Air Pollution and the Willingness to Pay of Exposed Individuals in Downtown Medellín, Colombia

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Abstract: *Within Colombia, Medellín holds the title of the city with the second worst air quality, and within the city, Downtown Medellín is one of the areas most affected by mobile gas emissions. Individuals that work downtown were surveyed in order to measure their willingness to pay (WTP) to reduce air pollution. Four groups are characterized according to the respondents' answers: Stated Preference (SP), Averted Costs (AV), both (SP and AV), and No WTP. Results show that age, income level, having a symptom/illness, and exposure to pollution (at different levels) are important for characterizing the respondents into these groups and have a direct effect on the probability of them stating a positive WTP.*

Key Words: *Air Pollution, Contingent Valuation, Willingness to Pay, Medellín*

JEL Classification: *Q53, Q51, Q59*

Disposición a pagar de los individuos expuestos a la contaminación del aire en el centro de Medellín, Colombia

Resumen: *En Colombia, Medellín ostenta el título de ser la segunda ciudad con la peor calidad de aire, y dentro de la ciudad el centro es considerado una de las zonas con mayor emisión de contaminación por fuentes móviles. Teniendo en cuenta este hecho, se entrevistaron a las personas que trabajan en esta zona con el fin de caracterizar su disposición a pagar por reducir la contaminación del aire. Se identificaron cuatro grupos de individuos a partir de las respuestas obtenidas: individuos con preferencias establecidas (SP), con costos evitados (AV), con ambos (SP y AV) e individuos sin disposición a pagar (No WTP). Los resultados muestran que la edad, el nivel de ingresos, presentar un síntoma o enfermedad y la exposición a la contaminación (en diferentes niveles) son características importantes para determinar a cuál de los grupos pueden pertenecer los individuos y, a su vez, afecta la probabilidad de responder una disposición a pagar positiva.*

Palabras claves: *Contaminación del aire, Valoración contingente, Disposición a pagar, Medellín*

Clasificación JEL: *Q53, Q51, Q59*

La disposition à payer des individus exposés à la pollution de l'air dans le centre-ville de Medellin, Colombie

Résumé: *Medellin est la deuxième ville la plus polluée de Colombie. Le centre-ville est considéré étant l'une des zones ayant la plus grande quantité d'émissions de substances polluantes dues aux véhicules. Les individus qui travaillent dans cette zone ont été interrogés, afin de caractériser leur disposition à payer pour réduire la pollution de l'air. Quatre groupes d'individus ont été identifiés à partir des réponses obtenues: ceux ayant des préférences établies (SP), ceux ayant des coûts évités (AV), ceux qui ont ces deux dernières caractéristiques (SP et AV) et, finalement, les individus sans disposition à payer (No WTP). Les résultats montrent que l'âge, le niveau de revenu, le fait d'avoir un symptôme ou bien une maladie et l'exposition à la pollution (à différents niveaux), sont des caractéristiques importantes pour déterminer le groupe auquel appartient chaque individu, ce qui veut dire qu'elles déterminent la disposition à payer.*

Mots-clés: *pollution de l'air, évaluation contingente, disposition à payer, Medellin*

Classification JEL: *Q53, Q51, Q59.*

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–Introduction. –I. Materials and Methods. –II. Statistical Tools and Method. –III. Results. –IV. Discussion. –Conclusions. –References. –Appendix

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Introduction

The relationship between the environment and economics has been broadly studied by academics of different fields of knowledge. Pollution (such as water, air, waste, noise, and nuclear radiation) has been of interest to economists recently due to the numerous adverse effects it has had on human health and human capital. Particularly, air pollution is recognized as one of the main sources of health problems globally (Burnett et al., 1999; Le Tertre et al., 2002; Zanobetti and Schwartz, 2002; O´Neill et al., 2003; World Health Organization (WHO, 2005); Zivin and Neidell, 2013 and has remained relevant for economists who have estimated relationships between air pollution and health so as to create measures of willingness to pay for air quality. Thus, the objective of this study is to estimate and analyze individuals' willingness to pay (WTP) to reduce the influence that air pollution has on their health (manifested in lung-related symptoms and illnesses) in Downtown Medellín, Colombia by using multi-logit estimation. The multi-logit approach and its marginal effects is part

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of the analysis used by the contingent valuation method (CVM). The CVM is used for assigning monetary values to environmental goods and services that do not have an apparent market (Carson, 2000). Also, it allows for the characterization of respondents according to their distinctive features and to distinguish individuals' preferences for air quality. This method gathers information about the values that individuals give to a non-market good by administering a survey. As well, the CVM is considered to be a 'stated' preference for a specific non-market good or service. Even though the CVM has been criticized among economists (Diamond and Hausman, 1994), it also has been recognized as a valid instrument to address preferences among individuals (Carson, Flores and Meade, 2001). In fact, it has been used extensively in developing and developed countries as an instrument to determine the value of environmental goods and services (Whittington, 2002).

In developing countries, due to the lack of environmental policies focused on reducing emissions, air pollution has been a serious concern due to its correlation with human health problems; due to the complexity of the impact, it is difficult to measure the benefits from air quality improvements among the members of a polluted society (Wang and Mullahy, 2006; Wang and Zhang, 2009; Nguyen and Shin, 2012). However, any achievement in improving air quality will affect the welfare of the whole society. Utilizing a dataset from a polluted area of Medellín, we present the characteristics of exposed individuals that are correlated to a positive or stated preference for air quality.

Medellín is considered to be the second most polluted city after Bogotá in Colombia. Bedoya and Martinez (2009) stated that in Medellín, air quality is critical and the city has failed to meet air standards, exposing the entire population to a higher risk of adverse health effects (Lenis and Ospina, 2003; Muñoz, Paz and Quiroz, 2007; Mazo, 2008). Through urbanization processes, the number of vehicles in the city has increased and therefore the consumption of fossil fuels, especially bad quality diesel and gasoline, which are regarded as the major sources of air pollution (Lenis and Ospina, 2003; Arias, 2004). This implies that within the urban population of Medellín, those who work or spend a significant amount of time in areas with heavy traffic are the people most exposed. Besides this, those that are exposed are more vulnerable to presenting health problems, which have a negative impact on their economic activities. Among the areas with the highest levels of pollution in the metropolitan area of Medellín are: Itagüí-Ditaires, Politécnico Jaime Isaza-Cadavid, and Downtown Medellín (specifically the area close to the Miguel de Aguinaga Building and San Antonio Park) (Rave et al., 2008). Because these are places recognized for having heavy traffic, they have set up meters that measure the amount of air pollutants, for example: Particulate Matter ($PM_{2.5}$ and PM_{10}).

