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Evidence from Columbia

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Exposure to Pollution and Infant Health:

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Abstract

We study the impact of air pollution exposure (CO, O3 and Pm10) during pregnancy and early years of life on infant health for a sample of children attending public kindergartens in Bogotá, Colombia. The study uses a unique database that gathers information on children health which allows to combine information of residential location of the mother with information from the city air quality monitors. To overcome endogeneity problems due to residential sorting we identify pairs of siblings in the dataset and implement panel data models with mother fixed effects. Results show evidence that mothers, who are exposed to higher levels of CO and O3 during pregnancy, have a higher probability of their babies being born with a low birth weight. Furthermore, a child exposed in-utero to higher levels of O3 has a higher probability of being diagnosed with a lung-related disease. Our findings advocate for more strict environmental regulations as a way to improve human capital in developing countries.

Keywords: Air Pollution, Infant Health, Mother-Family Fixed Effects, Panel Data

JEL Classification Codes: C33, J13, Q53

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1 Introduction

One of the consequences of rapid economic growth and industrialization in the developing world has been deterioration in environmental conditions and air quality. According to the Global Urban Ambient Air Pollution Database of WHO 98% of cities in low- and middle income countries with more than 100000 inhabitants do not meet WHO air quality guidelines while that percentage decreases to 56% in high income countries.

A growing literature using data from developed countries shows that exposure to high levels of pollution can constitute a threat to health and human capital formation. Studies have shown that being exposed to carbon monoxide (CO) during pregnancy increases infant mortality (Currie and Neidell, 2005) and reduces birth weight (Currie, 2011; Chay and Greenstone, 2003). Moreover, Currie (2001) shows that children exposed to higher levels of pollution are more prone to miss classes, achieve poorer grades, and to be less engaged at school, affecting their academic performance and their long-term cognitive development. Although pollution levels are higher in developing countries, the evidence of the link between air pollution and human capital formation coming from those countries is still scarce.

In this study, we assess the effect of exposure to air pollution in-utero and during the first years of life on infant health in Colombia using a unique dataset of children attending public kindergartens in Bogotá between 2010 and 2014. The data gathers information on children's health and allows us to overlap information on the mother's residential location with information from air quality monitors. Given that people choose their residential location based on attributes that could be correlated with pollution levels, simple OLS regressions would give biased estimates of the effect of interest. To overcome this endogeneity problem we identify pairs of siblings and implement panel data models with mother fixed effects.[1]

Our results show that higher in-utero exposure to carbon monoxide (CO) and ozone (03) increases the probability of the baby having low birth weight. Specifically, a one standard

[1]Other source of endogeneity in pollution exposure is avoidance behavior. Avoidance behavior arises when parents take actions (investments) to secure their children health during periods of exposure to high levels of pollution, which causes non-random effective pollution exposure (Currie et al., 2014). Given that we are not able to measure parent's actions to reduce the effective pollution exposure, our results should be interpreted as intention to treat effects. If something, our estimates would be downward biased if avoidance behavior is taking place.

deviation increase in CO and O3 during the second and third trimesters of pregnancy raises the probability of low birth weight by 14 and 10 percentage points, respectively. These results are consistent with the medical literature that suggests that pollution can affect fetus health both directly –going through the placenta– and indirectly –via a reduction of the mother's health–, mainly during the second and third trimesters of pregnancy. Moreover, the results indicate that the exposure to higher levels of O3 during pregnancy increases the probability of the child being diagnosed with a lung-related disease. A one standard deviation increase in levels of O3 during the second trimester raises the probability of the child suffering from a lung-related disease by about 11 percentage points. We show that all results are robust to different specifications and the inclusion of a comprehensive set of controls variables with individual, home and neighborhood characteristics.

Comparing the magnitude of our results with previous literature, the effect of pollution on low birth weight in Colombia seems to have similar or slightly larger effects than in developed countries. Given a low birth weight rate of 14.1%, a one standard deviation increase in pollution levels imply between 7 to 10% increase in low birth weight. Currie et al. (2009b) find that a one unit change in mean CO during the third trimester of pregnancy increases the incidence of low birth weight by about 8%.

The present study contributes to the scarce literature that aims to link air pollution with health outcomes in developing countries using a clear empirical strategy. To the best of our knowledge, this is the first study for Colombia that establishes a causal relationship between air pollution and infant health. Results found here implicitly indicate that any policies oriented towards decreasing air pollution will positively impact human capital formation by improving childrens health. Although there have been attempts to reduce air pollution in Colombia, the levels are still high. Our findings advocate for stricter environmental regulations mainly of automobile emissions, which are responsible for more than the 90% of pollution emissions.

2 Literature Review

Health consequences from being exposed to air pollution have been well-studied by epidemiologists (Brunekreef et al., 1995; Pope, 1989) and the World Health Organization (WHO). The common channels through which air pollution may affect pregnant women and young children's health are: *(i)* exposure to pollution in-utero, and *(ii)* exposure to pollution during the first years of life. The World Health Organization (World Health Organization, 2000) declares that CO is able to pass through the placenta, directly affecting the fetus' health, even in contexts where the CO levels are lower than the environmental standards (Currie, 2013). However, also being exposed to other pollutants during pregnancy can affect children's health by affecting mothers health. Economic literature connecting air pollution to young children's health and human capital formation has recently appeared, using natural experiments and other empirical strategies to overcome endogeneity problems (Currie et al., 2014; Currie, 2013; Graff-Zivin and Neidell, 2013; Almond and Currie, 2011; Currie, 2009).

The literature associating levels of air pollution and effects on human capital formation can be divided into short-term and long-term effects. In the long-term effects literature, there is evidence that shows how levels of pollution at early stages affect cognitive development and future earnings when adults.[2] Considering short-term effects, which is the focus of our paper, the literature has focused on the exposure to air pollution during pregnancy and its effect on infant health (mainly low birth weight and prematurity) and child mortality (Currie et al., 2011; Currie and Walker, 2011; Coneus and Spiess, 2010; Currie et al., 2009b; Currie and Neidell, 2005). Other studies have focused on cognitive development (Currie et al., 2009a) and labor market outcomes (Chang et al., 2016; He et al., 2015; Chang et al., 2014; Graff-Zivin and Neidell, 2012).[3]

[2] For cognitive development, the literature has analyzed school performance through standardized tests using panel data with mother/family fixed effects (Bharadwaj et al., 2017), or using an instrumental variables design, where the instrument for pollution (Total Suspended Particles -TSP-) is the relative share of county-level employment in manufacturing (Sanders, 2012). Other studies have used different sources of pollution such as radioactivity concentrations for Sweden (Nilsson et al., 2009), and Norway (Black et al., 2007), and lead concentrations for the U.S. (Currie and Almond, 2011; Reyes, 2011). For future earnings, there is evidence that shows how higher levels of exposure to pollution in-utero and in early childhood, negatively affect annual salaries later in life in the U.S. (Isen et al., 2017).

[3] As stated by Currie et al. (2014), the connection between early life exposure and long-term outcomes has been difficult to prove, therefore, many of the studies focus on short-term effects.

For instance, Currie and Neidell (2005) examine the impact of air pollution (CO, O3, and Pm10[4]) on low birth weight.[5] To address this, they used fixed effects models at the individual level, controlling for zip code-month fixed effects. To associate exposure to air pollution with low birth weight, they impute prenatal pollution exposure in each trimester using a radius of 10 kilometers (km) (6.2 miles) around the meter device. Results show no significant effect on low birth weight when the mother is exposed to air pollution during pregnancy. Similarly, using fixed effects at the individual level, Currie et al. (2009b) examine the effects of pollution (CO, O3, and Pm10) on birth weight and prematurity. For birth weight, they utilize a panel with a pollution monitor and mother locations fixed effects, in which averages of exposure to pollution are imputed for the three trimesters of pregnancy. Results show that a one-unit increase in CO during the third trimester leads to an average birth weight reduction of 16.65 grams. Currie et al. (2009b) regress levels of pollution during the three trimesters of pregnancy to different birth outcomes (including a model for child mortality). These authors use a rich set of controls as well as fixed effects for the closest air pollution monitor, an interaction between the monitor effect and each quarter of the year (to capture seasonal differences), and mother-specific fixed effects to control for time-invariant characteristics of neighborhoods and mothers. Results show that a one-unit increase in CO during the third trimester reduces birth weight on average by 16.65 grams (results were found at lower levels of CO). Currie and Walker (2011) exploit a policy that reduced traffic congestion in the U.S., in which electronic toll collector technology was implemented to look at the effects of traffic congestion on newborn health. This policy allowed them to implement a difference-in-differences design, in which the treatment group is made up of mothers living within two km of a toll plaza, while the control group is made up of those who live close to a highway, but between two km and 10 km of a toll plaza. Results suggest that implementing the E-ZPass[6] is associated with significant reductions in prematurity, by 8.6%, and in low birth weight, by 9.3%. Finally, Coneus and Spiess (2010) present a study using mother fixed effects and year/zip code effects together with an ample set

[4]Particulate Matter less than 10 microns.

[5]Low birth weight is defined as birth weight less than 2500 grams.

[6]The E-ZPass is a form of electronic payment where cars do not have to stop to pay, they just drive by the toll and the payment is automatically made from a card that drivers have in their cars.

of characteristics to analyze the effect of five pollutants (CO, NO2, SO2, O3, and Pm10) on childrens health (under the age of three). They find that high exposure to CO (particularly during the third trimester) leads to a 289 gram decrease in birth weight. Furthermore, they found that a one-unit increase in the three-year average of O3, increases the number of cases of bronchitis by 0.70% in children under the age of three.

For cognitive development, the literature examine two main channels: academic performance through test scores on the one hand, as done by Lavy et al. (2014) and Zweig et al. (2009), and school absenteeism on the other hand, as analysed by Ransom and Pope II (1992) and Currie et al. (2009a). Besides, in order to address the effects on labor market participation, different authors have exploited exogenous variations. Chang et al. (2014),[7] use as exogenous variation high-frequency fluctuations in Pm2.5; Hanna and Oliva (2015) use as an exogenous variation in pollution the closure of a large oil refinery in the Mexico City Metropolitan Area (March of 1991); and finally, Graff-Zivin and Neidell (2012) use exogenous variations in environmental ozone (O3).

Finally, by exploiting U.S. regulations such as the Clean Air Acts (1970 and 1977), Chay and Greenstone (2003) find how a one-unit drop in total suspended particles (TPS) reduces infant mortality by four to eight infant deaths per 100,000 live births. Currie and Neidell (2005), using a panel with zip code fixed effects, find that a one-unit reduction in CO would prevent 34 infant deaths per 100,000 live births.[8] Knittel et al. (2016) use instrumental variables, using traffic congestion as an instrument for air pollution, interacted with environmental variables, to find that a one-unit reduction in Pm10 drops deaths by 18 cases per 100,000 live births. For Mexico, Foster et al. (2009) use geographic data (proportion of certified industries, in a given month, within a specific area) together with satellite data, to construct an air quality indicator based on aerosol optical depth (AOD), to find that a 1% increase in AOD results in a 4.4% increase in respiratory mortality. For the United Kingdom, Janke et al. (2009) regress annual levels of air pollution using fixed effects to find that a 10 mg/m3 increase in Pm10 is linked

[7]These fluctuations are considered exogenous by the authors since they do not result from the activity of the factory itself, but instead they emanate from sources hundreds of miles away from the factory.

[8]Authors use a weekly hazard model where the risk of death is defined over weeks of life. Also, authors use a twenty-mile radius around of the zip codes center.

to a 2.8% increase in any-cause mortality. Finally, effects of exposure to Pm10 on mortality (not only child mortality) have been found by He et al. (2016) for China, and Ziebarth et al. (2013) for the U.S. and Germanythey find that exposure to NO, O3, and Pm10 increase cases of mortality.

As mentioned, for Colombia, academic literature addressing these problems is almost non-existent. Llorente and Wilkinson (2009) and Uribe-Botero (2004) focus on studying exposure to air pollution by using risk assessment tools and analyzing air pollution data: they find that higher concentrations of air pollution in *Bogotá* and *Medellín* produce a great risk for human health. These methodologies seek to document and highlight how high levels of air pollution put health at risk for different population groups in *Bogotá* and *Medellín.* Franco et al. (2009) use four schools in *Bogotá*, close to heavy traffic streets, as a treatment group, and four schools in rural areas near *Bogotá*, where levels of air pollution are low. Their results focus on comparing levels of pollution among schools (treatment and control), but besides this, they do not make conclusions about the effects of exposure to air pollution on health or educational outcomes. Within Colombia, other studies have associated levels of air pollution with the incidence of respiratory infections in children under five years old for *Bogotá* (Hernández et al., 2013a,b; **?**), as well as levels of air pollution and their effects on vulnerable people in high polluted areas of Downtown *Medellín* (Gaviria et al., 2012).

