%) answered the both question correctly. The 20 respondents who could not answer either of questions correctly received follow-up training until they finally understood.[26]

[26] In a regression analysis, we include dummy of making incorrect answers. However, this is not significant (the result is not reported in Table 3 and Table 4)

Table 8: Respondents' Understanding of Risk and Risk Reduction

Question	Correct Respondent ($N = 1000$)
The risk of dying in Road A is 1 in 10,000 and the risk of dying in Road B is 3 in 10,000. Which road is more risky? (Correct Answer = B)	987 (98.7%)
Which of the three risk reductions is preferable? (Correct Answer = 3) 1. 40 in 100,000 to 30 in 100,000 2. 40 in 100,000 to 20 in 100,000 3. 40 in 100,000 to 10 in 100,000	991 (99.1%)

4.2 Assessment with Theory and Past Studies

We further argue the validity of our estimate from theoretical perspective. Hammitt (2017) theoretically argues how income, mortality risk, health, life expectancy, and social norms, affect the amount of VSL. According to the standard theory, income or expenditure is positively associated with VSL, as expected. Instead, higher survival probability (due to healthier life, etc.) can be negatively associated because of the "dead-anyway effect" (Pratt and Zeckhauser, 1996), reflecting that if current probability of death is high, the VSL is large because the expected opportunity cost of current spending decreases. The impact of life expectancy at the time of survey is ambiguous as is the expected future health status. The impact of framing risk reduction as government programmes is also theoretically ambiguous.[27]

[27] Hammitt (2017) does not support simply transferring the VSL of one country to another, because the theory suggests that VSL value can be affected by many factors not only income, such as life expectancies and social norms, which are greatly diverse across nations.

OECD (2012) (or Lindhjem et al. (2011))[28], conducts a comprehensive meta-regression of VSL on various stated preference studies in OECD countries, aiming at pinning down relationships between VSL amount and characteristics of population and survey material. They conclude that income and risk reduction size are positively and negatively associated with VSL, with strongly significant coefficients. If the risk context is related to environ- mental issues, there is also a strong indication that the stated VSL tends to be lower. If the risk reduction is framed as a public good, the VSL is again likely to be lower compared to when it is being considered as a private issue.[29]

As a precious example of a non-OECD country which is comparable to ours, Guo et al. (2007) used a stated preference survey in Chengdu, China, on the WTP for reducing the risk of asthma and death from air pollution problem. Their survey was designed to analyse the impact of design choice, which is relevant to our case: (1) whether the risk reduction measure is contextualised as a public/governmental provision or as a private good, (2) in case it is a public provision, how respondents' belief in the effectiveness of government programs matters. According to their analysis, framing the risk reduction as a public provision significantly reduces the stated VSL, compared to the case where it is explained as a private good. Furthermore, they found that respondent confidence in the effectiveness of government programs significantly increase the VSL.

Our study context in Dhaka and Chittagong, Bangladesh, is a case of a very low income country, with a scenario with relatively large magnitude of risk reduction (1/2000), and framed as an environmental public goods. According to OECD (2012), this feature is strongly leaned to smaller VSL estimates. If our VSL is perfectly align with the model of OECD (2012), the VSL

[28] Specifically, chapter named "Meta-regression analysis of value of statistical life estimates".
[29] According to one of the estimated results that is most relevant to our setting (Table 3.4 in OECD (2012)), elasticity of VSL with respect to income is 0.783, with respect to the magnitude of risk reduction is -0.577, respectively. If the cause of fatality is framed as an environmental issue, the value of VSL declines by 0.606 (60.6%). If risk reduction program is framed as an public goods, it reduces the stated VSL by 91.3%.

should be 30,930 USD[30] Our mean estimates, ranging from 17,480 to 22,463 USD, are not seriously far from this value based on OECD (2012)'s model. Our estimates is therefore largely in line with past stated preference studies in OECD countries, with potentially hitting the lower bound of VSL.[31]

5. Conclusion

Even though cities in Bangladesh, especially the overly dense ones such as Dhaka and Chittagong, have become increasingly affected by severe air pollution that causes fatal illness among residents, there exists no study to measure people's willingness to pay for reducing mortality risk from air pollution. Our study is the first attempt to provide estimates of monetary value of air pollution risk reduction using the contingent valuation method in Dhaka and Chittagong.