Thus, the present study will utilize a multi-logit estimation to measure the WTP of exposed people by distinguishing four different groups of individuals according to their responses given in a survey performed during 2010 in Downtown Medellín. The purpose is to analyze exposed individuals of a specific polluted area who stated a positive WTP (Downtown Medellín) as well as their characteristics. The article is divided as follows: the first part describes the theoretical approach, the second section presents the model used, the third part highlights the results, and finally, we present the discussion and conclusion.

I. Materials and Methods

A. Particulate Matter Air Pollution in Downtown Medellín

Within Medellín, the downtown area is considered to be one of the most polluted areas. Levels of particulate matter are especially critical, for they exceed the norm set by the WHO of being a human health risk.[1] In the downtown area, there are two meters located at the Miguel de Aguinaga Building (which mainly measures $PM_{2.5}$) and San Antonio Park (which mainly measures PM_{10}).

Data provided by *Red de Vigilancia de la Calidad de Aire* (REDAIRE) for the meters located at Miguel de Aguinaga Building and San Antonio Park

1 The WHO (2008) set up the following levels of emissions, daily and annually, for particulate matter considered to be a risk to human health. For $PM_{2.5}$ (particulate matter under 2.5 microns), 10 $\mu g/m^3$ is the annual average and 25 $\mu g/m^3$, the daily average, while for PM_{10} (particulate matter between 2.5 and 10 microns), 20 $\mu g/m^3$ is the annual average and 50 $\mu g/m^3$, the daily average. The WHO does not set up monthly averages in any case.

exhibit that the levels of particulate matter emissions are critical. The meter located at Miguel de Aguinaga Building shows how in 2008 the annual average of emissions of $PM_{2.5}$ was 34µg/m^3 (above the norm established by the WHO). Measured by months in 2008, April and September had the highest emissions: 47 µg/m^3 y 39 µg/m^3, respectively, while the remaining months showed an emission average of 29 µg/m^3. Furthermore, from the 220 daily samples that were taken in 2008 (220 samples out of 365 possible), more than 200 exceeded the acceptable daily average set by the WHO. In 2009, overall, the monthly averages of $PM_{2.5}$ decreased (25 µg/m^3), while the daily concentrations showed that out of the 323 daily samples taken for that year, 250 went above the WHO's norm.

The meter located at San Antonio Park also shows that the PM_{10} emissions in 2008 went above the WHO's norm. The annual average was 61 µg/m^3 and the most polluted months were April (83 µg/m^3) and May (72 µg/m^3), while for the remaining months, the average emissions exceeded 60 µg/m^3 (except October with 49 µg/m^3). In 2009, the annual average was lower than in 2008 at 55 µg/m^3, but it still surpassed the WHO's norm. By month, the average emissions of all months went above 55 µg/m^3 and the most polluted months were December (69 µg/m^3) and October (66 µg/m^3).

The above data reveals that particulate matter emissions ($PM_{2.5}$ and PM_{10}) are substantial in Downtown Medellín. The concentrations of $PM_{2.5}$ are worrying, for this pollutant has a very negative effect on human health, and especially so for Downtown Medellín, where there are a vast number of people. It has been estimated that around 1 million people intermittently walk in Downtown Medellín every day. Besides this, unofficial data suggests that around 9,000 informal street vendors work in Downtown Medellín and therefore are exposed to substantial air pollution (not including the formal vendors that work in small cubicles outdoors). This makes this group of individuals one of the most vulnerable in developing lung-related illnesses.

B. The Survey

According to non-official data (Calle, 2009), in 2009 there were around 9,000 informal regulated vendors in Downtown Medellín. The survey was conducted between June and August 2010 and was given to 1,000 individuals that work in Downtown Medellín. After removing uncompleted and non-valid surveys, we had 963 individuals that represent 10.7% of the total population, which is representative regarding the amount of informal vendors. The places were divided into two zones: one between Carreras 50 and 52 and between Calles 51 and 54, close to Miguel de Aguinaga Building; the second area, between Carreras 49 and 51 and Calles 46 and 48, close to San Antonio Park. Before asking the questions, the interviewers were trained to express the true motives of the survey, emphasizing how air pollution can cause health problems. The questionnaire consisted of three parts: the first section contained socio-economic questions, including those related to age, gender, education, place of residence, economic activity (occupation), and monthly income. The second part included questions regarding each respondent's exposure to air pollution (which was measured in hours and months), work place (indoors or outdoors), their subjective view of the current air pollution situation, and the number of lung-related illnesses and symptoms presented by each respondent in the previous month. Considering the interviewees' potential lack of knowledge about the consequences that air pollution has on human health, there were a set of symptoms presented as less severe and lung-related illnesses which were presented as more severe, while leaving the question open for other symptoms or illnesses. The final part of the survey consisted of the CVM.

Within the CVM survey, interviewees were asked about the indirect monetary expenses paid out-of-pocket for recovering from lung-related problems due to air pollution. The expenses were classified into medical costs (including appointments, self medication, and prescribed medication), transportation costs (used for going to the doctor), working day cost losses (which was not relevant regarding the number of respondents), and other related costs, which were considered to be induced costs caused by air pollution. These costs are considered an indirect WTP for individuals (Courant and Porter, 1981; Calthrop and Maddison, 1996). The purpose of the question was to make respondents aware of the costs assumed due to air pollution so as to get a better understanding of the following question. Finally, there was a question that directly asked individuals about their WTP to avoid lung-related symptoms or illnesses. The information gathered by the survey about respondents' indirect WTP could be used for dose-response methods, however this was not the intention of the present study.