3 Identification Challenges

Mainly, endogenous problems are caused by omitted variables since unobserved characteristics that are correlated to the outcome of interest (health) are omitted in the estimation, causing bias. These factors are principally residential sorting and avoidance behavior. The main argument behind residential sorting, based on Tiebout´s argument (1956) is that people choose residential location based on certain attributes of the area, like security, environmental conditions or other attributes related to it. Thus, the poorest people tend to live in more polluted areas, which biases estimated results since there is no random assignment. However, Currie et al. (2014) suggest that residential sorting in response to environmental changes occurs more slowly than health changes, mainly due to the unawareness of mothers, who usually are more concerned about economic reasons (Currie and Walker, 2011; Currie, 2013).

Avoidance behavior also leads to bias in the estimates and occurs occurs when parents (or caretakers) take actions to protect their children's health when levels of pollution are high, which causes an ex-post non-random assignment of pollution exposure. A key aspect here is knowledge, since actions can be taken when parents (or caretakers), have information about adverse pollution levels.

To deal with residential sorting, academics have used quasi-experimental techniques, in which they use external pollution shocks like the closure of a factory, new government regulations, or catastrophic events, as natural experiments. Another way has been to use sibling comparisons, which allow for controlling for unobserved time-invariant family characteristics common to children from the same family, that can lead to endogenous exposure to poor environmental conditions (Bharadwaj et al., 2014). Dealing with avoidance behavior has been more complicated, which has lead studies to center only on measuring this effect (avoidance behavior) as a response to high levels of pollution (Moretti and Neidell, 2011; Graff-Zivin and Neidell, 2009; Neidell, 2009). The present article, acknowledges the existence of residential sorting and presents an empirical strategy, that overcomes it. While for avoidance behavior we cannot measure its impact given the current data.[9]

A final concern is our argument of which exposure to pollution during pregnancy would affect children's lungs-health. This argument represents a challenge since there is little direct evidence of this channel being analyzed in the literature. Nevertheless, Stern et al. (2007) present evidence of how exposure to indoor and outdoor air pollution in the first years of life has effects on lung development (this is independent from the adverse effects of in-utero exposure). Goldizen et al. (2016) review epidemiological studies highlighting the channels through which air pollution affects lung development, for example during the mother's gestation period (in-utero) as well as inhalation of pollutants during the child's early years. Moreover, it has been declared that early life respiratory exposure to air pollution can persist into adulthood and may increase the risk of developing adult lung diseases. Exposure during infancy and childhood could impact

[9]Thus, we are finding estimates for the effect of the intention-to-treat.

the healthy development of alveoli and lung growth Goldizen et al. (2016).

4 Data Sources

We use two sets of data so as to address the question proposed. First we use data from the *Centinela Vigila Survey* (CVS) which is conducted by the Division of Public Health from the Bogotá District Secretary of Health (*Secretaria Distrital de Salud de Bogotá) (SDSB).* This data is geographically matched with air pollution and environmental data from the Bogotá District Secretary of Environment (*Secretaria Distrital de Ambiente de Bogotá) (DAMA).*

4.1 Centinela Vigila Survey (CVS)

The Centinela Vigila Survey (CVS) is conducted by the Division of Public Environmental Health of the SDSB starting in 2007. From 2007 to 2009, the survey was only conducted in three out of the 19 localities in Bogotá (Fontibón, Kennedy, and Puente Aranda).[10] In 2010, two localities were added (Suba and Tunjuelito), in 2011 another 10,[11] and finally, in 2013, all localities were covered.[12] The aim of the survey is to gather information about the health status of children under the age of five who are attending public kindergartens. The survey is performed on children's caregivers at their homes (although sometimes it is performed in the kindergarten).[13] Approximately 80% of the caretakers interviewed are the mothers, while the rest are either the father, an uncle or an aunt. We use the ample set of information provided by the questionnaire on characteristics of the child, the parents, and the surroundings, as well as specific questions regarding the childrens health to build outcomes (low birth weight and child suffering a lung-related disease), as well as a big set of co-variates accounting for child and parents characteristics and home-living conditions (see Appendix A.1). The survey is

[10]In 2010, these three localities represented 22% (1,606,476 inhabitants) of the entire population of Bogotá.

[11]The added localities were: *Antonio Nariño, Barrios Unidos, Bosa, Ciudad Bolívar, Engativá, La Candelaria, Los Mártires, Rafael Uribe, Santafé,* and *Usaquén.*

[12]The last localities incorporated were: *Chapinero, San Cristóbal, Usme,* and *Teusaquillo.*

[13]The interviewer normally is a medical worker. Moreover, the CVS does not have questions informing us where the interview takes place, but managers of the CVS survey confirmed that between 80 to 90% are at home, since part of the survey collects information about the actual home (mainly observational).

representative at the locality level.[14]

4.2 Air Pollution and Atmospheric Data from DAMA

The Bogotá District Secretary of Environment (*Secretaria Distrital de Ambiente de Bogotá) (DAMA)* is a public entity that gathers information for Pollution and Atmospheric Variables (P&AV). The information is collected from 19 different measurement devices (henceforth station) all around Bogotá on an hourly basis every day. The P&AV provide information for the following pollutants: particulate matter less than 10 and 2.5 microns (Pm10 and Pm2.5), carbon monoxide (CO), and environmental ozone (O3). The P&AV data also collects atmospheric information such as temperature (T°C), and precipitation (P). Some of the stations measure only pollutants, others measure only atmospheric variables, and others measure both (see Appendix A.2, Table 9). Available data ranges from 2002 to 2014.[15]

We built using hourly data an eight-hour maximum (8hrs-max) average and a daily arithmetic average for each pollutant (CO, O3, and Pm10) as well as for precipitation, for different periods of time (first, second and third trimester, and first year of life) using child´s birth date and survey´s date.[16] We use only information that has more than 10% daily valid data.[17]

4.3 Geographical Match of the Data

To geographically combine pollution and atmospheric data with children's health, we use the address of each meter device (Graph (a), figure 1). Then, using spatial coordinates of addresses from Bogotá District Land Registry (*Catastro Distrital de Bogotá*) and the address where each child lives (according to the information reported in the survey), we are able to geo-reference

[14]'Locality' is an administrative-geographical division of Bogotá, that groups diverse neighborhoods into bigger areas.

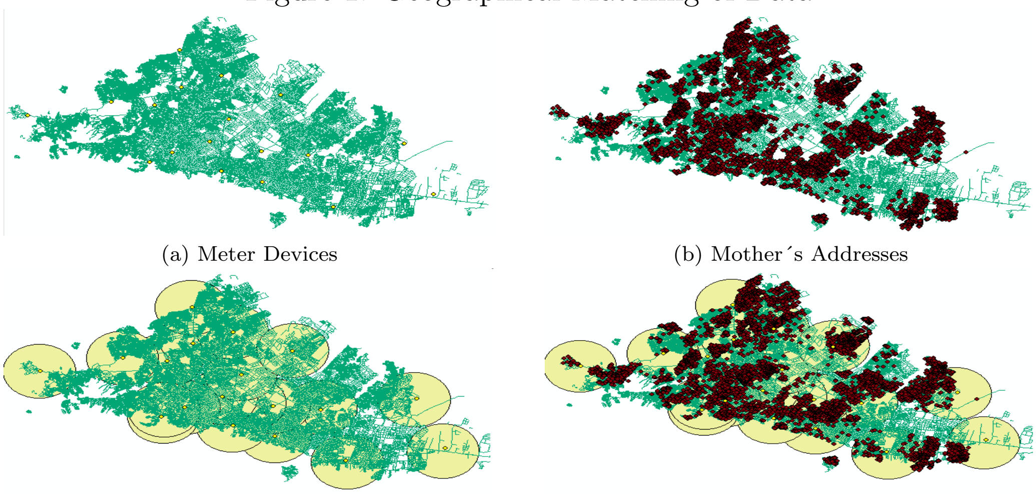
[15]The data from the P&AV are validated by DAMA before being released to the public.

[16]The 8hrs-max and the daily average are generally used for calculating critical values for pollutants. These measures are regularly used in similar papers. To calculate the 8hrs-max average, we divide the 24-hour sample into three sets of eight hours each, then we extract the maximum value of each set, and then we calculate the arithmetic average of these three maximum values.

[17]A similar rate is used by Auffhammer and Kellogg (2011), while Coneus and Spiess (2010) use a rate of 75%. However, using a specific criterion is not necessarily a concern, for instance Currie et al. (2009a) use data from devices that roughly record data every six days.

76%[18] of the children in the CVS data set (Graph (b)). This information, together with the exact location of the pollution and atmospheric measurement stations, allows us to assign the level of pollution which the child was exposed to at different stages of their life. One important assumption that we take into consideration, is the fact that a family has lived at the reported address from when the child was conceived.[19] Then, we define a four km radius around each station (which we call the 4 km buffer, Graph (c)). We keep all children whose address falls within this buffer and we assign them the pollution levels of the closest station (91% of the geo-referenced sample falls within the 4 km buffers: 12,772 out of the 14,011, Graph (d)).[20] Besides, given that pollution and atmospheric measurements were not available for some periods,[21] the final sample size is 75% of all individuals that were geo-referenced.[22]

Figure 1: Geographical Matching of Data



(a) Meter Devices

(b) Mother´s Addresses

(c) Meter Devices (Buffer of 4 kms)

(d) Matching Mother´s Addresses and Meter Devices

Source: Own Calculations.

[18]14,011 out of 18,664)

[19]Approximately 39% of the mothers or caretakers were not living in the same house as when the child was born.

[20]Whenever a child's address falls in the buffer of more than one station, we assign it to the nearest one according to the distance (in decimal degrees) from the meter to the home.

[21]Missing data is attributable mainly to malfunction of the devices or in some cases the device had to be removed to be repaired.

[22]Table 11 in Appendix A.3 provides descriptive statistics for the sample of matched children compared to the non-matched children in order to observe differences in characteristics among them. Comparing both samples, we observe that matched children on average have more chances of being born underweight or have poorer health outcomes than the non-matched children. Besides, the matched children have, on average, sicker parents, as well as mothers who were smoking when they were in-utero. Also, matched children live in worse home and surrounding conditions than the non-matched children.

4.4 Descriptive Statistics

To overcome endogeneity problems, we restrict our analysis to pairs of siblings. Although CVS has been collecting data since 2007, we use information from 2010 to 2014.[23] Descriptive statistics are provided in Table 1 for the sibling sample we use in the regressions (Column I) and the full sample (Column II). Within the sibling sample, children are on average 37 months old, 51% are females, 14.5% have low birth weight, 10% have been diagnosed with malnutrition,[24] 31% have been diagnosed with a lung-related disease, 30% currently live with smokers, 3.6% of their mothers smoked during pregnancy, 28% of the mothers were in presence of a smoker during pregnancy, 7.2% of the mothers smoked during the first two years of their childs life, 27.4% were in the presence of a smoker during the first two years of life, 47% of the caregivers are employed, 2.8% do not have any education, 62% have secondary school studies while 5.3% have university-level studies, 54.8% have healthcare through the contributory system, and 7.5% of parents have had a lung-related disease. Finally, on average there are 5.5 people living in the same house with 2.8 children from ages one to 14, 63% of the homes are close to some sort of industry, and 30% of the homes are close to an unpaved road.

Differences among samples (all children and siblings) show that siblings on average are younger, healthier, and have less of a probability of having a mother (or other person) smoking during pregnancy. In the sample of siblings, parents on average are less probable to be employed, studying, or belonging to the contributory healthcare system, whilst more probable to be sick. Siblings are also more likely on average to live with more people (and minors), while living close to an industry and to unpaved roads as well. When looking at pollution, both samples on average are exposed to similar levels of pollution.

Finally, it is worth noting that the average levels of exposure to Pm10 during the three trimesters of pregnancy are above international standards (annual mean 20 $\mu g/m^3$, and 24-hour mean 50 $\mu g/m^3$) given by the WHO (2009). These values are considered from moderate to highly dangerous for human health when exposed to them. Even though levels of exposure to CO are below international standards for all three trimesters, these low levels could still be

[23] From years 2007 to 2009, the CVS was conducted only for four out of 19 localities in the city.

[24] Children who have been diagnosed by a physician at some point before the interview.