Based on the collected data and regression results for selected individual characteristics, we calculated the bootstrapped average of mean and median WTPs as well as those of a VSL. The estimated mean VSL is ranged from 17,480 to 22,463 USD in PPP of or 9.78 to 12.57 times GDP per capita in 2013. While this could be interpreted as a substantial private contribution to

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[30] Using the regression coefficient from the meta-analysis (see footnote 29 for detail), the VSL from our survey consistent with their model can be calculated by,

$$30{,}930\text{USD} = 3\text{mil. USD} \times \left(\frac{2023}{30601}\right)^{0.783} \times \left(\frac{1/2000}{1/10000}\right)^{-0.577} \times \exp(-0.606) \times \exp(-0.913) \qquad (4)$$

where, the mean VSL , the mean income (in GDP per capita), and risk reduction magnitude of OECD (2012)'s study samples, were 3 million USD, 30,601 USD, and 1/10000, respectively. The annualized average expenditure from our survey is 2,023 USD. The coefficients were taken from the Model V of Table 3.4 of OECD (2012). If we use the coefficients of model IV of the same table, the value further drops to 24,733 USD. Bangladesh is a country where people may attach especially lower value when the risk reduction program is designed as a "government" program. In Bangladesh, the government can collect fewer tax per GDP compared to other countries and only 1.2% of population pay income tax. It is probable that many people do not think they are responsible for financing public policies and therefore framing the hypothetical program as a governmental one could have a large negative impact.

[31] We calculate the elasticity of VSL to expenditure by regressing log of predicted VSL on log of per capita expenditure. For all the sample, the elasticity is .955. Only for Dhaka, it is .652, while it rises to 1.661 for Chittagong. For the Stratum 1 and the Stratum 2, it is .643 and .581, respectively. These values are within the range found from past studies (e.g. Robinson et al., 2017; Viscusi and Masterman, 2017b; OECD, 2012; Hammitt and Robinson, 2011).

the risk reduction program with large externality, the estimated VSL is much smaller compared to studies conducted in other countries. This might be related to scope bias, as suggested in earlier literature in economics and psychology that argue that people tend to overestimate small risks and underestimate large risks (e.g. Tversky and Kahneman, 1992; Viscusi, 1992; Kahneman and Tversky, 2000).

In addition to this scope bias, our estimate could also be prone to bias due to aggregation of unweighted observations. However, as examined in Section 4, our estimates are not out of the range of the existing studies summarised in Robinson et al. (2017). Moreover, ours are not very far from the value obtained from a benefit transfer exercise using the result of OECD (2012).

Given these potential issues surrounding the valuation exercise, it is important to carefully interpret the estimates and we should not treat them as generic (context free) VSL in Bangladesh. Rather these may be regarded as a lower bound of benefit estimates for environmental policies or programs aiming at fatal risk reductions.

References

Arigoni Ortiz, R., A. Markandya, and A. Hunt (2009). Willingness to pay for mortality risk reduction associated with air pollution in S˜ao Paulo. *Revista Brasileira de Economia 63* (1), 3–22.

Arrow, K., R. Solow, P. R. Portney, E. E. Leamer, R. Radner, and H. Schuman (1993). Report of the NOAA Panel on Contingent Valuation. *Federal Register 58* (10), 4601–14.

Bhattacharya, S., A. Alberini, and M. L. Cropper (2007). The Value of Mortality Risk Reductions in Delhi, India. *Journal of Risk and Uncertainty 34* (1), 21–47.

Cameron, A. C. and D. L. Miller (2015). A Practitioner's Guide to Cluster-Robust Inference. *Journal of Human Resources 50* (2).

Chang, T., J. G. Zivin, T. Gross, and M. Neidell (2016). Particulate pollution and the productivity of pear packers. *American Economic Journal: Economic Policy 8* (3), 141– 69.

Dekker, T., R. Brouwer, M. Hofkes, and K. Moeltner (2011). The Effect of Risk Context on the Value of a Statistical Life: A Bayesian Meta-model. *Environmental and Resource Economics 49* (4), 597–624.

Desaigues, B., D. Ami, A. Bartczak, M. Braun-Kohlov´a, S. Chilton, M. Czajkowski, V. Far- reras, A. Hunt, M. Hutchison, C. Jeanrenaud, P. Kaderjak, V. M6ácA, O. Markiewicz, A. Markowska, H. Metcalf, S. Navrud, J. S. Nielsen, R. Ortiz, S. Pellegrini, A. Rabl, R. Riera, M. Scasny, M. E. Stoeckel, R. Sz´ant´o, and J. Urban (2011). Economic valua- tion of air pollution mortality: A 9-country contingent valuation survey of value of a life year (VOLY). *Ecological Indicators 11* (3), 902–10.

Duan, N., W. G. Manning, C. N. Morris, and J. P. Newhouse (1983). A Comparison of Alternative Models for the Demand for Medical Care. *Journal of Business & Economic Statistics 1* (2), 115–26.

Gibson, J., S. Barns, M. Cameron, S. Lim, F. Scrimgeour, and J. Tressler (2007). The Value of Statistical Life and the Economics of Landmine Clearance in Developing Countries. *World Development 35* (3), 512–31.

Guo, X., T. C. Haab, and J. K. Hammitt (2007). Contingent Valuation and the Economic Value of Air-Pollution-Related Health Risks in China. In *Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting*, Long Beach, California, pp. 1–38. AAEA.