One of the purposes of this study is to characterize the respondents' awareness about air pollution by comparing their WTP and characteristics such as gender, age, education, income, socio-economic strata,[2] and symptoms or illnesses suffered due to air pollution. In order to address this analysis, the variable WTP was used dividing respondents by groups. Part of the respondents showed indirect WTP (Averted Costs), however the number of respondents in this case was just 9.9%. This expenditure can be deemed a passive use value (or indirect valuation) for an improvement in air quality (Carson, 2000), susceptible of being used as a dependent variable in the model. However, the idea was dropped due to the low number of respondents and the poor significance of the model.

C. Willingness to Pay

In general, academics are concerned with finding an economic measure that gives non-market values of goods and services. In the specific case of air pollution, the typical methods used have been dose-response functions, observed behavioral methods consisting of health production function models, and hedonic property price or wage models (Jin-Lee et al., 2011). Critiques of these methods focus on the reliability of capturing the relationships and the values of the net benefits from improvements (Carlsson and Johansson-Stenman, 2000; Wang and Zhang, 2009).

Another widely-used method is Willingness to Pay (WTP), which has been applied in empirical studies of valuation so as to measure welfare changes on individuals and preferences over non-market good and services, which are considered behavioral methods. For instance, the Contingent Valuation Method (CVM) is a procedure that involves asking individuals for their wi-

2 "Socio-economic strata" refers to the area where individuals live based on how developed the neighborhood is. This measurement is different from the income earned by each individual (note by the author).

llingness to pay so as to evaluate preferences over certain goods and services, which has been extensively accepted by academics and policy-makers as a useful tool for valuing intangible goods or environmental quality (Wang et al., 2006). Willingness to Pay is one of the two standard measures of economic value (another one is Willingness to Accept) and it is the appropriate measure in a situation where an agent wants to acquire a good that is not ruled by a specific market (Carson, 2000). Thus, several studies which aim to evaluate intangible goods or services such as reductions in mortality (Krupnick et al., 2002; Alberini and Chiabai, 2007; Mahmud, 2009) or morbidity (Dickie and Gerking, 2002), or improvements in air quality (Carlsson and Johansson-Stenman, 2000; Jin-Lee et al., 2011), among other studies, have widely used this approach for asking individuals directly or indirectly about their WTP.

Measurements to valuate losses from air pollution are relevant in validating environmental policy changes because of the impacts that pollution can have on human health, the costs of public policies, as well as the economic activities of exposed individuals (Jin-Lee et al., 2011).

II. Statistical Tools and Method

To determine the possible relationships between individual characteristics and direct or indirect valuation for a reduction in pollution, we estimate a multinomial logistic regression. The dependent variable in our study is a categorical variable that is equal to:

1 if Stated Preferences=0 and Averted Costs=0[3]

2 if Stated Preferences=0 and Averted Costs>0

3 if Stated Preferences>0 and Averted Costs=0

4 if Stated Preferences>0 and Averted Costs>0

3 Stated preferences are positive when the respondent of the survey mentions an amount other than zero that he is willing to pay to avoid pollution. Averted costs are positive when the respondent of the survey mentions the positive amount he paid last month for medicines, doctor fees, travel expenses to the doctor's office or lost wages for being sick. This is an indirect measure of WTP.

The multinomial logistic regression is designed specifically to determine the probability that a survey respondent with certain observable characteristics belongs to a specific group in our dependent variable. In this case, we want to characterize the population willing to pay to avoid pollution (directly or indirectly) in contrast to the people not willing to pay.

The multinomial logistic regression compares the four different groups through a combination of three different estimated equations, since one of the groups is selected as the reference group (in our analysis: Stated preferences=0, Averted Costs=0). The coefficients for the reference group are all zeros and the three equations can be used to compute the probability that a respondent is classified to the group with the highest probability:

$$p_{ij} = p(y_i = j) = \frac{\exp(w_i'\boldsymbol{\beta}_j)}{\sum_{k=1}^{m} exp{=}(w_i'\boldsymbol{\beta}_k)}, \quad (1)$$

where p_{ij} is the probability of individual i to be in group j, w_i represents the independent variables in the regression for group j, and m is the quantity of the different groups minus the reference group. The independent (alternative-invariant) variables to be used in the analysis are related to socio-economic conditions, health-related variables, and exposure to pollutants in the area where the survey was conducted. The coefficient interpretation for alternative j is a comparison to the reference group; an increase in the independent variable makes the selection of alternative j more or less likely.

In addition to calculating the coefficients for making comparisons with the base group, we estimate the marginal effect of an increase of a variable on the probability of being selected to group j:

$$\frac{\delta p_{ij}}{\delta w_i} = p_{ij}(\boldsymbol{\beta}_j - \bar{\boldsymbol{\beta}}_1). \quad (2)$$

The marginal effects are different in both direction and magnitude from the estimated coefficients; it is also possible to calculate them for the base group and they are the same regardless of the reference group. The marginal effects can be interpreted as an increase in a unit of the independent variable that increases/decreases the probability of being in group j by the marginal effect represented as a percentage.

Finally, we will show which independent variables are statistically different between different pairs of groups by analyzing how variables vary when comparing each of the four outcomes to each other. This allows us to find significant differences in the characteristics of the groups and observe how these differences shape the probability of being classified in a certain group.