Table 1: Descriptive Statistics: All Sample, Years 2010 to 2014

	Column I. Siblings			**Column II. All Sample**		
Variable	Mean	Std. Dev.	Observations	Mean	Std. Dev.	Observations
Panel A. Children Characteristics						
Age in months	37,06	16,92	3538	38,403	17,926	18663
Female	0,496	0,500	3538	0,483	0,500	18664
Low birth weight	0,141	0,348	3498	0,142	0,349	18362
Malnutrition	0,090	0,287	3529	0,077	0,266	18622
Lung health problem	0,296	0,457	3538	0,294	0,456	18664
Presence of smoker pregnancy	0,283	0,451	3528	0,260	0,438	18461
Mom smoking pregnancy	0,037	0,188	3527	0,028	0,166	18490
Child lives with smoker	0,299	0,458	3537	0,257	0,437	18650
Mom smoking first two years	0,074	0,261	3536	0,057	0,231	18629
Child presence of smoker first two years	0,264	0,441	3533			
Panel B. Parent Characteristics						
Employed	0,461	0,499	3538	0,545	0,498	18664
Not studying	0,022	0,147	3538	0,010	0,100	18664
Primary	0,170	0,376	3538	0,154	0,361	18664
Secondary	0,638	0,481	3538	0,591	0,492	18664
University	0,050	0,218	3538	0,089	0,284	18664
Technical	0,120	0,325	3538	0,156	0,363	18664
Contributory healthcare	0,552	0,497	3538	0,652	0,476	18664
Subsidized healthcare	0,435	0,496	3538	0,340	0,474	18664
Parent with lung disease	0,070	0,256	3528	0,069	0,253	18549
Panel C. Home Characteristics						
# people living in house	5,438	4,369	3538	4,755	3,316	18660
# minors living in house	2,744	2,942	3538	2,034	2,237	18659
Cohabit room	0,893	0,309	3538	0,818	0,386	18655
Close to industry	0,598	0,490	3499	0,570	0,495	18456
Close to unpaved road	0,322	0,467	3536	0,285	0,451	18646
Panel D. Levels of Pollution Exposure During Pregnancy						
CO trimester 1	1,200	0,545	1047	1,198	0,512	5408
CO trimester 2	1,138	0,463	1077	1,170	0,477	5623
CO trimester 3	1,133	0,442	1109	1,149	0,456	5881
Pm10 trimester 1	71,53	24,58	1673	70,86	24,85	8567
Pm10 trimester 2	70,04	24,26	1681	69,52	24,64	8624
Pm10 trimester 3	68,39	23,22	1678	67,96	23,66	8647

Note: (^{a}) Daily average. (^{b}) 8-hrs max average. Sample variation among pollutants depends on pollution data availability.

dangerous for health, as highlighted by Currie et al. (2014).[25]

5 Empirical Strategy

We are interested in quantifying the causal effect of exposure to air pollution during pregnancy and at different stages of early life on children's health. As mentioned in a previous section, to claim causality there are potential challenges to be addressed. Particularly, residential sorting and omitted variables could bias the estimation. To overcome these potential problems, we identify in the CVS data set pairs of siblings to estimate specifications with family fixed effects. This approach compares two siblings from the same family who were born at different periods of time and were exposed to different levels of air pollution. Using family fixed effects will control for time invariant unobservable family characteristics common to both siblings that may be correlated with pollution exposure and the outcome of interest. The model is estimated on the sub-sample of siblings identifiable in the database, eliminating twins, third siblings, and

[25]International standard for carbon monoxide: 7 $\mu g/m^3$ or 6.11 ppm maximum 24-hour average exposure established by WHO for Europe in 2010.

singletons. We also control for an ample set of characteristics of the child, characteristics of the mother at the childs birth and at the moment of the interview, and living conditions and characteristics of the surroundings at the date of the interview. The specification also controls for station and time (year and month of birth) fixed effects.

The equation using family fixed effects is essentially a first difference across siblings, as follows:

$$\Delta Y_{ijt-i'jt'} = \rho_1 \Delta P_{jt-jt'} + \rho_2 \Delta W_{jt-jt'} + \rho_3 \Delta C_{jt-jt'} + \rho_6 \Delta M\&Y_{jt-jt'} + \Delta \xi_{jt-jt'} \tag{1}$$

where ΔY is the difference in the outcome of interest of the child i, living in the surroundings (4 km buffer) of station j, measured in time t, and their sibling i' measured in time t'. Given that both siblings were born on separate dates, we differentiate the time in which each sibling was exposed to air pollution by using t and t'. Similarly, the difference applies for all the characteristics we control for ΔP: difference in pollution exposure, ΔW: difference in precipitation levels, ΔC: includes difference in covariates like child characteristics, mother´s behavior during pregnancy, home and home surroundings characteristics, and $\Delta M\&Y$: difference in month and year of birth. The coefficient of interest is ρ_1 which is expected to have a positive sign since exposure to higher levels of pollution may increase the incidence of bad health outcomes (low birth weight and lung disease).

6 Results

Given the high correlation among pollutant measures (See appendix A.6, Table 16), most of our results presented in this section are estimated using equation 1 separately for each measure of pollution and for each period of time. For instance, when using low birth weight as an outcome, each estimation uses Equation 1 including only an average level of pollution for either CO, O3 or Pm10 during the first, second, or third trimester of pregnancy, then we gather all individual estimates into one table. There are estimates in which we include two measures for levels of pollution. We clearly state these cases.

6.1 Effect of Pollution Exposure on Low Birth Weight

Table 2 presents the effect of exposure to pollution during pregnancy on the probability of low birth weight. The literature suggests that CO as a pollutant is able to pass through the placenta, affecting the fetus directly. However, there are other channels through which exposure to other pollutants (Pm10 or O3) during pregnancy will affect the fetus through its effects on the mother's health, as observed by Bharadwaj et al. (2014). Additionally, the relation between pollution and infant health might be not linear (Arceo et al., 2016). Hence, Table 2 reports both the coefficients of the linear and the quadratic pollution terms, as well as the marginal effect. Furthermore, we include station and time fixed effects (interactions of month and year of birth to control for unobserved seasonal effects).

Table 2: Effect of Exposure to Pollution During Pregnancy on Probability of Low Birth Weight

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A. Only Levels of CO([a])		Panel B. Only Levels of Pm10([a])		Panel C. Only Levels of O3([a1])	
Trim 1 (lin)	0.047	0.006	0.011	0.030	0.023	0.021
	(0.057)	(0.079)	(0.024)	(0.036)	(0.024)	(0.041)
Trim 1 (sqr)	-0.046**	-0.054*	-0.013	-0.034**	-0.009	-0.035*
	(0.019)	(0.029)	(0.011)	(0.016)	(0.011)	(0.019)
Trim 1 (dy/dx)	0.044	0.002	0.002	0.006	0.018	0.003
	(0.056)	(0.078)	(0.019)	(0.030)	(0.020)	(0.036)
Observations	802	802	1,413	1,413	764	764
Trim 2 (lin)	0.132**	0.137**	0.044*	-0.011	0.036*	0.024
	(0.056)	(0.067)	(0.026)	(0.041)	(0.019)	(0.043)
Trim 2 (sqr)	-0.072**	-0.071**	-0.005	-0.005	0.006	0.005
	(0.029)	(0.033)	(0.013)	(0.016)	(0.009)	(0.014)
Trim 2 (dy/dx)	0.141**	0.146**	0.041*	-0.015	0.039**	0.027
	(0.059)	(0.070)	(0.021)	(0.037)	(0.018)	(0.039)
Observations	810	810	1,410	1,410	807	807
Trim 3 (lin)	0.043	-0.030	0.018	-0.005	0.017	0.080*
	(0.068)	(0.069)	(0.032)	(0.045)	(0.023)	(0.048)
Trim 3 (sqr)	0.002	0.007	-0.004	-0.002	0.003	-0.006
	(0.038)	(0.039)	(0.017)	(0.021)	(0.010)	(0.014)
Trim 3 (dy/dx)	0.043	-0.031	0.017	-0.006	0.099**	0.078*
	(0.070)	(0.072)	(0.027)	(0.040)	(0.045)	(0.044)
Observations	840	840	1,402	1,402	828	828
All controls		X		X		X

Note: Each coefficient shows the effect, using equation 1, for separately measure of levels of pollution per each trimester. Precipitation and levels of CO, Pm10, and O3 are quadratic; all pollution measures are standardized by subtracting the average pollution (2002-2014) and dividing it by the standard deviation (2002-2014); table reports the linear (lin), quadratic (sqr), and marginal effects (dy/dx) of a one standard deviation increase in the level of pollution exposure. Robust standard error in parenthesis; ([a]): daily average; ([a1]): 8hrs-max average; ([b]): gender ([c]): smoked or cohabitated with a smoker during pregnancy; ([d]): house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic and mobility; ([e]): poverty rate, level of education (the rate of completed high school studies for people under the age of 20), and proportion of people with health insurance (these characteristics were taken from Multipurpose Survey of Bogotá (EMB) 2007, 2011, and 2014); *** p$\leq$ 0.01, $**p \leq 0.05$, $*p \leq 0.1$.

Marginal effects estimates show a statistically significant positive relation between the level of CO exposure during the second trimester of pregnancy and the probability of low birth weight. The same positive relation is observed between the level of O3 exposure during the third trimester of pregnancy and the probability of low birth weight. This result is robust when controlling for different characteristics (child, mother, home surroundings, and locality). Specifically, an increase by one standard deviation in the average daily level of CO during the second trimester of pregnancy increases the probability of being underweight at birth (comparing to his/her sibling) by about 14 percentage points (Column 4, Table 2) while a one standard deviation rise in O3 during the third trimester increases the probability of being reported with low birth weight by about 8 percentage points (Column 12, Table 2). The results suggest that pollution may have an effect on childrens health at birth both through a direct channel (i.e. CO affecting children's health directly), as well as an effect through the mother's health. These results are also robust to similar specifications using measures of pollution that consider the 8hrs-max average rather than the daily average.[26] Pm10 does not seem to affect weight at birth.[27]

Table 3 presents the estimates of specifications where we include in the regression two measures of pollution in a given trimester (either CO and PM10, or CO and O3, or O3 and Pm10). An important limitation of these specifications is the notorious reduction in the sample size for a certain combination of pollutants. This is due to the fact that not all stations measure all pollutants in the same period of time. The effect of exposure to higher levels of CO during the second trimester of pregnancy on low birth weight still holds when controlling for levels of Pm10 during the same trimester, although they do not remain statistically significant when controlling for O3. However, in a later regression, about 40% of the sample is lost due to missing data. Also, the effect of exposure to higher levels of O3 during the third trimester of pregnancy on low birth weight still holds but only when controlling for all controls. This happens for both specifications when combining O3 with CO, as well as combining O3 with Pm10.[28]

[26]Appendix A.6, Tables 18 and 19, show results for estimates for the 8hrs-max daily average for CO, O3, and Pm10.

[27]We estimate Equation 1 using monthly averages for CO, O3, and Pm10 (separately for each month of pregnancy, and for combining pollutants). Results show statistically significant results for exposure to O3 during the fifth month (see Table 20, Appendix A.7). Estimates when combining pollutants show mixed statistically significant results that are in more accordance to results found in Table 3 (see Table 21, Appendix A.7).

[28]Correlation between CO, O3, and Pm10 are presented in Appendix A.6, Table 14.