Hammitt, J. K. (2017). Extrapolating the Value Per Statistical Life Between Populations: Theoretical Implications. *Journal of Benefit-Cost Analysis 8* (02), 215–25.

Hammitt, J. K. and J. D. Graham (1999). Willingness to Pay for Health Protection: Inadequate Sensitivity to Probability? *Journal of Risk and Uncertainty 18* (1), 33–62.

Hammitt, J. K. and L. A. Robinson (2011). The Income Elasticity of the Value per Statistical Life: Transferring Estimates between High and Low Income Populations. *Journal of Benefit-Cost Analysis 2* (1).

Hammitt, J. K. and Y. Zhou (2006). The Economic Value of Air-Pollution-Related Health Risks in China: A Contingent Valuation Study. *Environmental and Resource Economics 30* (3), 399–423.

Hoffmann, S., A. Krupnick, and P. Qin (2017). Building a Set of Internationally Compara- ble Value of Statistical Life Studies: Estimates of Chinese Willingness to Pay to Reduce Mortality Risk. *Journal of Benefit-Cost Analysis 8* (2), 251–89.

Hoffmann, S., P. Qin, A. Krupnick, B. Badrakh, S. Batbaatar, E. Altangerel, and L. Sereeter (2012). The willingness to pay for mortality risk reductions in Mongolia. *Resource and Energy Economics 34* (4), 493–513.

Kahneman, D. and A. Tversky (2000). *Choices, Values and Frames*. Cambridge: Cambridge University Press.

Khan, N. I., R. Brouwer, and H. Yang (2014). Household's willingness to pay for arsenic safe drinking water in Bangladesh. *Journal of Environmental Management 143*, 151–61.

Kline, P. M. and A. Santos (2012). A Score Based Approach to Wild Bootstrap Inference. *Journal of Econometric Methods 1* (1), 23–41.

Kochi, I., B. Hubbell, and R. Kramer (2006). An Empirical Bayes Approach to Combining and Comparing Estimates of the Value of a Statistical Life for Environmental Policy Analysis w. *Environmental and Resource Economics 34*, 385–406.

Landrigan, P. J., R. Fuller, N. J. Acosta, O. Adeyi, R. Arnold, N. Basu, A. B. Bald´e, R. Bertollini, S. Bose-O'Reilly, J. I. Boufford, P. N. Breysse, T. Chiles, C. Mahidol, A. M. Coll-Seck, M. L. Cropper, J. Fobil, V. Fuster, M. Greenstone, A. Haines, D. Hanrahan, D. Hunter, M. Khare, A. Krupnick, B. Lanphear, B. Lohani, K. Martin, K. V. Mathiasen, M. A. McTeer, C. J. Murray, J. D. Ndahimananjara, F. Perera, J. Potočnik, A. S. Preker, J. Ramesh, J. Rockstrom, C. Salinas, L. D. Samson, K. Sandilya, P. D. Sly, K. R. Smith, A. Steiner, R. B. Stewart, W. A. Suk, O. C. van Schayck, G. N. Yadama, K. Yumkella, and M. Zhong (2017). The Lancet Commission on pollution and health. *The Lancet 6736* (17).

Lindhjem, H., S. Navrud, N. A. Braathen, and V. Biausque (2011). Valuing Mortality Risk Reductions from Environmental, Transport, and Health Policies: A Global Meta- Analysis of Stated Preference Studies. *Risk Analysis 31* (9), 1381–1407.

Mahmud, M. (2009). On the contingent valuation of mortality risk reduction in developing countries. *Applied Economics 41* (2), 171–81.

Mahmud, M. and Y. Sawada (2018). Urbanization and Subjective Well-Being in Bangladesh. In *Economic and Social Development of Bangladesh*, pp. 215–32. Cham: Palgrave Macmillan.

Masterman, C. and W. K. Viscusi (2018). The Income Elasticity of Global Values of a Statistical Life: Stated Preference Evidence. *Journal Benefi-Cost Analysis 9* (3), 407–34.

Miller, T. R. (2000). Variations between countries in the evalues of statistical life. *Journal of Transport Economics and Policy 34* (2), 169–88.

Narain, U. and C. Sall (2016). Methodology for valuing the health impacts of air pollution: discussion of challenges and proposed solutions.

OECD (2012). *Mortality Risk Valuation in Environment, Health and Transport Policies*. OECD Publishing.

Robinson, L. A. (2017). Estimating the Values of Mortality Risk Reductions in Low- and Middle-Income Countries. *Journal of Benefit-Cost Analysis 8* (02), 205–14.

Robinson, L. A., J. K. Hammitt, and L. O'Keeffe (2017). Valuing Mortality Risk Reductions in Global Benefit-Cost Analysis. *Working Paper*.

Roodman, D., J. G. MacKinnon, M. O. Nielsen, and M. D. Webb (2018). Fast and Wild: Bootstrap Inference in Stata using boottest.