III. Results

A. Validation

The literature recognizes that the CVM questions are hypothetical and it is standard procedure to make a validation of the results based on the acceptance of the survey by the respondents (Carson, et al. 2001; Wang and Zhang, 2009). In this study, the questionnaire was well accepted by the respondents regarding questions about exposure and socio-economic variables, which means that more than 98% gave a positive response. However, the questions about expenses and their WTP were not that well accepted. Respondents whom stated a positive WTP represented 51% (487/963) of the total, while for a positive averted cost it was 67.7% (652/963). This rate is below the rate suggested by Carson (2000), which highlights the typical number of non-responses in a CV study range being from 20% to 30%. One main problem of why respondents did not state a value in their WTP is perception, for people exposed do not consider air pollution a relevant problem (they care about their income and job opportunities more). The common responses by individuals so as to avoid giving a value were linked to the fact that the respondents believed that the question would be used to charge a tax to those exposed (even if the interviewer explained in detail that this was an academic exercise not related to local government policies). If we consider that the number of respondents who either claimed an averted cost or a positive willingness to pay was 221, equivalent to 23%, which gives us a total of 77% (742/963) who gave either a direct or indirect positive response (henceforth positive stated preference or SP), then we can use this as an indirect measure. By stating a positive response, direct or indirect, individuals are disclosing their preferences for reducing air pollution, which gives us insights about their demand function for air quality. Even though using an averted cost as a measure of willingness to pay has been widely discussed as an unsure measure and has been deemed a lower bound, we are using it because of the nature of the survey and the interviewed people.

Then, regarding the number of respondents with a positive WTP, the results are relevant and can be used to make inferences. Table 1 presents the variables used in the model, which includes socio-economic strata, health status, pollution status, expenditure, and their perspective of their WTP.

Table 1. *Descriptions of the Variables, the Mean and the Standard Deviation (S.D.) of the Responses*

Variables	N	mean	S.D.	min	max
Male	961	0.42	0.49	0.0	1.0
Age	961	39.2	14.34	15.0	82.0
High education	963	0.57	0.49	0.0	1.0
Income level	961	1.51	0.62	0.0	4.0
Working place inside=1	961	0.42	0.49	0.0	1.0
Hours work place	961	10.29	2.11	0.0	18.0
Months in the area	961	82.78	91.92	0.0	540.0
No health care	963	0.04	0.19	0.0	1.0
Symptom/illness	963	0.64	0.48	0.0	1.0
Long daily exposure>8 h	963	0.77	0.42	0.0	1.0
Long exposure>60 months	963	0.41	0.49	0.0	1.0
Months exposure (square)	961	15,293	33,197	0.0	291,600
Total exposure *	961	866	1,010	0.0	6,480
Total exposure square **	961	1,769,546	4,236,927	0.0	41,990,400
Averted costs	963	12,904	51,925	0.0	1,000,000
WTP	963	5,392	15,746	0.0	200,000

Notes: *Total exposure as months times hours; **The square of the variable.
Source: Compiled by authors.

Of the respondents, 58% are female and the average age of the respondents is 39. Forty-eight percent of the respondents belong to the subsidized health care system, and 4% do not belong to either a contributive or subsidized system. The daily average time spent by a respondent in the area of study is 10 hours. Furthermore, the average in months that respondents have been working in the area is 83 months. The average income level of respondents is 1.5 monthly minimum wages (equivalent to 773,000 COP or US$405)[4]. Respondents on average studied to some level of secondary school (not necessarily having graduated). Finally, respondents that incurred a positive expenditure on average spent 12,904 COP (US$6.80) per month on lung-related problems, while respondents with a positive WTP on average are willing to pay 5,391 COP (US$2.90).

B. ANOVAs to Explore Differences in the Respondents

The variance analysis is not significant between groups in terms of gender, no health care, time in the area, or any of the exposure variables. We find significant differences at the 5% level for the variables: age, highest level of education, level of income, and symptom or illness. The ANOVA is a simple correlation analysis between the groups in which individuals are divided (No WTP, Averted Costs -AC-, Stated Preferences -SP-, and both AC and SP) and a specific independent variable of interest. This analysis gives us a first measure of the difference of the individuals within the above groups (No WTP, AC, SP, and both AC and SP).

By looking at descriptive statistics we found that younger respondents are more aware of the implications of air pollution given their positive SP. In general, an improvement in air pollution is more relevant for younger respondents compared to older respondents. By the level of education, respondents with a higher educational level, have higher awareness of the consequences of air pollution. Finally, the amount of money expressed by respondents in general is low regarding the effects and cost consequences that air pollution has on human health.

Consequently, by looking at Income Level, respondents with a higher income are more aware of the health problems caused by air pollution. In

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4 Using the average exchange rate for 2010 throughout this paper (1,910 COP = US$1, Banco de la República de Colombia, 2011). The monthly minimum wage in Colombia in 2010 was 515,000 COP (equivalent to US$270).

terms of the variables Symptoms and Illness, by comparing both variables, it is apparent that respondents who suffered from a symptom have more awareness of air pollution. In numbers, respondents adhering to the subsidized health care system are more aware of the air pollution problem than those with private health care. Possibly, individuals with subsidized health care more frequently have to pay out-of-pocket if they get sick compared to the privately insured respondents, which makes them more aware of the relevance of improvements in air quality. This result can also be explained because the dynamics of the subsidized system's services in terms of timeliness are slower than those of the private system. Then it is probable that respondents value being healthy more so as to avoid losing time and therefore money.

C. Multinomial Logit Model

We estimate four different models that show differences among them according to the definition of the pollution variables (see Table 1 in the Appendix). The first model includes only a dummy variable that accounts for Exposure to the Pollutants. The second model includes the continuous variable of Hours per Day, the amount of Months Working in the Area, and the square exponential of this last variable. The third and fourth regressions include the interaction between the amount of Hours per Day and the amount of Months in the Area, but the third regression also includes the continuous variables of Exposure.

The coefficients are read as estimated coefficients that compare the groups with positive stated preferences with a reference group, which is No WTP. The coefficients associated to WTP via Only AC are significant for the Symptoms/Illness variable and the Exposure variables. This could be explained by the fact that the difference between the Only AC and No WTP is the incurrence of medical expenses by the second group, therefore the Symptoms/Illness variable is clearly significant almost by design.

For both the Only SP group and both SP and AC, the coefficients for Age, Symptoms/Illness, Higher Education, and Higher Earnings are significant when comparing them to the base group; some Exposure variables are significant yet they are not significant for both stated preference groups. It is important to notice that for the population with a stated preference to WTP, socio-economic variables play a significant role. The sign of the coefficients indicate that younger people are more willing to pay, more educated people are willing to pay more to avoid pollution, and higher wage earners do pay more in order to avoid pollution.