Table 3: Effect of Exposure to Pollution During Three Trimesters of Pregnancy on Probability of Low Birth Weight, Combined Pollutants

	(1)	(2)	(3)	(4)	(5)	(6)
CO([a]) trim 1 (lin)	0.051	0.014	0.093	0.081		
	(0.058)	(0.079)	(0.075)	(0.123)		
CO trim 1 (sqr)	-0.047**	-0.054*	-0.059	-0.103		
	(0.019)	(0.028)	(0.056)	(0.098)		
CO trim 1 (dy/dx)	0.047	0.009	0.107	0.106		
	(0.056)	(0.077)	(0.084)	(0.130)		
Pm10([a]) trim 1 (lin)	-0.0125	0.0353			0.029	0.083*
	(0.037)	(0.078)			(0.031)	(0.048)
Pm10 trim 1 (sqr)	-0.029	-0.074**			0.013	-0.049
	(0.023)	(0.034)			(0.021)	(0.034)
Pm10 trim 1 (dy/dx)	-0.026	0.000			0.0240	0.104**
	(0.034)	(0.070)			(0.034)	(0.053)
O3([a1]) trim 1 (lin)			0.037	0.122	0.022	0.048
			(0.035)	(0.075)	(0.024)	(0.039)
O3 trim 1 (sqr)			-0.008	-0.096***	-0.007	-0.047**
			(0.015)	(0.028)	(0.011)	(0.020)
O3 trim 1 (dy/dx)			0.035	0.095	0.018	0.024
			(0.032)	(0.069)	(0.021)	(0.034)
Observations	790	790	514	514	757	757
CO trim 2 (lin)	0.129**	0.147**	0.067	0.028		
	(0.056)	(0.067)	(0.078)	(0.121)		
CO trim 2 (sqr)	-0.066**	-0.078**	-0.140**	-0.056		
	(0.029)	(0.031)	(0.069)	(0.103)		
CO trim 2 (dy/dx)	0.136**	0.155**	0.110	0.0455		
	(0.059)	(0.069)	(0.095)	(0.132)		
Pm10 trim 2 (lin)	0.081*	0.168**			0.038	0.001
	(0.048)	(0.082)			(0.039)	(0.052)
Pm10 trim 2 (sqr)	-0.029	-0.020			-0.001	0.009
	(0.022)	(0.028)			(0.021)	(0.030)
Pm10 trim 2 (dy/dx)	0.068	0.159**			0.038	-0.003
	(0.042)	(0.076)			(0.042)	(0.057)
O3 trim 2 (lin)			0.042	-0.019	0.032*	0.017
			(0.029)	(0.105)	(0.019)	(0.045)
O3 trim 2 (sqr)			-0.009	-0.022	0.007	0.006
			(0.010)	(0.031)	(0.009)	(0.014)
O3 trim 2 (dy/dx)			0.039	-0.025	0.035**	0.019
			(0.028)	(0.099)	(0.018)	(0.040)
Observations	802	802	527	527	804	804
CO trim 3 (lin)	0.045	-0.027	0.084	0.223*		
	(0.071)	(0.072)	(0.084)	(0.130)		
CO trim 3 (sqr)	0.006	0.007	-0.079	-0.079		
	(0.039)	(0.039)	(0.061)	(0.092)		
CO trim 3 (dy/dx)	0.045	-0.028	0.111	0.249*		
	(0.073)	(0.073)	(0.098)	(0.135)		
Pm10 trim 3 (lin)	0.014	-0.056			0.029	0.073
	(0.047)	(0.068)			(0.038)	(0.076)
Pm10 trim 3 (sqr)	0.025	0.092**			0.001	0.028
	(0.026)	(0.039)			(0.027)	(0.035)
Pm10 trim 3 (dy/dx)	0.022	-0.025			0.029	0.058
	(0.043)	(0.067)			(0.045)	(0.081)
O3 trim 3 (lin)			0.016	0.156**	0.014	0.085*
			(0.034)	(0.078)	(0.021)	(0.049)
O3 trim 3 (sqr)			-0.000	-0.031	0.003	-0.008
			(0.011)	(0.022)	(0.010)	(0.014)
O3 trim 3 (dy/dx)			0.016	0.152**	0.015	0.082*
			(0.032)	(0.076)	(0.019)	(0.046)
Observations	822	822	543	543	822	822
All Controls([b])		X		X		X
Precipitation		X		X		X

Note: Each coefficient shows the effect, using equation 1, for two different measures of levels of pollution (either CO and O3, or CO and Pm10, or O3 and Pm10) per each trimester. All pollution measures are standardized by subtracting the average pollution (2002-2014) and dividing it by the standard deviation (2002-2014); table reports the linear (lin), quadratic (sqr), and marginal effects (dy/dx) of a one standard deviation increase in the level of pollution exposure. Robust standard error in parenthesis; ([a]): daily average; ([a1]): 8hrs-max average; ([b]): gender, mother smoked or cohabitated with a smoker during pregnancy, house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic, mobility, locality poverty rate, level of education (the rate of completed high school studies for people under the age of 20), and proportion of people with health insurance (last three characteristics were taken from Multipurpose Survey of Bogotá (EMB) 2007, 2011, and 2014). *** $p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.1$.

6.2 Effects of Pollution Exposure on Developing Lung-related Diseases

Table 4 presents results of the effect of exposure to air pollution during pregnancy on the probability of having been diagnosed with a lung-related disease. Again, we estimate the regression including one measure of pollution at the time during a particular trimester of pregnancy (i.e. reported coefficients in each panel come from a separate regression where the measure of pollution is either the level of CO, O3, or Pm10 during a trimester of pregnancy). Epidemiologists suggest that the lungs mature during the second and third trimesters (Stern et al., 2007), therefore any shock occurring at that time (like being exposed to high levels of pollution during second/third trimester of the mother's pregnancy), may possibly affect lung development.

Table 4: Effect of Exposure to Pollution During Pregnancy on Probability of Suffering from a Lung-related Disease (LRD)

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A. Levels of CO([a])		Panel B. Levels of Pm10([a])		Panel C. Levels of O3([a1])	
Trim 1 (lin)	0.037	0.001	0.094*	0.091	0.048	0.120*
	(0.102)	(0.110)	(0.056)	(0.056)	(0.067)	(0.068)
Trim 1 (sqr)	-0.026	0.011	-0.028	-0.031	-0.020	-0.033
	(0.034)	(0.034)	(0.028)	(0.029)	(0.026)	(0.026)
Trim 1 (dy/dx)	0.036	0.002	0.076*	0.072	0.037	0.102*
	(0.101)	(0.108)	(0.046)	(0.046)	(0.059)	(0.061)
Observations	701	701	1,199	1,199	654	654
Trim 2 (lin)	0.115	0.096	0.050	0.057	0.104**	0.129**
	(0.098)	(0.108)	(0.054)	(0.052)	(0.052)	(0.058)
Trim 2 (sqr)	-0.017	0.012	0.028	0.024	-0.019	-0.031
	(0.048)	(0.045)	(0.026)	(0.026)	(0.018)	(0.021)
Trim 2 (dy/dx)	0.117	0.094	0.065	0.070	0.095**	0.114**
	(0.103)	(0.112)	(0.046)	(0.044)	(0.048)	(0.053)
Observations	716	716	1,189	1,189	691	691
Trim 3 (lin)	-0.075	-0.059	0.026	-0.010	0.013	-0.037
	(0.107)	(0.126)	(0.060)	(0.066)	(0.077)	(0.080)
Trim 3 (sqr)	-0.029	-0.082	0.042	0.054**	0.017	0.027
	(0.063)	(0.071)	(0.026)	(0.026)	(0.021)	(0.022)
Trim 3 (dy/dx)	-0.071	-0.049	0.042	0.010	0.019	-0.027
	(0.112)	(0.132)	(0.056)	(0.061)	(0.072)	(0.075)
Observations	727	727	1,177	1,177	711	711
All controls		X		X		X

Note: Each coefficient shows the effect, using equation 1, for separately measure of levels of pollution per each trimester. Precipitation and levels of CO, Pm10, and O3 are quadratic; all pollution measures are standardized by subtracting the average pollution (2002-2014) and dividing it by the standard deviation (2002-2014); table reports the marginal effects (dy/dx) of a one standard deviation increase in the level of pollution exposure. Robust standard error in parenthesis; ([a]): daily average; ([a1]): 8hrs-max average; ([b]): gender, being diagnosed with malnutrition, age in months, child shares bedroom with other people; ([c]): healthcare coverage at the time of the interview, secondary studies, employed, mother smoked or cohabitated with a smoker during pregnancy, parents diagnosed with a lung disease, parents exposed to toxic substances at work; ([d]): energy source, household size, presence of fungus & pests, pets, house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic, mobility; these variables are extracted from the Multipurpose Survey of Bogotá (EMB) 2007, 2011, and 2014. *** $p \leq 0.01$, $**\,p \leq 0.05$, $*p \leq 0.1$.

Marginal effect estimates show a statistically significant positive relation between the level of O3 exposure during the second trimester of pregnancy and the probability of being diagnosed with a lung-related disease. The result is robust when controlling for different characteristics (child, mother, home surroundings, and locality). Particularly, an increase in one standard deviation in the average daily level of O3 during the second trimester of pregnancy increases the probability of being diagnosed with a lung-related disease (comparing to his/her sibling) by about 11 percentage points (Column 12, Table 4). Again, the result suggests that pollution may have an effect on children's health through an indirect channel, i.e. the mother's health. Also, considering that Stern et al. (2007) affirm how being exposed to levels of pollution during the first year of life increases the chances of developing a lung-related disease, we estimate similar regressions of those on table 4 but controlling for levels of pollution during the first year of child´s life. Given the high correlation among levels of pollution (see Table 15, appendix A.5), we use on each regression the first year average of pollution (CO, Pm10, or O3) separately for each level of pollution on each trimester (i.e. one model includes level of pollution for first trimester of CO and the level of pollution for the first trimester for CO. Similarly, we do for each trimester and pollutant). Estimates presented on Table 21, (Appendix A.7) show that when including levels of pollution during the first year of child´s life, results found on Table 4 do not change.

Table 5 presents the estimates of specifications where we include more than one measure of pollution in a given trimester. The effect of exposure to higher levels of O3 during the second trimester of pregnancy on being diagnosed with a lung-related disease holds when controlling for levels of Pm10 during the same trimester, although it is not the case when controlling for CO.

7 Robustness Checks

7.1 Geographical Match of the Data

Our previous analysis matched individual outcomes with the pollution measures of their closest pollution measurement stations. We restricted our analysis to all individuals who live within a 4 km buffer around a measurement station. In this section, we consider radiuses of different sizes to show results are robust for the choice of the size of the buffer.

Table 6 presents the results of estimations considering buffers ranging from three to six km.

Table 5: Effect of Exposure to Pollution During Pregnancy on Probability of Suffering from a Lung-related Disease (LRD). Combined Pollutants

	(1)	(2)	(3)	(4)	(5)	(6)
Co trim 1 (lin)	0.399**	0.509**	0.059	0.034		
	(0.169)	(0.211)	(0.101)	(0.104)		
Co trim 1 (sqr)	-0.201*	-0.124	-0.025	0.006		
	(0.115)	(0.146)	(0.031)	(0.034)		
Co trim 1 (dy/dx)	0.469***	0.552**	0.058	0.035		
	(0.179)	(0.228)	(0.099)	(0.102)		
Pm10 trim 1 (lin)			0.344***	0.191*	0.042	-0.023
			(0.105)	(0.111)	(0.0963)	(0.112)
Pm10 trim 1 (sqr)			-0.151***	-0.165***	-0.150**	-0.176***
			(0.046)	(0.043)	(0.058)	(0.054)
Pm10 trim 1 (dy/dx)			0.281***	0.122	0.122	0.071
			(0.093)	(0.104)	(0.104)	(0.117)
O3 max trim 1 (lin)	-0.055	-0.014			0.0511	0.135*
	(0.103)	(0.123)			(0.070)	(0.070)
O3 max trim 1 (sqr)	-0.003	-0.005			-0.029	-0.047
	(0.041)	(0.041)			(0.031)	(0.029)
O3 max trim 1 (dy/dx)	-0.055	-0.015			0.034	0.107*
	(0.101)	(0.121)			(0.060)	(0.062)
Observations	435	435	690	690	648	648
Co trim 2 (lin)	-0.022	0.139	0.103	0.082		
	(0.192)	(0.208)	(0.104)	(0.113)		
Co trim 2 (sqr)	0.415**	0.534**	-0.016	0.018		
	(0.178)	(0.231)	(0.049)	(0.046)		
Co trim 2 (dy/dx)	-0.171	-0.054	0.105	0.0799		
	(0.195)	(0.231)	(0.108)	(0.117)		
Pm10 trim 2 (lin)			-0.086	-0.123	0.023	0.023
			(0.103)	(0.106)	(0.086)	(0.085)
Pm10 trim 2 (sqr)			0.022	0.032	0.002	0.008
			(0.046)	(0.049)	(0.062)	(0.062)
Pm10 trim 2 (dy/dx)			-0.076	-0.109	0.022	0.018
			(0.094)	(0.096)	(0.093)	(0.099)
O3 max trim 2 (lin)	-0.014	0.117			0.151**	0.174**
	(0.094)	(0.128)			(0.059)	(0.068)
O3 max trim 2 (sqr)	-0.018	-0.051			-0.035	-0.051**
	(0.039)	(0.053)			(0.022)	(0.024)
O3 max trim 2 (dy/dx)	-0.015	0.111			0.131**	0.146**
	(0.092)	(0.124)			(0.053)	(0.060)
Observations	450	450	708	708	688	688
CO trim 3 (lin)	-0.249	-0.240	-0.089	-0.075		
	(0.163)	(0.167)	(0.108)	(0.126)		
CO trim 3 (sqr)	-0.196*	0.059	-0.015	-0.042		
	(0.118)	(0.171)	(0.067)	(0.075)		
CO trim 3 (dy/dx)	-0.166	-0.265	-0.088	-0.071		
	(0.162)	(0.197)	(0.113)	(0.132)		
Pm10 trim 3 (lin)			0.154	0.194*	0.039	-0.045
			(0.111)	(0.117)	(0.087)	(0.098)
Pm10 trim 3 (sqr)			0.079	0.038	-0.018	0.005
			(0.054)	(0.056)	(0.051)	(0.053)
Pm10 trim 3 (dy/dx)			0.180*	0.206*	0.051	-0.048
			(0.103)	(0.109)	(0.085)	(0.098)
O3 max trim 3 (lin)	0.171*	0.242**			0.056	-0.009
	(0.092)	(0.106)			(0.076)	(0.082)
O3 max trim 3 (sqr)	-0.006	-0.010			0.009	0.025
	(0.025)	(0.028)			(0.022)	(0.024)
O3 max trim 3 (dy/dx)	0.171*	0.242**			0.060	0.002
	(0.092)	(0.106)			(0.069)	(0.076)
Observations	462	462	712	712	705	705
All controls(b)		X		X		X

Note: Each coefficient shows the effect, using equation 1, for two different measures of levels of pollution (CO and O3, or CO and Pm10, or O3 and Pm10) per each trimester. Precipitation and levels of CO, Pm10, and O3 are quadratic; all pollution measures are standardized by subtracting the average pollution (2002-2014) and dividing it by the standard deviation (2002-2014); table reports the marginal effects (dy/dx) of a one standard deviation increase in the level of pollution exposure. Robust standard error in parenthesis; (a): daily average; (a1): 8hrs-max average; (b): gender, being diagnosed with malnutrition, age in months, child shares bedroom with other people, healthcare coverage at the time of the interview, secondary studies, employed, mother smoked or cohabitated with a smoker during pregnancy, parents diagnosed with a lung disease, parents exposed to toxic substances at work, energy source, household size, presence of fungus & pests, pets, house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic, mobility. *** $p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.1$.