Tekesin, C. and S. Ara (2014). Measuring the value of mortality risk reductions in Turkey. *International Journal of Environmental Research and Public Health 11* (7), 6890–6922.

Tversky, A. and D. Kahneman (1992). Advances in prospect theory: cumulative representation of uncertainty. *Journal of Risk and Uncertainty 5*, 297–323.

U.S. Environmental Protection Agency's Office of Policy (2016). Valuing mortality risk reductions for policy: a meta-analytic approach. Technical report, USEPA, Washington DC.

Vassanadumrongdee, S. and S. Matsuoka (2005). Risk Perceptions and Value of a Statistical Life for Air Pollution and Traffic Accidents: Evidence from Bangkok, Thailand. *Journal of Risk and Uncertainty 30* (3), 261–87.

Viscusi, W. K. (1992). *Fatal Tradeoffs: Public and Private Responsibilities for Risk*. New York: Oxford University Press.

Viscusi, W. K. (2017). Best Estimate Selection Bias in the Value of a Statistical Life. *Journal of Benefit-Cost Analysis 9* (2), 1–42.

Viscusi, W. K. and J. E. Aldy (2003). The Value of a Statistical Life: A critical Review of Market Estimate Throughout the World. *Journal of Risk and Uncertainty 27* (1), 5–76.

Viscusi, W. K. and C. Masterman (2017a). Anchoring biases in international estimates of the value of a statistical life. *Journal of Risk and Uncertainty 54* (2), 103–28.

Viscusi, W. K. and C. Masterman (2017b). Income Elasticity and the Global Value of a Statistical Life. *Journal of Benefit-Cost Analysis 8* (2), 226–50.

Wang, H. and J. Mullahy (2006). Willingness to pay for reducing fatal risk by improving air quality: A contingent valuation study in Chongqing, China. *Science of the Total Environment 367*, 50–57.

Wang, Y. and Y.-s. Zhang (2009). Air quality assessment by contingent valuation in Ji'nan, China. *Journal of Environmental Management 90* (2), 1022–29.

Webb, M. D. (2014). Reworking Wild Bootstrap Based Inference for Clustered Errors.

World Bank (2006). Bangladesh Country Environmental Analysis, Volume I: Main Report. Technical Report No.36945-BD.

World Bank and Institute for Health Metrics and Evaluation (2016). The Cost of Air Pollution: Strengthening the Economic Case for Action. Technical report.

Zivin, J. G. and M. Neidell (2018). Air Pollution's Hidden Impact. *Science 359* (6371), 39–40.

Zuthi, M. F. R., M. Biswas, and M. N. Bahar (2009). Assessment of Supply Water Quality in the Chittagong City of Bangladesh. *ARPN Journal of Engineering and Applied Sciences 4* (3), 73–80.

Appendix: Survey Questionnaire

This is an English translation of questionnaire for respondents in Dhaka. For those in Chittagong, “Dhaka” is replaced by “Chittagong”.

Survey on Choice between Alternative Life-saving Programs

Leave Blank:

1) Questionnaire ID:______________________________
2) Questionnaire Set:______________________________
3) Area Code: ______________________________

Invitation to Survey [enumerator reads the statement to selected household/individual]:

Sir/Madam**,**
We have come for a survey from (E.R.G) Economic Research Group.

In this survey we intend to gather knowledge about people's preferences for different lifesaving programs that the government often undertakes to save lives. This study is conducted with financial support from Japan International Cooperation Agency Research Institute (JICA-RI) in Tokyo, Japan. It will take about 45 minutes of your time, and all information we gather will be kept confidential. The data will only be used for research purposes where individuals' identity will not be disclosed in any case. For compensation of your time, we have arranged a small gift worth Taka 100(or cash 100 Taka) as a token of appreciation.

Thank you for your cooperation!
Best regards,
Research Team
Risk and Life-Saving Project

Economic Research Group (E.R.G.)

Q1. Do you agree to participate in our survey by answering all relevant questions?
1) Yes 2) No

Q2. Date of the survey(yy/mm/dd): ____________________________

Q3. Start time:__________hr__________min

A. Respondent Characteristics and Background Information [For questions 4-6, record your observation

Q4. What is main material of the roof of the house?
1) Natural roof: Katcha (Bamboo/Thatch)
2) Rudimentary roof:Tin
3) Finished roof: (Pukka) Cement/Concrete/Tiles
77) Other (Specify) ____________________________

Q5. What is the main material of the walls?
1) Natural walls: Jute/Bamboo/Mud (Katcha)
2) Rudimentary walls: Wood
3) Finished walls: Bricks/Cement
4) Tin
77) Other (Specify)____________________________

Q6.What is the main material of the floor?
1) Natural floor: Earth/Bamboo (Katcha)
2) Rudimentary floor: Wood
3) Finished floor: Bricks/Cement/Tiles
77) Other (Specify)____________________________