D. Marginal Effects on the Independent Variables

The marginal results are presented in four different tables in the Appendix. Each table presents one of the four different groups, for which we analyze the marginal effects that different variables have on the probability of pertaining to a specific group. We read each marginal effect by how one marginal change increases/decreases the percentage of belonging to a particular group. Results from the No WTP (if Stated Preferences=0 and Averted Costs=0) show that the probability of belonging to this group increases with age, while it decreases with level of education, income level, and presenting a symptom or illness (Table 2). At the same time, the variables of Exposure are not consistent between models. In one case (Model 2), Exposure in Months reduces the probability of belonging to the No WTP group, and the square effect of this variable shows a U-shaped relation (once we control for the Total Exposure, the effect reverses). Also, when including only the Total Exposure (the variable and its square effect), the result is the same, supporting the U shape. In general the U shape exposure presents how individuals at the beginning (when they are exposed by pollution in the area) are more likely to incur a positive SP (Averted Cost or WTP), but once time passes their probability of belonging to the group with no WTP increases. This interesting result propose that people exposed at the beginning have better awareness, but with time the perception fades away.

Table 2. *Marginal Effects for the Group No Willingness to Pay*

Variables	(1) Marginal effects	(2) Marginal effects	(3) Marginal effects	(4) Marginal effects
No Willingness to Pay (WTP)				
Male	-0.0102	-0.00791	-0.00447	-0.0113
	(0.0294)	(0.0297)	(0.0299)	(0.0297)
Age	0.00222**	0.00219*	0.00209*	0.00248**
	(0.00112)	(0.00114)	(0.00115)	(0.00115)
High education	-0.0362	-0.0399	-0.0412	-0.0381
	(0.0337)	(0.0342)	(0.0344)	(0.0342)
Income level	-0.0411*	-0.0422*	-0.0414*	-0.0423*
	(0.0239)	(0.0238)	(0.0241)	(0.0238)
No health care	-0.00179	-0.0128	-0.0175	-0.0108
	(0.0671)	(0.0658)	(0.0642)	(0.0663)
Working place	0.0218	0.0213	0.0217	0.0259
Inside	(0.0307)	(0.0309)	(0.0308)	(0.0306)
Symptom or	-0.123***	-0.123***	-0.123***	-0.124***
Illness	(0.0299)	(0.0300)	(0.0300)	(0.0298)
Months exposure		-0.000856**	0.00165	
in area		(0.000409)	(0.00183)	
Months exposure		2.39e-06**	-1.20e-06	
in area (square)		(1.07e-06)	(3.10e-06)	
Hours work place		-0.0111	-0.000278	
		(0.00678)	(0.0109)	
Long daily	-0.0483			
exposure>8h	(0.0346)			
Long exposure	-0.0322			
>60 months	(0.0306)			
Total exposure			-0.000244	-8.26e-05**
month*hours			(0.000169)	(3.51e-05)
Total exposure			3.20e-08	1.82e-08**
(month*hours)^2			(2.24e-08)	(7.23e-09)
Observations	961	961	961	961

Note: Standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
Source: Compiled by authors.

By looking at the group Only Averted Cost (if Stated Preferences=0 and Averted Costs>0), we can see how Age, presenting a Symptom/Illness, and Exposure Longer than 8 Hours have a positive probability of belonging to the Averted Cost group, while Income Level reduces the probability of pertaining to this group (see Table 3). For this analysis the Exposure variables have no significant effect, only Long Daily Exposure Greater than 8 Hours is relevant, meanwhile, the higher positive effect of Symptom/Illness is consistent with pertaining to this group. It is more probable that people who have a symptom or illness are in the Only Averted Cost group. Table 4 for the group Only Stated Preference (if Stated Preferences>0 and Averted Costs=0) shows that age reduces the probability of belonging to this group while presenting a symptom or illness increases the probability of pertaining to this group. It is interesting to see that for the Exposure variables we can see an inverted U-shaped relation, significant for Model 2 for Months Exposed in the Area and for Model 4 with Total Exposure (though the reverse is not significant). Thus, at the beginning individuals are more aware of air pollution, but with time they get used to it, therefore the probability to pertain to this group reduced. It results in being opposite and consistent if we compare it to the No WTP group.

Table 3. *Marginal Effects for the Group Only Averted Cost*

	(1)	(2)	(3)	(4)
Variables	**Marginal effects**	**Marginal effects**	**Marginal effects**	**Marginal effects**
	Only_Averted Costs			
Male	-0.0321	-0.0322	-0.0309	-0.0255
	(0.0305)	(0.0309)	(0.0311)	(0.0309)
Age	0.00308***	0.00326***	0.00323***	0.00305**
	(0.00117)	(0.00121)	(0.00122)	(0.00119)
High education	0.0219	0.0213	0.0204	0.0182
	(0.0361)	(0.0366)	(0.0367)	(0.0366)
Income level	-0.0462*	-0.0464*	-0.0465*	-0.0446*
	(0.0245)	(0.0249)	(0.0250)	(0.0248)
No health care	-0.0495	-0.0486	-0.0514	-0.0478
	(0.0700)	(0.0709)	(0.0712)	(0.0708)
Working place	-0.00703	-0.00710	-0.00642	-0.0138

(Continue)

Table 3. (*Continuation*)

	(1)	(2)	(3)	(4)
Variables	**Marginal effects**	**Marginal effects**	**Marginal effects**	**Marginal effects**
		Only_Averted Costs		
inside	(0.0319)	(0.0323)	(0.0323)	(0.0319)
Symptom or	0.0678**	0.0665**	0.0668**	0.0679**
illness	(0.0291)	(0.0295)	(0.0295)	(0.0294)
Months exposure		-0.000539	0.000592	
in area		(0.000453)	(0.00207)	
Months exposure		1.51e-06	1.60e-08	
in area (square)		(1.19e-06)	(3.47e-06)	
Hours work place		0.0120*	0.0171	
		(0.00676)	(0.0110)	
Long daily	0.0696**			
exposure>8h	(0.0329)			
Long exposure	-0.0139			
>60 months	(0.0327)			
Total exposure			-0.000109	-3.60e-05
month*hours			(0.000190)	(3.90e-05)
Total exposure			1.36e-08	9.95e-09
(month*hours)^2			(2.59e-08)	(8.43e-09)
Observations	961	961	961	961

Notes: Standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
Source: Compiled by authors.