Panel A presents the results for the impact of pollution on low birth weight, and Panel B shows results for lung-related diseases.

According to the marginal effects estimates, we conclude that the positive effects of levels of CO (second trimester of pregnancy) and O3 (third trimester of pregnancy) exposure on the probability of low birth weight hold when changing the area of influence around a station. Additionally, the magnitude of the effect of both CO and O3 is very similar across alternatives. Similarly, the effects of exposure to O3 during the second trimester of pregnancy on the probability of being diagnosed with a lung-related disease hold for different sizes of the buffer. The magnitude also remains almost unchanged across alternatives.

7.2 Mobility and Infant Health

All our estimates for the three outcomes control for whether the mother did or did not move from her home before the child was born. We built this variable using information from CVS.[29] The percentage of mothers who moved is 39% for all the sample and 36% for the sibling sample. Although we control for this characteristic, we acknowledge that this can raise measurement error, given that levels of pollution are assigned as if the mother was always living in the last declared residence, even during pregnancy. Besides, the CVS does not provide any information about where the mother lived before moving to the current place. It is of our interest to better understand our baseline results to perceive any potential biases. For instance, we expect the effect that levels of CO and O3 during pregnancy have on low birth weight and lung-related disease to be bigger for mothers who did not move.

Table 7 presents results for estimates for low birth weight (Column I) and lung-related disease (Column II), differentiating between mothers who moved and mothers who did not move their current place of residence before their child was born. Marginal effects confirm a positive, statistically significant effect for levels of CO during the second trimester and low birth weight for mothers who did not move. The estimated effect found, as expected, is bigger for those mothers who did not move residences before their children were born. Although the effect

[29]Section 4.1.2, Footnote 25 describes how this variable is built.

Table 6: Estimates for Low Birth Weight, Levels of Pollution During Pregnancy, Different Buffers of Incidence

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	6km	5km	4km	3km	6km	5km	4km	3km	6km	5km	4km	3km
	Panel A. Levels of pollution for low birth weight (LBW)											
	Column I. Only Levels of CO				Column II. Only Levels of Pm10				Column III. Only Levels of O3			
Trim 1	0.023	0.024	0.007	0.041	0.023	0.024	0.030	0.035	0.029	0.029	0.021	0.057
	(0.060)	(0.062)	(0.079)	(0.095)	(0.034)	(0.035)	(0.036)	(0.039)	(0.040)	(0.040)	(0.041)	(0.043)
Trim 1 (sqr)	-0.059**	-0.059**	-0.054*	-0.072	-0.023	-0.026*	-0.034**	-0.039**	-0.038**	-0.038**	-0.035*	-0.043**
	(0.024)	(0.024)	(0.029)	(0.050)	(0.014)	(0.015)	(0.016)	(0.017)	(0.019)	(0.019)	(0.019)	(0.019)
Trim 1 (dy/dx)	0.014	0.015	0.002	0.042	0.002	0.002	0.006	0.010	0.013	0.013	0.003	0.032
	(0.058)	(0.059)	(0.078)	(0.096)	(0.027)	(0.028)	(0.030)	(0.033)	(0.036)	(0.036)	(0.036)	(0.038)
Observations	938	916	802	722	1,614	1,574	1,413	1,291	805	802	764	702
Trim 2	0.0977*	0.105*	0.137**	0.100	-0.001	-0.001	-0.011	-0.019	0.033	0.033	0.024	0.038
	(0.059)	(0.059)	(0.067)	(0.073)	(0.036)	(0.038)	(0.041)	(0.044)	(0.041)	(0.041)	(0.043)	(0.046)
Trim 2 (sqr)	-0.063**	-0.065**	-0.071**	-0.075**	-0.006	-0.008	-0.005	0.011	0.003	0.003	0.005	0.002
	(0.032)	(0.032)	(0.033)	(0.035)	(0.015)	(0.015)	(0.016)	(0.017)	(0.012)	(0.012)	(0.014)	(0.014)
Trim 2 (dy/dx)	0.099*	0.107*	0.146**	0.112	-0.006	-0.008	-0.015	-0.014	0.034	0.034	0.027	0.039
	(0.059)	(0.061)	(0.070)	(0.077)	(0.032)	(0.032)	(0.037)	(0.041)	(0.037)	(0.037)	(0.039)	(0.041)
Observations	950	925	810	730	1,609	1,569	1,410	1,291	849	847	807	743
Trim 3	-0.086	-0.089	-0.030	-0.028	0.007	0.016	-0.005	0.009	0.077*	0.077*	0.080*	0.089*
	(0.064)	(0.066)	(0.069)	(0.077)	(0.042)	(0.043)	(0.045)	(0.049)	(0.045)	(0.045)	(0.048)	(0.051)
Trim 3 (sqr)	0.029	0.030	0.007	-0.007	-0.002	-0.002	-0.002	0.003	-0.008	-0.008	-0.006	-0.011
	(0.039)	(0.039)	(0.039)	(0.044)	(0.019)	(0.019)	(0.021)	(0.022)	(0.013)	(0.013)	(0.014)	(0.015)
Trim 3 (dy/dx)	-0.086	-0.089	-0.031	-0.027	0.005	0.015	-0.006	0.009	0.0736*	0.074*	0.078*	0.084*
	(0.064)	(0.067)	(0.072)	(0.080)	(0.036)	(0.036)	(0.040)	(0.045)	(0.042)	(0.042)	(0.044)	(0.046)
Observations	978	951	840	756	1,601	1,562	1,402	1,283	873	870	828	761
	Panel B. Levels of pollution for lung-related diseases (LRD)											
	Column I. Only Levels of CO				Column II. Only Levels of Pm10				Column III. Only Levels of O3			
Trim 1 (lin)	0.051	0.079	0.001	0.017	0.086	0.091*	0.091	0.099	0.110*	0.110*	0.120*	0.133*
	(0.101)	(0.103)	(0.110)	(0.133)	(0.053)	(0.053)	(0.057)	(0.061)	(0.064)	(0.064)	(0.068)	(0.074)
Trim 1 (sqr)	-0.013	-0.019	0.011	0.034	-0.035	-0.037	-0.031	-0.038	-0.035	-0.035	-0.033	-0.043
	(0.030)	(0.031)	(0.034)	(0.062)	(0.028)	(0.028)	(0.029)	(0.032)	(0.025)	(0.025)	(0.026)	(0.026)
Trim 1 (dy/dx)	0.049	0.078	0.0016	0.015	0.058	0.063	0.072	0.078	0.092	0.092	0.102*	0.105
	(0.099)	(0.101)	(0.108)	(0.135)	(0.041)	(0.041)	(0.047)	(0.051)	(0.058)	(0.058)	(0.061)	(0.066)
Observations	814	796	701	628	1,356	1,325	1,199	1,100	685	684	654	597
Trim 2 (lin)	0.094	0.101	0.096	0.055	0.048	0.045	0.058	0.041	0.148***	0.148***	0.129**	0.150**
	(0.102)	(0.100)	(0.108)	(0.113)	(0.050)	(0.049)	(0.052)	(0.055)	(0.055)	(0.055)	(0.058)	(0.063)
Trim 2 (sqr)	0.036	0.041	0.012	0.007	0.018	0.017	0.024	0.038	-0.034*	-0.034*	-0.031	-0.051**
	(0.048)	(0.047)	(0.045)	(0.042)	(0.026)	(0.025)	(0.026)	(0.025)	(0.019)	(0.019)	(0.021)	(0.021)
Trim 2 (dy/dx)	0.092	0.098	0.094	0.054	0.061	0.056	0.070	0.058	0.132***	0.132***	0.114**	0.118**
	(0.104)	(0.102)	(0.112)	(0.118)	(0.040)	(0.040)	(0.045)	(0.049)	(0.051)	(0.051)	(0.053)	(0.057)
Observations	830	811	716	644	1,342	1,311	1,189	1,093	722	721	691	632
Trim 3 (lin)	-0.031	-0.031	-0.059	-0.073	0.003	0.002	-0.011	0.003	-0.003	-0.003	-0.037	0.013
	(0.116)	(0.115)	(0.126)	(0.122)	(0.062)	(0.061)	(0.066)	(0.067)	(0.079)	(0.079)	(0.079)	(0.084)
Trim 3 (sqr)	-0.083	-0.067	-0.082	-0.009	0.049**	0.049**	0.054**	0.053**	0.019	0.019	0.027	0.017
	(0.069)	(0.068)	(0.071)	(0.092)	(0.025)	(0.025)	(0.026)	(0.025)	(0.021)	(0.021)	(0.022)	(0.022)
Trim 3 (dy/dx)	-0.025	-0.025	-0.049	-0.071	0.031	0.028	0.010	0.021	0.003	0.003	-0.027	0.021
	(0.119)	(0.119)	(0.132)	(0.131)	(0.056)	(0.056)	(0.061)	(0.064)	(0.074)	(0.074)	(0.075)	(0.076)
Observations	841	820	727	654	1,330	1,300	1,177	1,082	743	742	711	650
All Controls(c)	X	X	X	X	X	X	X	X	X	X	X	X
Precipitation	X	X	X	X	X	X	X	X	X	X	X	X
All FE(d)	X	X	X	X	X	X	X	X	X	X	X	X

Note: Each coefficient shows the effect, using equation 1, for separately measures of levels of pollution per each trimester. Precipitation and levels of CO, Pm10 and O3 are quadratic; all pollutant measures are standardized by subtracting the average pollution (2002-2014) and dividing it by the standard deviation (2002-2014). Table reports linear (lin), quadratic (sqr), and marginal effects (dy/dx); robust standard errors reported in parenthesis. ([a]): standardized daily average. Estimated coefficients using robust standard errors. ([b]): standardized 8hrs-max average. ([c]): controls for low birth weight (LWB): gender, mother smoked or cohabitated with a smoker during pregnancy, house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic, mobility, locality poverty rate, level of education (the rate of completed high school studies for people under the age of 20), and proportion of people with health insurance (last three characteristics were taken from Multipurpose Survey of Bogotá (EMB) 2007, 2011, and 2014). Controls for lung-related disease (LRD): gender, being diagnosed with malnutrition, age in months, child shares bedroom with other people, coughing at night (persistently), healthcare coverage at the time of the interview, secondary school studies, employed, mother smoked or cohabitated with a smoker during pregnancy, parents diagnosed with a lung disease, parents exposed to toxic substances at work, energy source, household size, presence of fungus & pests, pets, house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic, mobility; ([d]): station and month and year of birth.*** p$\leq$ 0.01, $**p \leq 0.05$, $*p \leq 0.1$.

for mothers who moved is also positive, this is not statistically significant. Levels of Pm10 for the first trimester are also statistically significant for the same group of mothers. Interestingly, our baseline result for levels of O3 during the third trimester of pregnancy and low birth weight holds for mothers who moved. Furthermore, negative effects appear for levels of CO during the third trimester and lung-related disease for this group of mothers. However, we rely more on results for mothers who did not move, rather than for mothers who did move, given the sample size reduction and the measurement error for mothers who moved.

Marginal effects show a positive statistically significant effect for levels of O3 during the first trimester (and almost for the second trimester) of pregnancy and the probability of suffering from a lung-related disease for each mother who did not move.

Overall, results expose that levels of CO during the second trimester of pregnancy affect low birth weight of both groups of mothers, but the effect is more intense for mothers who did not move, as expected. Whether the mother moved or not, it is not totally decisive for the relation between level of O3 (for the second trimester) and suffering a lung-related disease.