Q7. Does your household have access to electricity?
1) Yes 2) No 3) Yes, but rented from neighbor

Q8. Does your household have access to gas connection?
1) Yes 2) No 3) Yes, but rented from neighbor

Q9. Name of the respondent: ____________________________________

Q10. Gender of the respondent: 1) Male 2) Female

Q11. Relationship with the household head:

1) Self	4) Mother/Mother-in-law	7) Grand parents
2) Husband	5) Uncle	77) Other (Specify) _______
3) Father/Father-in-law	6) Aunt	

Q12. Age of the respondent:__________________years

Q13. Religion of the respondent:

1) Islam
2) Hinduism
3) Buddhism
4) Christianity
77) Other (Specify) _______

Q14. Highest education level of the respondent:

1) None and illiterate
2) None, but literate
3)Primary incomplete
4) Primary completed
5) Primary completed but secondary incomplete
6) Secondary completed
7) Higher secondary completed
8) Bachelors/Honors completed
9) Masters completed
77) Other (Specify) _______

Q15. Main occupation of the respondent:

1) Farmer
2) Fisherman
3) Trader
4) Artisan
5) Industrialist/Manufacturer
6) Public/private sector officer
7) Unskilled laborer of private sector
8) Skilled laborer of private sector
9) Unskilled laborer of public sector
10) Skilled laborer of public sector
11) Housewife
12) Student
13) Retired
14) Informal sector laborer
77) Other (Specify) _______

Q16. Household size (how many persons dine in your household everyday)?: ___in number

Q17. No. of child (under five years):_______________________

Q18. No. of income-earners including the respondent (*pensioners included):*___________

Q19. Average total monthly household expenses (excluding festivals): Tk. ___________

Q20. At present which of these is the principal source of drinking water for your household

1) Piped water into dwelling
2) Piped water to yard/plot
3) Public tap/standpipe
4) Tubewell/borehole
5) Rainwater collection
6) Bottled water
7) Cart with small tank/drum
8) Tanker-truck
77) Other (Specify) _______

Q21. What kind of toilet facility does your household have?

1) Flash toilet
2) Water sealed slab
3) Slab latrine
4) Open latrine
77) Other (Specify) _______

Q22. Does more than one household share the same toilet? - 1) Yes 2) No

a-3

Q23. How many of the following does your household/family own?

	Number [If none, write '0' (zero)]
1) Cycle	
2) Electric appliances (e.g.: Computer, Laptop, Refrigerator, Washing machine, Vacuum cleaner, Blender, Electric iron, A.C., Oven etc.)	
3) Radio/Cassette player/CD player	
4) Television/VCD	
5) Mobile	

Q24. How much agricultural land (other than homestead) does your household have? (1 Acre = 3.025 Bigha and 1 Bigha = 20 Katha)____________________Acre/ Bigha/ Katha

Q25. What type of stove do you use for cooking?

1) Traditional stove without chimney (e.g.: Clay Stove)
4) Electric stove
3) Gas stove
5) Kerosene stove
2) Improved stove with chimney

Q26. What fuel do you use for your cooking stove mainly?

1) Charcoal
2) Wood branches
3) Kerosene
4) Gas
5) Cow dung
77) Other (Specify) ________

Q27. How does your household dispose most of its rubbish?

1) Throw in a specified place (e.g. Dustbin)
2) Throw in any vacant lots
3) Throw in drains/lake/river/swamp
77) Other (Specify) ________

Q28. How would you describe the quality of the water that you and the others in your household drink?

1) Very bad
2) Bad
3) Neither good nor bad
4) Good
5) Very good

Q29. Has any member of your family including you caught victim of any waterborne disease during the last three months? - 1) Yes 2) No

Q30. How would you describe the quality of the air that you breathe in your neighborhood?

1) Very bad
2) Bad
3) Neither good nor bad
4) Good
5) Very good

Q31. Has any member of your family including you caught breathing problem or lung problem during the last one year? - 1) Yes 2) No

Q32. Please name three most problematic diseases in your area. (Do not read list of responses. Use tick marks to the right of three diseases that the respondent mentions and circle the one that seems to be prevalent.)

1) Common cold/fever
2) Diarrhea
3) Diabetes
4) Heart disease
5) Lung disease/breathing problem
6) Dengue
7) Malaria
8) Tuberculosis
9) HIV AIDS
10) Eye disease
11) Malnutrition
77) Others (Specify) ________
99) Don't know

(Skip Q33 if the answer to Q17 is '0' zero.)

Q33. In the last month, has any child (ren) in your household had diarrhea? - 1) Yes 2) No

Q34. Like many households, how many each of the vehicle(s) listed below does your household own?