Table 4. *Marginal Effects for the Group Only Stated Preferences*

	(1)	(2)	(3)	(4)
Variables	**Marginal effects**	**Marginal effects**	**Marginal effects**	**Marginal effects**
		Only Stated Preferences		
Male	0.00966	0.00906	0.00524	0.00736
	(0.0206)	(0.0194)	(0.0189)	(0.0194)
Age	-0.00166*	-0.00158*	-0.00148*	-0.00163*
	(0.000880)	(0.000880)	(0.000855)	(0.000877)
High education	-0.0118	-0.0119	-0.00962	-0.0107

(Continue)

Table 4. (*Continuation*)

	(1)	(2)	(3)	(4)
Variables	**Marginal effects**	**Marginal effects**	**Marginal effects**	**Marginal effects**
		Only Stated Preferences		
	(0.0247)	(0.0238)	(0.0237)	(0.0237)
Income level	0.0251	0.0254	0.0243	0.0245
	(0.0158)	(0.0156)	(0.0150)	(0.0155)
No health care	-0.0300	-0.0272	-0.0221	-0.0275
	(0.0430)	(0.0427)	(0.0440)	(0.0422)
Working place	0.0157	0.0152	0.0146	0.0167
inside	(0.0220)	(0.0213)	(0.0209)	(0.0209)
Symptom or	0.0462***	0.0457***	0.0456***	0.0453***
illness	(0.0178)	(0.0172)	(0.0168)	(0.0173)
Months exposure		0.000715**	-0.00221	
in area		(0.000327)	(0.00162)	
Months exposure		-2.42e-06**	2.24e-06	
in area (square)		(1.18e-06)	(2.67e-06)	
Hours work place		-0.00156	-0.0128*	
		(0.00422)	(0.00734)	
Long daily	-0.0158			
exposure>8h	(0.0233)			
Long exposure	0.0238			
>60 months	(0.0229)			
Total exposure			0.000284*	6.25e-05**
month*hours			(0.000161)	(3.09e-05)
Total exposure			-4.23e-08	-1.83e-08
(month*hours)^2			(3.32e-08)	(1.20e-08)
Observations	961	961	961	961

Notes: Standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
Source: Compiled by authors.

Table 5 presents the marginal effects for the composition of both groups: Averted Costs and Stated Preferences (if Stated Preferences>0 and Averted Costs>0). Results express that age reduces the probability that individuals are in this group, while income level raises their probability. For the rest of the coefficients the effect is not statistically significant.

Table 5. *Marginal Effects for the Group Both: Averted Costs and Stated Preferences*

Variables	(1) Marginal effects	(2) Marginal effects	(3) Marginal effects	(4) Marginal effects
	Both Averted Costs_and_Stated Preferences			
Male	0.0326	0.0311	0.0301	0.0294
	(0.0350)	(0.0351)	(0.0352)	(0.0348)
Age	-0.00363***	-0.00387***	-0.00385***	-0.00390***
	(0.00139)	(0.00145)	(0.00146)	(0.00144)
High education	0.0261	0.0305	0.0304	0.0306
	(0.0406)	(0.0408)	(0.0409)	(0.0407)
Income level	0.0623**	0.0633**	0.0636**	0.0624**
	(0.0282)	(0.0282)	(0.0283)	(0.0283)
No health care	0.0813	0.0886	0.0911	0.0861
	(0.0832)	(0.0832)	(0.0831)	(0.0830)
Working place inside	-0.0305 (0.0366)	-0.0294 (0.0366)	-0.0299 (0.0366)	-0.0289 (0.0364)
Symptom or illness	0.00910 (0.0337)	0.0104 (0.0339)	0.0110 (0.0339)	0.0103 (0.0338)
Months exposure in area		0.000680 (0.000502)	-3.37e-05 (0.00228)	
Months exposure in area (square)		-1.48e-06 (1.36e-06)	-1.06e-06 (4.01e-06)	
Hours work place		0.000636	-0.00394	
		(0.00778)	(0.0125)	
Long daily exposure>8h	-0.00544 (0.0397)			
Long exposure >60 months	0.0224 (0.0374)			
Total exposure month*hours			6.86e-05 (0.000210)	5.61e-05 (4.34e-05)
Total exposure (month*hours)^2			-3.25e-09 (2.84e-08)	-9.80e-09 (9.18e-09)
Observations	961	961	961	961

Notes: Standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
Source: Compiled by authors.

E. Differences Among Groups

In this section we perform an examination of all multi-logit models estimated, but this time we do not restrict the base outcome to be the group No WTP, instead we compare for each model whether or not the independent variables remain significant and with the correct sign when using each group in the dependent variable as a base group. This means that for all the independent variables used, we change the base outcome and observe whether the differences between groups are significant or not.

For the first model the variables Male, Education Level, No Health Care, Working Place, and Long Exposure Greater than 60 Months do not show significant differences between groups when baseline outcomes changed. Meanwhile, Age, Income Level, Symptom/Illness, and Long Daily Exposure Greater than 8 Hours are significantly different when baseline outcomes change. Interestingly, for Age, it is relevant when comparing the following groups: Only AC to Only SP, Only AC to both AC and SP, Only SP to Only AC, and Only SP to No WTP. This means that Age (which is significantly different between groups) is important when comparing whether individuals pertain to one group or another. Table 6 summarizes the comparisons between two alternatives for the first multinomial model. Since the same variables continue to be relevant regardless of the specification of the multinomial model, we omit the comparisons for the rest of the regressions.

An interesting pattern emerges in Table 6: we find that both groups which included positive stated preferences are not significantly different in either Age or Income Level, yet there exist significant differences with the remaining groups for which respondents declare 0 when asked for their direct WTP. Younger individuals consistently declare being willing to pay to avoid pollution, regardless of their averted costs. In the same direction, people with higher incomes tend to be willing to pay to avoid air pollution and once again this happens despite their averted costs.