7.3 Controlling for Observables Estimates

We complement our baseline results (family fixed effects) by calculating a controlling-for-observables model, taking advantage of the ample set of variables of the CVS. The specification used is the following:

$$Y_{ijt} = \delta_0 + \delta_1 P_{ijt} + \delta_2 Pp_{ijt} + \delta_3 C_{ijt} + \delta_4 M_{ijt} + \delta_5 H\&S_{ijt} + \delta_6 L_{ijt} + \kappa_t + \varsigma i + \psi_{ijt} \tag{2}$$

where Y_{ijt} refers to the outcome of interest (low birth weight or diagnosed with a lung-related disease) for the child i, exposed to a level of pollution measured in station j at the time t; P_{ijt} and Pp_{ijt} are vectors of daily averages for pollutants and precipitation variables; C_{ijt}: set of controls regarding characteristics of the child; M_{ijt}: vector with characteristics of the mother; $H\&S_{ijt}$: vector with home and surroundings characteristics; L_{ijt}: vector with socio-economic characteristics at the locality level; ς and κ are station and month and year of birth

Table 7: Estimates for Low Birth Weight and Lung-related Disease and Levels of Pollution During Pregnancy. Mothers Who Did or Did Not Move

	Mother did move	Mother did not move	Mother did move	Mother did not move
	Column I. Low birth weight		Column II. Lung-related disease	
	Panel A. Levels of CO			
CO trim 1 (lin)	0.142	0.028	0.033	-0.072
	(0.123)	(0.146)	(0.161)	(0.166)
CO trim 1 (sqr)	-0.067	0.029	-0.016	-0.030
	(0.048)	(0.033)	(0.067)	(0.064)
CO trim 1 (dy/dx)	0.136	0.0278	0.030	-0.071
	(0.118)	(0.142)	(0.152)	(0.166)
Observations	215	508	225	359
CO trim 2 (lin)	0.098	0.23***	0.141	0.109
	(0.078)	(0.086)	(0.117)	(0.122)
CO trim 2 (sqr)	-0.042	-0.22***	-0.100*	0.278*
	(0.035)	(0.080)	(0.060)	(0.146)
CO trim 2 (dy/dx)	0.103	0.26***	0.145	0.064
	(0.081)	(0.0892)	(0.119)	(0.134)
Observations	215	501	225	356
CO trim 3 (lin)	-0.051	0.157	-0.122	-0.445***
	(0.108)	(0.100)	(0.107)	(0.108)
CO trim 3 (sqr)	0.018	-0.074	0.019	0.141
	(0.051)	(0.085)	(0.089)	(0.121)
CO trim 3 (dy/dx)	-0.049	0.168	-0.119	-0.474***
	(0.104)	(0.104)	(0.099)	(0.119)
Observations	250	419	225	357
	Panel B. Levels of Pm10			
Pm10 trim 1 (lin)	-0.071	0.123**	-0.056	0.045
	(0.058)	(0.052)	(0.079)	(0.074)
Pm10 trim 1 (sqr)	0.027	-0.07***	0.024	-0.035
	(0.026)	(0.025)	(0.039)	(0.039)
Pm10 trim 1 (dy/dx)	-0.029	0.112**	-0.021	0.042
	(0.028)	(0.049)	(0.039)	(0.073)
Observations	425	695	368	597
Pm10 trim 2 (lin)	-0.018	0.066	0.049	0.103
	(0.060)	(0.058)	(0.083)	(0.079)
Pm10 trim 2 (sqr)	0.018	-0.025	-0.017	0.003
	(0.027)	(0.030)	(0.036)	(0.040)
Pm10 trim 2 (dy/dx)	0.006	0.064	0.026	0.103
	(0.031)	(0.058)	(0.045)	(0.079)
Observations	428	689	368	589
Pm10 trim 3 (lin)	-0.039	0.058	-0.034	0.080
	(0.062)	(0.084)	(0.088)	(0.088)
Pm10 trim 3 (sqr)	-0.001	0.031	0.017	0.042
	(0.032)	(0.039)	(0.036)	(0.039)
Pm10 trim 3 (dy/dx)	-0.040	0.058	-0.015	0.076
	(0.040)	(0.084)	(0.060)	(0.090)
Observations	428	681	368	580
	Panel C. Levels of O3			
O3 trim 1 (lin)	-0.001	-0.026	0.014	0.212**
	(0.036)	(0.050)	(0.061)	(0.084)
O3 trim 1 (sqr)	0.006	-0.025	-0.053	-0.073*
	(0.009)	(0.023)	(0.035)	(0.037)
O3 trim 1 (dy/dx)	0.003	-0.046	-0.010	0.172**
	(0.033)	(0.046)	(0.055)	(0.074)
Observations	197	479	159	408
O3 trim 2 (lin)	0.038	0.089	0.035	0.178*
	(0.030)	(0.056)	(0.053)	(0.098)
O3 trim 2 (sqr)	-0.000	-0.008	-0.048	-0.075**
	(0.010)	(0.021)	(0.031)	(0.031)
O3 trim 2 (dy/dx)	0.038	0.086*	0.018	0.142
	(0.027)	(0.052)	(0.049)	(0.089)
Observations	197	501	159	428
O3 trim 3 (lin)	0.088*	0.087	0.026	0.154
	(0.048)	(0.064)	(0.068)	(0.104)
O3 trim 3 (sqr)	-0.026	-0.010	0.005	-0.013
	(0.021)	(0.016)	(0.026)	(0.030)
O3 trim 3 (dy/dx)	0.079*	0.077	0.027	0.148
	(0.043)	(0.062)	(0.066)	(0.096)
Observations	201	507	159	431
All controls([b])	X	X	X	X
Precipitation	X	X	X	X
All FE	X	X	X	X

Note: Each coefficient shows the effect, using equation 1, for separately measures of levels of pollution per each trimester. Precipitation and levels of CO, Pm10, and O3 are quadratic; all pollutant measures are standardized by subtracting the average pollution (2002-2014) and dividing it by the standard deviation (2002-2014). Table reports linear (lin), quadratic (sqr), and marginal effects (dy/dx); robust standard errors reported in parenthesis. ([a]): daily average. Estimated coefficients using robust standard errors. ([a1]): daily 8hrs-max average. ([b]): controls for low birth weight: gender, mother smoked or cohabitated with a smoker during pregnancy, house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic, mobility, locality poverty rate, level of education (the rate of completed high school studies for people under the age of 20), and proportion of people with health insurance (last three characteristics were taken from EMB 2007, 2011, and 2014). Controls for lung-related disease: gender, healthcare coverage at the time of the interview, secondary school studies, employed, mother smoked or cohabitated with a smoker during pregnancy, parents diagnosed with a lung disease, parents exposed to toxic substances at work. Due to the small sample size, we cannot include all controls. ([c]): station and month and year of birth. *** $p \leq 0.01, **p \leq 0.05, *p \leq 0.1$.

fixed effects.[30] We estimate Equation 2 by OLS.

Table 8 presents the OLS estimates of the correlation between air pollution and the probability of having a low birth weight (Column I) and between pollution and the probability of suffering from a lung-related disease (Column II). The results are reported for the sample of siblings used in the previous sections (Panel A) and for the complete sample of children in the CVS (Panel B). Linear (lin), quadratic (sqr), and marginal effects (dy/dx) are reported.

Table 8: Pollution and Infant Health Outcomes: OLS Estimates

	Column I. Low birth weight			**Column II. Lung-related disease**		
	Panel A. Sibling sample					
	CO([a])	Pm 10([a])	O3([a1])	CO([a])	Pm 10([a])	O3([a1])
Trim 1 (lin)	-0.057	0.007	0.038	-0.023	0.023	0.008
	(0.048)	(0.026)	(0.032)	(0.063)	(0.037)	(0.048)
Trim 1 (sqr)	0.008	-0.009	-0.006	0.019	0.001	-0.014
	(0.015)	(0.012)	(0.013)	(0.021)	(0.018)	(0.017)
Trim 1 (dy/dx)	-0.056	-0.000	0.034	-0.022	0.023	0.000
	(0.047)	(0.021)	(0.029)	(0.062)	(0.032)	(0.042)
Observations	802	1,413	764	701	1,199	654
Trim 2 (lin)	-0.019	0.003	-0.002	0.017	0.013	0.020
	(0.040)	(0.029)	(0.033)	(0.063)	(0.039)	(0.047)
Trim 2 (sqr)	-0.004	-0.011	0.016	-0.015	-0.007	0.007
	(0.023)	(0.012)	(0.013)	(0.033)	(0.017)	(0.018)
Trim 2 (dy/dx)	-0.019	-0.004	0.007	0.019	0.009	0.024
	(0.042)	(0.025)	(0.030)	(0.066)	(0.035)	(0.043)
Observations	810	1,410	807	701	1,189	691
Trim 3 (lin)	-0.021	-0.043	0.061*	0.054	-0.070*	0.008
	(0.042)	(0.028)	(0.035)	(0.063)	(0.042)	(0.048)
Trim 3 (sqr)	0.003	0.017	0.001	-0.009	0.037*	0.004
	(0.022)	(0.014)	(0.013)	(0.036)	(0.019)	(0.015)
Trim 3 (dy/dx)	-0.021	-0.034	0.061*	0.055	-0.056	0.010
	(0.044)	(0.025)	(0.032)	(0.066)	(0.038)	(0.045)
Observations	840	1,402	828	727	1,177	711
	Panel B. All children sample					
Trim 1 (lin)	0.013	-0.007	0.001	-0.021	-0.002	-0.002
	(0.019)	(0.011)	(0.013)	(0.024)	(0.015)	(0.019)
Trim 1 (sqr)	-0.009	-0.000	-0.008	0.005	0.004	-0.008
	(0.006)	(0.005)	(0.005)	(0.009)	(0.007)	(0.007)
Trim 1 (dy/dx)	0.012	-0.007	-0.004	-0.020	0.001	-0.007
	(0.018)	(0.009)	(0.012)	(0.023)	(0.013)	(0.017)
Observations	4,179	7,344	4,292	3,625	6,279	3,600
Trim 2 (lin)	-0.020	-0.009	0.004	0.011	0.009	-0.009
	(0.018)	(0.011)	(0.013)	(0.024)	(0.016)	(0.018)
Trim 2 (sqr)	0.005	-0.003	-0.005	-0.00	0.002	0.006
	(0.010)	(0.005)	(0.005)	(0.009)	(0.007)	(0.007)
Trim 2 (dy/dx)	-0.020	-0.011	0.002	0.010	0.010	-0.006
	(0.018)	(0.009)	(0.012)	(0.023)	(0.014)	(0.016)
Observations	4,328	7,349	4,505	3,752	6,232	3,789
Trim 3 (lin)	0.026	-0.023**	-0.004	0.073***	0.002	-0.009
	(0.019)	(0.011)	(0.014)	(0.026)	(0.017)	(0.017)
Trim 3 (sqr)	-0.002	0.003	0.000	-0.024*	-0.002	0.004
	(0.010)	(0.005)	(0.004)	(0.013)	(0.008)	(0.006)
Trim 3 (dy/dx)	0.026	-0.021**	-0.004	0.074***	0.001	-0.007
	(0.019)	(0.009)	(0.012)	(0.026)	(0.016)	(0.017)
Observations	4,523	7,314	4,695	3,863	6,145	3,958
All controls([b])	X	X	X	X	X	X
Precipitation	X	X	X	X	X	X
All FE	X	X	X	X	X	X

Note: Each coefficient shows the effect, using equation 1, for separately measures of levels of pollution per each trimester. Precipitation and levels of CO, Pm10, and O3 are quadratic; all pollutant measures are standardized by subtracting the average pollution (2002-2014) and dividing it by the standard deviation (2002-2014). Table reports linear (lin), quadratic (sqr), and marginal effects (dy/dx); robust standard errors reported in parenthesis. ([a]): daily average. Estimated coefficients using robust standard errors. ([a1]): daily 8hrs-max average. ([b]): controls for low birth weight: gender, mother smoked or cohabitated with a smoker during pregnancy, house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic, mobility, locality poverty rate, level of education (the rate of completed high school studies for people under the age of 20), and proportion of people with health insurance (last three characteristics were taken from EMB 2007, 2011, and 2014). Controls for lung-related diseases: gender, being diagnosed with malnutrition, age in months, child shares bedroom with other people, healthcare coverage at the time of the interview, secondary school studies, employed, mother smoked or cohabitated with a smoker during pregnancy, parents diagnosed with a lung disease, parents exposed to toxic substances at work, energy source, household size, presence of fungus & pests, pets, house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic, mobility; ([c]): station and month and year of birth.*** $p \leq 0.01, **p \leq 0.05, *p \leq 0.1$.