	Number [Write '0' (zero) if owns none of the followings]
1) Rickshaw/ Bicycle/Van (similar)	
2) Motorcycle/Auto-rickshaw	
3) Car/Taxi Cab	
4) Tempo/Laguna	
5) Mini-bus	
6) Bus/Truck	
7) Others (Specify) _________	

Q35. (Generally) What is your main mode of transport? (Medium used to reach in the workplace, if the person is working)

1) Walk
2) Rickshaw
3) Bicycle
4) Motorcycle
5) CNG auto rickshaw
6) Taxi
7) Tempo/Leguna
8) Mini-bus
9) Bus
10) Personal /family car
77) Others (Specify) ________

Q36. How often do you travel by highway?

1) Less than once a year
2) Once or twice a year
3) More than twice a year
4) Once a month
5) More than once a month
6) Once a week
7) More than once a week
8) Everyday of the week

Q37. Can you drive? - 1) Yes 2) No (Skip next) 3) Not relevant (Skip next)

Q38. Are you currently driving? - 1) Yes 2) No

Q39. Did you encounter road accidents in the last 1 year? - 1) Yes 2) No

Q40. Have any of your friends or family members become victim of road accident in the last 1 year? - 1) Yes 2) No

Q41. Did you see any road accident to occur in the last 1 year? -1) Yes 2) No

Q42. Did any of your family members ever encounter any fatal road accident? –
1) Yes 2) No

Q43. Could you please tell us how much money did your household spend during the last month on each of the followings?

	Taka [Write '0' (zero) in this column if there is no expenditure in any of the followings]
1) Food and beverage	
2) Clothing and foot wear	
3) Housing/house rent	
4) Fuel and lighting	
5) Health and medicine	
6) Educational expense	
7) Household effects	
8) Miscellaneous	

Q44. What was the total monthly expenditure of your household in the last month?
Tk. ___________________

Q45. On an average, what is the total monthly expenditure of your household?
Tk. ___________________

(Skip Q46 and Q47 if the answer of Q17 is '0' (zero))
Q46. Is there any sick child at your household?-
1) Yes 2) No (Skip next) 3) Do not answer (Skip next)

Q47. Is the sickness chronic or temporary? - 1) Chronic 2) Temporary

Q48. Have you any elderly person sick at your household?
1) Yes 2) No (Skip next) 3) Do not answer (Skip next)

Q49. Is the sickness chronic or temporary? - 1) Chronic 2) Temporary

Q50. Have you had lost any of your children? - 1) Yes 2) No

Q51. Did you or your family member encounter any misfortune in the last 1 year?
1) Yes 2) No (Skip next)

Q52. (If yes) Mention the type of misfortune: ___________________________________

____

Q53. Did you directly (physically) encounter the following disasters in the last 10 years?

	Yes = 1, No = 2
1) Flooding	
2) Storm/Cyclone	
3) Others (Specify): ___________	

Q54. Has any female among your relatives or friends died (in your lifetime) during child birth? - 1) Yes 2) No

Q55. How would you say your health is in general?

1) Very good 2) Good 3) Fair 4) Poor 5) Very poor

Q56. Have you ever been diagnosed with one of the following diseases?

	Yes=1, No=2		Yes=1, No=2
1) Asthma/Respiratory disease		7) Hepatitis B (Jaundice)	
2) Bronchitis or chronic cough		8) High blood pressure	
3) Cancer		9) HIV	
4) Chronic dysentery		10) Malaria	
5) Diabetes		11)Tuberculosis (TB)	
6) Heart disease		12) Low blood pressure	

Q57. Please say if you …

1) Smoke regularly
2) Smoke sometimes
3) Smoke rarely
4) Used to smoke but have given up
5) Never smoke

Q58. Kindly tell us do you take any type of (smokeless) tobacco item (like: *Shada pata*, Snuff, *Jorda*, Dipping Tobacco: *gool*, **etc.)?-** 1) Yes 2) No

Q59. For the purpose of our research, would you please tell us in which of the following categories does your total monthly household income fall into- please sum up your income from all sources like, wage, rent, agriculture etc.

1) Up to Taka 5000
2) 5001-10000 Taka
3) Taka 10001-20000
4) 20001-30000 Taka
5) Taka 30001-40000
6)Above Taka 40000

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Q60. All things considered, how satisfied are you with your life? Please answer by using the following scale in which 0 means „completely dissatisfied" and 10 means „completely satisfied". [Let the respondent circle the number]

10 (Completely satisfied) 9 8 7 6 5 4 3 2 1 0 (Completely dissatisfied)

Q61. On a scale from 1 to 6, please indicate your level of agreement with the statement "Most people can be trusted":

1(strongly disagree) 2 3 4 5 6 (strongly agree)

Q62. How often do you spend time in praying?