Regarding the indicator variable of Symptom/Illness, No WTP people consistently did not report symptoms in comparison to all other groups including the Only SP with No AC. This could mean that people who have not been sick (symptom/illness) are less aware of air pollution.

Table 6. *Comparison Between Baseline Outcomes for Different Variables*

Odds comparing Alternative 1 to Alternative 2								
	Age		Income Level		Symptom /Illness		Long Daily Exposure>8h	
Comparison	**b**	**P>|z|**	**b**	**P>|z|**	**b**	**P>|z|**	**b**	**P>|z|**
Only_AC-No_WTP					0.7780	0.000	0.4880	0.033
Only_AC - Only_SP	0.0304	0.010	-0.4576	0.034				
Only_AC -Both_AC	0.0203	0.003	-0.3229	0.021				
Only_SP - Only_AC	-0.0304	0.010	0.4576	0.034				
Only_SP - Both_AC					0.5421	0.043		
Only_SP - No_WTP	-0.0285	0.018	0.4647	0.039	107.21	0.000		
Both_AC- Only_AC	-0.0203	0.003	0.3229	0.021				
Both_AC -Only_SP					-0.5421	0.043		
Both_AC - No_WTP	-0.0184	0.010	0.3300	0.029	0.5300	0.002		
No_WTP - Only_AC					-0.7780	0.000	-0.4880	0.033
No_WTP - Only_SP	0.0285	0.018	-0.4647	0.039	-107.21	0.000		
No_WTP- Both_AC	0.0184	0.010	-0.3300	0.029	-0.5300	0.002		

Source: Compiled by authors.

Finally, people who spend more time in the polluted area of Downtown Medellín on a daily basis tend to incur higher averted costs, but the channel of this effect is not the awareness of the pollution since the difference is significant between Only AC and No WTP. There is a silver lining though, since the more time they have spent in Downtown Medellín (measured in months) significantly increases the probability to state a positive direct WTP.

IV. Discussion

Regarding the percentage of respondents with a positive stated preference (67.7%), this number is below the threshold recognized by the CVM literature and also is a lower bound of the WTP, but still the results are consistent with other studies that used a similar methodology. The area of study, Downtown Medellín, is an area where the daily levels of pollution are significant and have possible impacts on human health; therefore, those individuals that spend a considerable amount of time there (hours or months) are vulnerable and perceive air pollution as a health problem (extrapolating their valuation of improving air quality). The study area accumulates a significant number of vehicles that emit high levels of pollutants and also concentrates a lot of people who work and walk the area for different reasons; therefore it is relevant to make individuals aware of air pollution and its consequences on their health.

The purpose of the present study reflects that, besides some issues with the survey, factors that influenced individuals' positive WTP are similar to the results found by Zhang et al. (1999), Carlsson and Johansson-Stenman (2000), Wang and Mullahy (2006), and Wang and Zhang (2009). Additionally, Wang et al. (2006) presents that the aggregate monetary value of the WTP given by people does not reflect the actual valuation, therefore this may not be reflected in a CVM survey. Besides, as acknowledged by Whittington (2002), it is common that WTP studies in developing countries assess a relatively low value. A possible explanation can be linked to low payment capacity or low salaries; also there is a high probability that people have partial or low insight into the possible benefits from air quality improvements or in general from improvements in environmental quality.

Although the literature has undervalued the results of the CVM in developing countries due to the low income level effect, this method is a useful mechanism for addressing questions regarding environmental improvements. It would be interesting to compare results with those of other studies done in similar areas, but there is a lack of empirical research on this subject.

Conclusions

The purpose of the current study is to elucidate how air pollution in a specific polluted area in Downtown Medellín influences individuals to express a positive willingness to pay (WTP) to reduce air pollution. The article did not aim to control for non-exposed individuals, on the contrary the aim was to identify how exposed people perceive air pollution by stating their positive WTP. The expectation was that gender, age, income level, level of education, different levels of exposure, and suffering from a lung-related symptom/illness have a direct influence on the probability of stating a positive WTP. By dividing respondents into four groups so as to compare differences in characteristics of individuals from each group, we confirmed all the expected relationships except gender and the level of education, which were not significant among all estimations. Results from the multi-logit estimations and their marginal effects, express that individuals' length of exposure and suffering a symptom/illness are relevant for them to state a positive WTP and have awareness about air pollution. We conclude that exposed individuals in Downtown Medellín, who did not give a positive WTP, are characterized by getting used to pollution over time because individuals are more aware if they have been in the area for less time, but once time passes the effect reverses and individuals are *less aware* This result is consistent with results found for individuals who stated a positive WTP (for whom the results are opposite). Perhaps, there is an *adaptation* effect among individuals—after a while of being exposed, they become accustomed to the poor air quality, have only minor symptoms (such as a slight cough, stuffy nose, eye allergies, etc.) and therefore do not perceive it as an acute problem.

It is important to highlight how younger individuals represent a fraction of the population with a higher level of consciousness about air pollution problems. Also individuals who remain for a longer time in Downtown Medellín have a tendency to incur higher averted costs and therefore, suffer more from a symptom or an illness than the rest of the individuals. Income level has a different direction (positive or negative) depending on the outcome (group) we are considering; we expected to find that the higher the income level, the higher the WTP, which was confirmed for individuals within this group, but also the results show that for individuals who are in the group of Only AC and No WTP, the relation is opposite (negative).

Even though using Averted Costs is a lower bound of the WTP, it gives us insights on comparing different groups and it allows us to identify the main features of exposed individuals regarding their preferences for air quality. Also, the multi-logit estimations and the marginal effects typify individuals' preferences regarding their *demand* for air quality. Thus, people's preferences for air quality vary with age, income level, exposure to pollution (based on the time spent in the area), and suffering from a symptom/illness. Particularly, younger individuals are more aware of pollution than older people, while in Downtown Medellín, people who have suffered a symptom/illness are more aware of pollution and have a higher preference for air quality. Lastly, we conclude that on average, individuals are willing to pay an amount less than US$3 for reducing air pollution, while individuals who are affected by a symptom/illness are willing to pay an average of approximately US$6, which is higher than the direct WTP. We believe that individuals exposed are not aware of the *real* costs that they would incur if they got sick due to air pollution.