Looking at the marginal effects for the sibling sample, we see a positive, statistically signif-

[30]Similar to the baseline results, levels of pollution and controls change according to the outcome of interest.

icant effect for O3 (third trimester) on the probability of having a low birth weight, similar in the magnitude to the one found using the baseline specification. No other positive, statistically significant effect on low birth weight is obtained for the sibling sample.

Moreover, marginal estimates for the all children sample present a positive, statistically significant effect of levels of CO (third trimester) on the probability of suffering from a lung-related disease, not seen in the baseline results, as well as a negative, statistically significant effect of levels of Pm10 (third trimester) on the probability of having a low birth weight. No other statistically significant result is found for the all children sample.

Although the controlling-for-observables (OLS) approach controls for an ample set of characteristics and allows us to use all the sample, there is a disadvantage due to the fact that it is not possible to control for unobserved features as the family fixed effects does.

8 Discussion and Conclusion

In this study, we assess the effect of exposure to air pollution in-utero and during the first years of life on different measures of infant and young children's health as well as that of children in public kindergartens in Bogotá, Colombia. Our findings suggest that exposure to high levels of CO during the second trimester of pregnancy and higher levels of 03 during the third trimester of pregnancy increase the probability of low birth weight. Additionally, exposure to higher levels of O3 during the second trimester of pregnancy increases young children's probability of being diagnosed with a lung-related disease. Results for levels of O3 exposure during the third trimester of pregnancy and the probability of the child having a low birth weight are robust among specifications and controls, but for levels of CO during the second trimester of pregnancy, they are robust only to changes in controls. Furthermore, exposure to levels of O3 during the second trimester of pregnancy is associated with the child later suffering from a lung-related disease. Result that is robust to different controls but not for different specifications.

Our results provide evidence for the fact that in-utero fetus health is directly and indirectly affected by being exposed to levels of air pollution during the second and third trimesters of pregnancy. Our evidence suggests that low birth weight is being affected via a direct channel when the mother is exposed to higher levels of CO during the second trimester of pregnancy (i.e. CO going through the placenta and affecting the fetus health) and by an indirect mechanism when the mother is exposed to higher levels of O3 during the third trimester (i.e. levels of O3 directly affecting the mother's health). Specifically, a one standard deviation increase in levels of CO during the second trimester of pregnancy, compared to his or her sibling, increases a child's probability of low birth weight by 14 percentage points. Moreover, a one standard deviation in levels of O3 during the third trimester of pregnancy, compared to his or her sibling, also increases their probability of a low birth weight by 10 percentage points. Lastly, when levels of O3 exposure during the second trimester of pregnancy rise by one standard deviation, the probability of the child being diagnosed with a lung-related disease increases by about 11 percentage points when compared to their sibling.

Our result for low birth weight is larger in magnitude when compared to results obtained by other studies. For example, Currie et al. (2009b) find that an increase in the CO daily average during the third trimester of pregnancy increases the incidence of low birth weight for the child by about 8%. Our results also go in the same direction as those found by Coneus and Spiess (2010), whom estimate that the levels of CO exposure during pregnancy lowers birth weight, on average, by 289 grams. However, this result is not a probability of occurrence, which limits comparability with our study. Results evidencing the indirect mechanism, in which being exposed to levels of Pm10 and O3 impairs the mothers health, affecting the fetus healthBalsa et al. (2014) find that an increase in Pm10 (second trimester) increases the probability of the child having a low birth weight by 1 percentage point, and Dugandzic et al. (2006) find that exposure to levels of Pm10 during the first trimester, increases the risk of the child having a low birth weight by 33%. A similar indirect effect, in which an increase in the daily average levels of O3 during the second and third trimesters of pregnancy, is associated with the child having a lower birth weight, on average, of about 35 grams Salam et al. (2005). Unfortunately, we cannot compare the magnitude of the incidence.

When comparing our results to those found by García-Gómez (2015) and Camacho (2008), who study how negative shocks (different to pollution exposure) during pregnancy affect birth weight (to be lower), our results go in the same direction. For instance, García-Gómez (2015) finds how an expansion in gold production due to a gold boom price decreases birth weight by about 1.4 standard deviations. Camacho (2008) finds that children born in places with fewer land-mine explosions during pregnancy weigh on average 27.76 grams less.

Results found here implicitly indicate that any policies oriented towards decreasing air pollution will positively impact human capital formation by improving children's health. Pollution is a big problem in big cities and Bogotá is not exempt from this. Bad gas and diesel quality, together with an increasing number of vehicles, are more than enough to exacerbate air pollution problems. Our findings advocate for stricter regulations in order to decrease pollution levels. Efforts have been made to improve pollution levels, but more has to be done. For instance, it is necessary to meet international standards for diesel and gas quality, as well as environmental standards for pollution emissions.

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A Appendix

A.1 Characteristics: Children, Parents, Living Conditions, and Surroundings

We constructed the following variables using questions from the CVS (each variable is matched with its respective question):

1. Outcomes
   - Birth weight: Was the child born with weight less than 2.500 grams?
   - Lung related disease: Combination of the following questions:
     (a) Has the child being diagnosed by a physician with any lung or bronchus disease?
     (b) Has the child being diagnosed by a physician with pneumonia?
     (c) Has the child being diagnosed by a physician with asthma?
     (d) Has the child being diagnosed by a physician with any other lung disease?

2. Child characteristics
   - Age in months: Current age of the child in months?
   - Gender: Gender of the child?
   - Malnutrition: Has the child been diagnosed with malnutrition by a physician during their lifetime?

3. Caregiver characteristics
   - Education: What is the highest level of schooling achieved by the caregiver (primary, secondary, technical, college, post graduate)?
   - Health insurance: Does the caregiver have health insurance (contributory system, subsidized system, uninsured)?
   - Lung disease: Have either the mother or father suffered from a lung-related disease?
   - Mother mobility: How many months has the mother lived in the current place?
   - Smoked during pregnancy: Did the mother smoke during pregnancy?
   - Smokers during pregnancy: Was the mother in the presence of or cohabiting with a smoker during pregnancy?
   - Smoked after pregnancy: Did the mother smoke during the first two years of her childs life?
   - Toxic substances: Are any of the parents exposed to toxic substances at work?
   - Unemployed: : Is the caregiver currently employed or not?

4. Household characteristics
   - Shared bedroom: Does the child share the bedroom with someone else?
   - Fungus: Is there presence of fungus inside the house (walls, floor, etc.)?
   - Home shared with factory: Is the house shared with a factory or a business?
   - House type: Type of house the child lives in (independent house, apartment, shared room, other: which?)
   - Indoor pollution: Is the child living with a person who smokes? Does that person smoke in his/her presence?
   - Number of children living in home: Number of children between 0 and 14 years old living with the child?
   - Pets: Are there dogs, cats or other pets in the home? Pests: Is there any presence of cockroaches or mice inside the house?

5. Home surroundings characteristics
   - Close to source of pollution: Is the home close to a source of pollution (industry, burning chimney, parking lot or bus stop)?
   - Close to heavy trafficked street: Type of traffic circulating on the nearest street (trucks, buses, light cars, motorcycles)?

A.2 Measure Devices of Pollutants by Year

This section contains information about the type of pollutant measured by each meter devices in the city of Bogotá (Table 9), as well as the period of time in which there are available information by each meter device (Table 10).

Table 9: Pollution and Atmospheric Measures by Station, Bogotá

	Pollutant			Environmental	
Meter Device	PM10	O3	CO	T(°C)	P
Guaymaral	X	X		X	X
Usaquén	X	X	X	X	X
Suba	X	X		X	X
Bolivia					X
Las Ferias	X	X	X	X	X
Parque Simón Bolívar	X	X	X	X	X
Sagrado Corazón	X	X			X
Fontibón	X	X	X	X	X
Puente Aranda	X	X	X	X	X
Kennedy	X		X	X	X
Carvajal	X	X	X	X	X
Tunal	X	X	X	X	X
San Cristóbal	X	X	X	X	X

Note: Pm10: particulate matter less than 10 microns; O3: ozone; CO: carbon monoxide; T(°C): temperature (Celsius degrees); P: precipitation.

Table 10: Data for Particulate Matter Less than 10 Microns, Years

Devices/Years	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Carvajal (Sony)	X	X	X	X	X	X	X	X	X	X	X	X	X
Cazuca	X	X	X	X	X	X	X	X					
Chico lago (Santo Tomas)	X	X	X	X	X	X	X	X	X				
Fontibón	X	X	X	X	X	X	X	X	X	X	X	X	X
Guaymaral (Escuela)	X	X				X	X	X	X	X	X	X	X
Las Ferias (Carrefour)	X	X	X	X	X	X	X	X	X	X	X	X	X
Sagrado Corazón MAVDT	X	X					X	X	X	X	X	X	X
Parque Simón Bolívar (IDRD)			X	X		X	X	X	X	X	X	X	X
Puente Aranda	X	X	X	X	X	X	X	X	X	X	X	X	X
Suba (Corpas)	X	X	X	X	X	X	X	X	X	X	X	X	X
Usaquén (Bosque)	X	X	X	X	X	X	X	X	X	X	X	X	X
Tunal					X	X	X	X	X	X	X	X	X
Kennedy				X	X	X	X	X	X	X	X	X	X
San Cristóbal									X	X	X	X	X

A.3 Comparison of Different Samples

In this section, we present descriptive statistics for the sample of children who were matched with levels of pollution, compared with children who could not be matched with levels of pollution. Table 11 presents a comparison between Matched and Non-matched Children (children who fell within an area of influence -4kms- of one of each meter device with children who fell out of those areas). Since the sub-sample of siblings is around 20% of the total geographically-matched sample, Table 12 presents the differences among these groups on different character-isitcs.

Table 11: Differences in Averages for All Children and Siblings Groups

Characteristics	Non-matched	Matched	Differ	P value	Obs Non-Mat([a])	Obs Mat([b])
	Panel A. Child Characteristics and Outcomes					
Age in months	38.728	38.295	0.433	0.154	4,653	14,010
Estrata	2.110	2.390	-0.280	0.000	4,653	14,010
Female	0.476	0.485	-0.009	0.314	4,653	14,011
Months living in area	32.195	31.443	0.753	0.296	4,652	14,008
Low birth weight	0.120	0.150	-0.030	0.000	4,566	13,796
Malnutrition	0.063	0.081	-0.019	0.000	4,640	13,982
Lung-related disease	0.247	0.309	-0.062	0.000	4,653	14,011
Noise in the chest	0.985	0.975	0.010	0.000	4,651	14,009
Cough	0.282	0.373	-0.091	0.000	4,370	12,969
Child shares bed	0.571	0.560	0.011	0.261	3,350	10,900
	Panel B. Parent Characteristics					
Contributory system	0.640	0.656	-0.015	0.061	4,653	14,011
Primary school	0.150	0.155	-0.005	0.412	4,653	14,011
Secondary school	0.618	0.582	0.036	0.000	4,653	14,011
Employed	0.552	0.542	0.010	0.247	4,653	14,011
Parents lung disease	0.050	0.075	-0.025	0.000	4,626	13,923
Parents toxic subs	0.074	0.106	-0.032	0.000	4,642	13,965
Mother smoked pregnant	0.026	0.029	-0.003	0.232	4,602	13,888
Mother smoked first 2 yrs	0.045	0.061	-0.016	0.000	4,647	13,982
	Panel C. Living Conditions					
Household members	4.764	4.752	0.012	0.836	4,652	14,008
Children 0-14 years old	2.035	2.034	0.002	0.959	4,651	14,008
Rooms for sleeping	2.423	2.359	0.064	0.010	4,652	14,007
Child cohabitated room	0.753	0.839	-0.086	0.000	4,651	14,004
Smoking in presence	0.232	0.266	-0.034	0.000	4,649	14,001
Natural gas	0.851	0.823	0.028	0.000	4,653	14,011
Contact smoker 2 yrs	0.219	0.244	-0.025	0.000	4,644	13,981
Presence of fungus	0.182	0.238	-0.056	0.000	4,648	13,984
Pets	0.292	0.315	-0.022	0.004	4,648	13,999
Pests	0.077	0.105	-0.027	0.000	4,648	13,995
Windows	0.668	0.634	0.034	0.000	4,648	13,992
	Panel D. Surroundings					
Industry within the house	0.117	0.166	-0.049	0.000	4,652	14,006
Close to road	0.257	0.294	-0.037	0.000	4,649	13,997
Heavy traffic	0.391	0.472	-0.082	0.000	4,652	14,007
Close source pollution	0.240	0.303	-0.063	0.000	4,519	13,937

Note: ([a]) Non-Mat: group of non-matched; ([b]) Mat: matched group. The differences in means were found using the student t-statistic, assuming that both samples have unequal variance.

A.4 Correlations and Estimates for Different Models

This part includes several estimates complementing results presented in Section 5. First, we present a table with the correlations between levels of exposure for CO and Pm10 during pregnancy.