1) 5 times a day or more
2) More than once a day but less than 5 times
3) Once a day
4) Less than once a day but at least once a week
5) 5 times a day or more

B. Introducing some risk factors

In the context of Bangladesh, now I will talk about mortality risk associated with road accident, polluted air and contaminated water as well as risk of maternal death. There are several risk factors that cause large number of deaths in Bangladesh. Fortunately, these mortality figures can be reduced by taking appropriate measures and right investment.

Road Accident

It is estimated that more than 2,000 people are killed in road accidents every year, i.e. about 6 persons every day in the country. In fact, the leading injury-related cause of death among people aged 15-44 years is traffic injuries. The main causes of accidents are poor road safety (infrastructural), reckless driving, and lack of implementation of regulations. Moreover, considering drivers' involvement in accidents, about half of the drivers were of the age group 26-35, in the recent years.

Water Contamination

Approximately 64,970 deaths every year are attributable to water, sanitation and hygiene in Bangladesh. For children under 5 years old, the number of deaths was 58,639. One particular illness, diarrhea, is particularly linked to bad water. One of the leading causes of diarrhea is drinking, washing with, or bathing in contaminated water. Diarrhea kills about 20000 children every year in Bangladesh.

Air Pollution

Estimates suggest that air pollution kills 15,000 persons every year in Bangladesh. Air pollution causes lung diseases which mostly affect children and the elderly people. It is estimated that if the extent of air pollution can be reduced up to 20 to 80 percent, then survival of 1200 to 3500 people is possible in each year.

Maternal Mortality
There are about 240 maternal deaths per 100,000 live births. This means that these women die during child birth. Causes of death include pregnancy or its management, excluding accidental or incidental causes. The government has a target of reducing this number about half (to 143 per 100,000 live births) by 2015.

Therefore, we now know about increasing probability of death due to reckless driving of comparatively young drivers, child death due to contaminated water, lung diseases due to huge air pollution, maternal death due to lack of proper care during pregnancy period. Therefore, we should be more careful about this.

C. Risk Perceptions

We have discussed about various risk factors for life and health e.g. road accident, polluted air and contaminated water and maternal death in the context of Bangladesh. However, not everyone faces the same risk given his or her specific context. *While answering the following questions, think in terms of the risk to you or to your household member wherever appropriate.*

Q63. How would you describe the risk of being injured or killed in a road accident, for you, or for any member of your household?

1) Very low risk 3) Moderate risk 5) Very high risk
2) Some risk 4) High risk

Q64. How would you describe the air quality in the area you live, thinking in terms of risk to your health?

1) Very low risk 3) Moderate risk 5) Very high risk
2) Some risk 4) High risk

Q65. How would you describe the quality of water that you (and your household) drink every day, thinking in terms of risk to your health?

1) Very low risk 3) Moderate risk 5) Very high risk
2) Some risk 4) High risk

[If the answer of Q17 is '0' (zero), skip Q66 and 67]
Q66. At how much risk of getting ill from bad water quality is your child?

1) Very low risk 3) Moderate risk 5) Very high risk
2) Some risk 4) High risk

Q67. At how much risk of getting ill from (breathing problem/ lung disease) from bad air is your child?

1) Very low risk 3) Moderate risk 5) Very high risk
2) Some risk 4) High risk

D. Understanding of risk and risk reduction

Generally, reduction of risk to health and mortality would entail individual and/or collective efforts, safety measures as well as private or public investments. We will now discuss the meaning of risk reduction so that you understand what it means to reduce, say certain percentage of reduction of, some risks.

Suppose there are two roads which are very prone to accidents. The risk of dying in Road A is 1 in 10,000 and the risk of dying in Road B is 3 in 10,000.

Q68. Which road is more risky to take?

1) Road A
2) Road B

If the answer is wrong, explain until correct answer is given and write down how many times you had explained. The respondent was explained …………………… times.

- Suppose the risk of dying for a road user from traffic accident is 40 in 100,000(40 in one lac). Now suppose a reduction in mortality risk, through improved road safety measure, could reduce the mortality risk from 40 in 100,000 to 30 in 100,000. This means that, on average, 10 out of 40 lives would be saved by the measure.

Q69. Do you understand this risk reduction?

1) Yes
2) No

If no, explain again and make sure that the respondent understands and write down how many times you had to explain. The respondent was explained …………………… times.

- Similarly, if the risk was reduced from 40 in 100,000 to 20 in 100,000; this means that on average 20 out of 40 lives would be saved.

Q70. Do you understand this risk reduction?

1) Yes
2) No

If no, explain again and make sure that the respondent understands and write down how many times you had to explain. The respondent was explained …………………… times.

- If the risk was reduced from 40 in 100,000 to 10 in 100,000; this means that on average 30 out of 40 lives would be saved.

Q71. Do you understand this risk reduction?

1) Yes
2) No

If no, explain again and make sure that the respondent understands and write down how many times you had to explain. The respondent was explained …………………… times.