Finally, there were a few logistical problems regarding the CVM. Some issues included: some individuals had little experience with public surveys (for example, somehow they believed that the information would be used against them); and the place of the survey was actually some of the respondents' workplace, therefore making it difficult for some of them to answer accurately or coherently (for example, the respondents were more concerned about customers than answering the survey questions). Individuals are not aware of the importance of improvements to air quality, because by looking at the monetary amounts claimed, it is not a true subject of concern. We think that people are worried about surviving, which means they are more concerned about earning an income over the level of pollution they are exposed to. Also, we think that one reason why the amount of money stated was so low is because the people interviewed are informal vendors whose income level is relatively low, which affects the amount of money stated. Also, air quality could be considered a luxury good for these individuals located in Downtown Medellín. Not withholding the inconveniences of the survey, the results are relevant and can be used by policy-makers to address air pollution issues, especially in areas where people are over-exposed.

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Appendix

Table 1. *Multi-logit Estimated Coefficients for the Four Different Outcomes (Groups: No WTP, AC, SP, and Both)*

Variables	(1) Coeff	(2) Coeff	(3) Coeff	(4) Coeff	(1) Coeff	(2) Coeff	(3) Coeff	(4) Coeff	(1) Coeff	(2) Coeff	(3) Coeff	(4) Coeff
	Only Averted Cost				Only Stated Preference				Both Averted Cost and Stated Preference			
Male	-0.0775	-0.0874	-0.0972	-0.0466	0.153	0.140	0.0827	0.135	0.122	0.108	0.0904	0.119
	(0.201)	(0.203)	(0.204)	(0.203)	(0.283)	(0.278)	(0.281)	(0.280)	(0.185)	(0.187)	(0.187)	(0.186)
Age	0.00184	0.00258	0.00288	0.000491	-0.0285**	-0.0281**	-0.0270**	-0.0301**	-0.018***	-0.0188**	-0.0183**	-0.021***
	(0.00749)	(0.00765)	(0.00771)	(0.00758)	(0.0120)	(0.0125)	(0.0125)	(0.0125)	(0.00713)	(0.00737)	(0.00737)	(0.0074)
High education	0.242	0.256	0.257	0.236	0.0275	0.0366	0.0653	0.0432	0.221	0.247	0.252	0.240
	(0.229)	(0.233)	(0.233)	(0.233)	(0.333)	(0.333)	(0.341)	(0.332)	(0.209)	(0.211)	(0.212)	(0.211)
Income level	0.00706	0.0124	0.00843	0.0197	0.465**	0.484**	0.476**	0.474**	0.330**	0.337**	0.333**	0.335**
	(0.161)	(0.162)	(0.163)	(0.160)	(0.225)	(0.226)	(0.225)	(0.226)	(0.151)	(0.150)	(0.152)	(0.151)
No health care	-0.198	-0.142	-0.132	-0.148	-0.396	-0.318	-0.225	-0.332	0.185	0.250	0.276	0.236
	(0.502)	(0.507)	(0.509)	(0.505)	(0.801)	(0.802)	(0.796)	(0.800)	(0.408)	(0.413)	(0.408)	(0.412)
Working place	-0.123	-0.121	-0.120	-0.166	0.0782	0.0808	0.0782	0.0785	-0.169	-0.164	-0.166	-0.183
inside	(0.205)	(0.207)	(0.206)	(0.204)	(0.298)	(0.298)	(0.300)	(0.292)	(0.192)	(0.192)	(0.192)	(0.191)
Symptom or	0.778***	0.769***	0.772***	0.777***	1.072***	1.084***	1.105***	1.083***	0.530***	0.531***	0.535***	0.534***
illness	(0.194)	(0.195)	(0.195)	(0.194)	(0.282)	(0.281)	(0.285)	(0.282)	(0.173)	(0.174)	(0.174)	(0.173)
Months exposure		0.00177	-0.00509			0.0121**	-0.0339			0.0054**	-0.00740	
in area		(0.0028)	(0.012)			(0.00472)	(0.0240)			(0.00257)	(0.0113)	
Months exposure		-4.9e-06	5.4e-06			-3.9e-05**	3.2e-05			-1.4e-05**	2.8e-06	
in area (square)		(7.3e-06)	(2.1e-05)			(1.7e-05)	(3.9e-05)			(6.6e-06)	(1.9e-05)	
Hours work		0.0943**	0.0653			0.0308	-0.153			0.0506	-0.00806	
place		(0.0454)	(0.0716)			(0.0620)	(0.114)			(0.0425)	(0.0680)	
Long daily	0.488**				0.0329				0.190			
exposure>8h	(0.229)				(0.299)				(0.203)			
Long exposure	0.0917				0.406				0.198			
>60 months	(0.212)				(0.305)				(0.196)			
Total exposure			0.00067	0.00023			0.00449*	0.0011**			0.00124	0.00049**
month*hours			(0.0012)	(0.00024)			(0.0024)	(0.00044)			(0.00104)	(0.00022)
Total exposure			-9.0e-08	-4.3e-08			-6.5e-07	-2.9e-07**			-1.5e-07	-1.1e-07**
(month*hours)^2			(1.6e-07)	(5.3e-08)			(4.0e-07)	(1.4e-07)			(1.5e-07)	(4.7e-08)
Constant	-0.891*	-1.548**	-1.264	-0.549	-1.494**	-2.123**	-0.313	-1.73***	0.167	-0.362	0.221	0.200
	(0.467)	(0.649)	(0.859)	(0.431)	(0.700)	(0.926)	(1.295)	(0.667)	(0.431)	(0.599)	(0.814)	(0.417)
Observations	961	961	961	961	961	961	961	961	961	961	961	961

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: Compiled by authors.