Q72. Which of the above risk reductions would you prefer? [circle one]

1) 40 in 100,000 to 30 in 100,000
2) 40 in 100,000 to 20 in 100,000
3) 40 in 100,000 to 10 in 100,000

E. Willingness to pay for risk reduction

The questions underneath (Questions 78 – 80) are applicable only for cities/urban area

We will now move towards the discussion on air pollution again. If air pollution is reduced, your death risk from this pollution will decline. We will want to know whether you agree to spend for the purpose of reducing air pollution or not. We will now talk about air pollution of Dhaka/Chittagong. Dhaka is one of the most polluted cities in Asia.

The main underlying reasons for air pollution in Dhaka cover:

1. Motor-driven public and private transports.
2. Presence of garment and leather factories within cities.
3. The brickfields at the outskirts of Dhaka

Due to increase in demand with increasing population, the number of motor-driven vehicles is rising at an average rate of 7 to 16 percent every year. Therefore, air pollution is increasing at an extreme rate. And for this reason various environmental, social and health related problems are arising.

As seen in a survey, 15000 people become victims of premature death each year due to air pollution in Dhaka. That means, as the current population of Dhaka is 1 crore 20 lakh (Bangladesh Statistical Pocket Book, 2007), 125 people out of 10000 die from air pollution in Dhaka every year. To reduce this number we have to bear some expenses.

Emitted smoke from vehicles is marked as the main reason for air pollution. Therefore, one effective way for reducing air pollution can be maintenance of vehicles by proper care resulting in not allowing the amount of pollution to go beyond a certain level.

Suppose, the government took an initiative for which vehicles have been well maintained. Along with it the death risk due to air pollution declined from 125 people out of 10000 to 120 people out of 10000. You are told to donate a certain amount of tax/fee per year for this public project. On the one hand, this project will reduce your death risk due to air pollution to 5 out of 10000 people, but on the other hand, you cannot use your money spent for this project to any other area. However, you do not have to spend any money for this survey.

Q77. If you are told that death risk in Dhaka due to air pollution can be reduced by a government initiative from 125 out of 10000 to 120, would you then spend for it?
(Answer using the criteria '1 = not sure at all and 5 = absolutely sure')

Yes=1/No=2	How much sure

(If the answer to question number 78 is *no*, then go to question number 80 and if the answer is *yes*, then avoid question number 80.)

Q78. (If the answer is *yes* for question number 78) What is the maximum amount which you would be willing to pay annually to decrease your yearly death risk from 125 out of 10000 to 120?

Amount of money	How much sure (Answer using the criteria '1 = not sure at all and 5 = absolutely sure')

Q79. "I do not want to spend money to reduce air pollution" Why? (There may be more than one answer)

1) I do not think that it is necessary
2) Polluters, such as vehicle owners should expend money
3) There should be government steps
4) This type of step is unrealistic
5) I am not concerned about air pollution
6) I want air pollution to remain in the present condition
7) It does not harm me
8) I think the government will take steps in this case anyway

77) Others (Please specify):___________________________

Q80. Lastly, what is your opinion of this survey? *(Circle all that apply)*

1) Interesting 3) Unrealistic 5) Difficult to understand
2) Too long 4) Informative 77) Other (Specify): ____________

ENUMERATOR"S SECTION

Q81. Time taken to complete the survey:_____ hr_____minutes.

Q82. Respondent was interviewed:

1) At first visit 2) At second visit 3) At third visit

Q83. Whether the respondent received (as preferred) cash prize or gift?

1) Respondent preferred and received cash
2) Respondent preferred and received gift
3) Respondent was indifferent about cash and gift
4) Respondent declined to accept gift or cash

Q84. Respondent's address and mobile number (if possible): ___________________________

____

Enumerator's ID: ___________________________
Supervisor's ID: ___________________________
Date of data entry (YY/MM/DD): _______________
Data entry operator's ID: ____________________

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Abstract (In Japanese)

要約

本稿は、大気汚染による死亡という文脈で、バングラデシュ都市部住民の統計的生命価値（value of statistical life）を仮想評価（contingent valuation）法を用いて計測した初の試みを紹介している。仮想評価法による調査は、2013 年に同国で最も人口密度の高いダッカ及びチッタゴンで実施された。調査では、死亡率を下げる大気汚染改善施策に対する個人の支払意思を聴取した。支払意思額と、調査対象者の社会・経済的特性、健康状態、リスク認識等との相関は、他国の既存研究の例と整合的であった。ブートストラップ法を用いて統計的生命価値の平均値の信頼区間を求めたところ、17,480 ドル～22,463 ドル（購買力平価換算）となり、これは 2013 年の同国一人当たり GDP の 9.78 倍～12.57 倍であった。この結果は、調査に用いた設定を考慮すると、環境リスクに対する同国市民の統計的生命価値評価の下限を示していると考えられる。

キーワード：統計的生命価値、支払意思、仮想評価法、大気汚染、バングラデシュ

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