A.5 Estimates for Low Birth Weight, Levels of Pollution, Nine Months of Pregnancy

These estimates exhibit a positive effect between levels of pollution for CO during the 2nd and 3rd months of pregnancy. Results are not robust when controlling for different characteristics.

A.6 Estimates for Lung Related Disease, and Levels of Pollution during Pregnancy

Table 12: Differences in Averages for Matched and Non-matched Groups

Characteristics	All children	Siblings	Differ	P value	Obs all children	Obs siblings
	Panel A. Child Characteristics and Outcomes					
Age in months	38.632	36.932	1.700	0.000	16,161	2,502
Estrata	2.330	2.260	0.070	0.000	16,161	2,502
Female	0.478	0.511	-0.033	0.002	16,162	2,502
Months living in area	31.800	30.454	1.346	0.141	16,158	2,502
Low birth weight	0.142	0.143	0.000	0.954	15,886	2,476
Malnutrition	0.073	0.102	-0.029	0.000	16,125	2,497
Lung-related disease	0.291	0.313	-0.022	0.027	16,162	2,502
Noise in the chest	0.978	0.978	0.000	0.927	16,158	2,502
Cough	0.351	0.345	0.005	0.603	14,967	2,368
Child shares bed	0.556	0.594	-0.038	0.001	12,129	2,126
	Panel B. Parent Characteristics					
Contributory system	0.668	0.543	0.125	0.000	16,162	2,502
Subsidized system	0.324	0.445	-0.121	0.000	16,162	2,502
Primary school	0.151	0.177	-0.026	0.001	16,162	2,502
Secondary school	0.586	0.621	-0.035	0.001	16,162	2,502
Employed	0.556	0.468	0.088	0.000	16,162	2,502
Parents lung disease	0.068	0.075	-0.007	0.168	16,055	2,493
Parents toxic subs	0.095	0.123	-0.029	0.000	16,109	2,498
Mother smoked pregnant	0.027	0.034	-0.007	0.056	15,995	2,495
Mother smoked first 2 yrs	0.054	0.070	-0.016	0.001	16,129	2,500
	Panel C. Living Conditions					
Household members	4.653	5.417	-0.765	0.000	16,158	2,502
Children 0-14 years old	1.923	2.753	-0.830	0.000	16,157	2,502
Rooms for sleeping	2.391	2.275	0.117	0.000	16,157	2,502
Child cohabitated room	0.804	0.906	-0.102	0.000	16,153	2,502
Smoking in presence	0.249	0.308	-0.059	0.000	16,149	2,501
Natural gas	0.833	0.810	0.023	0.005	16,162	2,502
Contact smoker 2 yrs	0.232	0.274	-0.042	0.000	16,126	2,499
Presence of fungus	0.218	0.264	-0.046	0.000	16,132	2,501
Pets	0.306	0.328	-0.022	0.028	16,145	2,502
Pests	0.093	0.129	-0.036	0.000	16,144	2,499
Windows	0.645	0.636	0.009	0.379	16,143	2,495
	Panel D. Surroundings					
Industry within the house	0.152	0.163	-0.012	0.137	16,156	2,502
Close to road	0.281	0.308	-0.027	0.006	16,146	25,00
Heavy traffic	0.444	0.503	-0.058	0.000	16,157	2,502
Close source pollution	0.286	0.297	-0.010	0.289	15,970	2,485

Note: The differences in means were found using the student t-statistic, assuming that both samples have unequal variance.

Table 13: Correlation Between Levels of CO and Pm10 for Three Trimesters During Pregnancy and First Year of Child´s Life

	CO trim 1	CO trim 2	CO trim 3	CO 1st year	Pm10 trim 1	Pm10 trim 2	Pm10 trim 3	Pm10 1st year	O3 trim 1	O3 trim 2	O3 trim 3	O3 1st year
CO trim 1	1											
CO trim 2	0,763	1										
CO trim 3	0,692	0,775	1									
CO 1st year	0,773	0,770	0,825	1								
Pm10 trim 1	0,625	0,599	0,569	0,752	1							
Pm10 trim 2	0,578	0,661	0,612	0,751	0,835	1						
Pm10 trim 3	0,544	0,596	0,713	0,744	0,717	0,814	1					
Pm10 1st year	0,713	0,681	0,675	0,806	0,821	0,867	0,870	1				
O3 trim 1	-0,103	-0,156	-0,243	-0,172	-0,168	-0,232	-0,301	-0,216	1			
O3 trim 2	-0,153	-0,09	-0,142	-0,174	-0,392	-0,228	-0,253	-0,262	0,329	1		
O3 trim 3	-0,216	-0,118	-0,118	-0,207	-0,420	-0,422	-0,245	-0,329	0,240	0,401	1	
O3 1st year	-0,369	-0,307	-0,270	-0,374	-0,557	-0,604	-0,599	-0,624	0,285	0,446	0,584	1

Table 14: Effect of Exposure to CO Pollution During Pregnancy on Low Birth Weight, Using the 8hr-Max Average

Variables	Panel A. Levles of CO Max		Panel B. Levles of Pm10 Max		Panel C. Levles of O3 Max	
Trim 1 (lin)	0.016	-0.016	0.015	0.039	0.026	0.009
	(0.052)	(0.078)	(0.026)	(0.038)	(0.024)	(0.037)
Trim 1 (sqr)	-0.039**	-0.038	-0.017	-0.045***	-0.014	-0.029*
	(0.019)	(0.029)	(0.012)	(0.017)	(0.009)	(0.016)
Trim 1 (dy/dx)	-0.021	-0.014	0.004	0.011	0.019	-0.004
	(0.075)	(0.074)	(0.021)	(0.032)	(0.021)	(0.033)
Observations	802	802	1,413	1,413	764	764
Trim 2 (lin)	0.112**	0.122*	0.045	-0.018	0.028	-0.016
	(0.053)	(0.065)	(0.029)	(0.043)	(0.019)	(0.042)
Trim 2 (sqr)	-0.077**	-0.089**	-0.007	-0.005	0.013	0.012
	(0.032)	(0.038)	(0.014)	(0.017)	(0.0097)	(0.012)
Trim 2 (dy/dx)	0.126*	0.134**	0.042*	-0.021	0.034*	-0.009
	(0.066)	(0.065)	(0.024)	(0.039)	(0.019)	(0.039)
Observations	810	810	1,41	1,41	807	807
Trim 3 (lin)	0.033	-0.063	0.013	-0.006	0.016	0.073*
	(0.066)	(0.066)	(0.035)	(0.047)	(0.023)	(0.042)
Trim 3 (sqr)	0.008	0.014	-0.002	-0.003	-0.001	-0.010
	(0.040)	(0.040)	(0.019)	(0.022)	(0.009)	(0.012)
Trim 3 (dy/dx)	-0.063	-0.066	0.013	-0.007	0.016	0.069*
	(0.066)	(0.067)	(0.030)	(0.042)	(0.021)	(0.039)
Observations	840	840	1,402	1,402	828	828
All Controls		X		X		X

Note: Precipitation and levels of CO, Pm10 and O3 are quadratic; all pollution measures are standardized by subtracting the average pollution (2002-2014) and dividing it by the standard deviation (2002-2014); table reports the linear (lin), quadratic (sqr), and marginal effects (dy/dx) of a one standard deviation increase in the level of pollution exposure. Robust standard error in parenthesis; ([a]): 8hrs-max average; ([a1]): daily average; ([b]): gender ([c]): smoked or cohabitated with a smoker during pregnancy; ([d]): house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic and mobility; ([e]): poverty rate, level of education (the rate of completed secondary school studies for people under the age of 20), and proportion of people with health insurance (these characteristics are taken from the EMB for 2007, 2011, and 2014); these variables are extracted from the EMB for 2007, 2011, and 2014. *** p$\leq$ 0.01, $**p \leq 0.05, *p \leq 0.1$.

Table 15: Effects of Exposure to Pollution During Pregnancy on Low Birth Weight (LBW), Combined Pollutants

Variables	LBW	LBW	LBW	LBW	LBW	LBW
Comax trim 1([a])	0.0247	-0.0162	0.0316	0.0714		
	(0.0544)	(0.0795)	(0.0665)	(0.121)		
Comax trim 1 (sqr)	-0.0420**	-0.0329	-0.0229	-0.0588		
	(0.0198)	(0.0284)	(0.0357)	(0.0621)		
Comax trim 1 (dy/dx)	0.0173	-0.0220	0.0330	0.0749		
	(0.0517)	(0.0757)	(0.0680)	(0.123)		
Pm10max trim 1([a])	-0.0199	0.0137			0.0239	0.0638
	(0.0405)	(0.0804)			(0.0328)	(0.0573)
Pm10max trim 1 (sqr)	-0.0226	-0.0666**			-0.000615	-0.0526
	(0.0215)	(0.0321)			(0.0193)	(0.0323)
Pm10max trim 1 (dy/dx)	-0.0305	-0.0177			0.0242	0.0869
	(0.0359)	(0.0725)			(0.0370)	(0.0612)
O3max trim 1([a])			0.0422	0.131*	0.0215	0.0476
			(0.0359)	(0.0733)	(0.0239)	(0.0391)
O3max trim 1 (sqr)			-0.0104	-0.0955***	-0.00779	-0.0483**
			(0.0156)	(0.0285)	(0.0114)	(0.0203)
O3max trim 1 (dy/dx)			0.0392	0.104	0.0176	0.0233
			(0.0327)	(0.0678)	(0.0206)	(0.0344)
Observations	790	790	514	514	757	757
COmax trim 2	0.104**	0.124*	0.0547	-0.0734		
	(0.0526)	(0.0647)	(0.0843)	(0.125)		
COmax trim 2 (sqr)	-0.0727**	-0.100**	-0.0594	-0.00976		
	(0.0329)	(0.0401)	(0.0426)	(0.0661)		
COmax trim 2 (dy/dx)	0.106**	0.126*	0.0641	-0.0719		
	(0.0531)	(0.0652)	(0.0903)	(0.129)		
Pm10max trim 2	0.0656	0.150			0.0358	0.00377
	(0.0535)	(0.0942)			(0.0417)	(0.0559)
Pm10max trim 2 (sqr)	-0.0156	0.000509			-0.00181	-0.000236
	(0.0241)	(0.0325)			(0.0193)	(0.0296)
Pm10max trim 2 (dy/dx)	0.0591	0.150*			0.0368	0.00389
	(0.0463)	(0.0865)			(0.0467)	(0.0613)
O3max trim 2			0.0400	-0.0304	0.0320*	0.0185
			(0.0304)	(0.109)	(0.0189)	(0.0440)
O3max trim 2 (sqr)			-0.0101	-0.0279	0.00669	0.00480
			(0.0113)	(0.0315)	(0.00894)	(0.0143)
O3max trim 2 (dy/dx)			0.0372	-0.0382	0.0355**	0.0210
			(0.0282)	(0.102)	(0.0177)	(0.0397)
Observations	802	802	527	527	804	804
COmax trim 3	0.0358	-0.0614	0.0468	0.0564		
	(0.0704)	(0.0671)	(0.0863)	(0.111)		
COmax trim 3 (sqr)	0.00842	0.00618	-0.0221	-0.0845		
	(0.0421)	(0.0422)	(0.0487)	(0.0663)		
COmax trim 3 (dy/dx)	0.0363	-0.0611	0.0506	0.0709		
	(0.0688)	(0.0660)	(0.0925)	(0.113)		
Pm10max trim 3	0.00408	-0.0631			0.0265	0.0806
	(0.0491)	(0.0739)			(0.0394)	(0.0781)
Pm10max trim 3 (sqr)	0.0184	0.0825**			-0.00636	0.0179
	(0.0258)	(0.0365)			(0.0255)	(0.0304)
Pm10max trim 3 (dy/dx)	0.00948	-0.0389			0.0302	0.0705
	(0.0451)	(0.0725)			(0.0480)	(0.0840)
O3max trim 3			0.0195	0.158*	0.0141	0.0819*
			(0.0329)	(0.0808)	(0.0218)	(0.0491)
O3max trim 3 (sqr)			-0.00201	-0.0369*	0.00197	-0.00802
			(0.0106)	(0.0218)	(0.0107)	(0.0141)
O3max trim 3 (dy/dx)			0.0192	0.153*	0.0148	0.0787*
			(0.0319)	(0.0789)	(0.0199)	(0.0458)
Observations	822	822	543	543	822	822
All Controls([b])		X		X		X

Note: Precipitation and levels of CO, Pm10 and O3 are quadratic; all pollution measures are standardized by subtracting the average pollution (2002-2014) and dividing it by the standard deviation (2002-2014); table reports the linear (lin), quadratic (sqr), and marginal effects (dy/dx) of a one standard deviation increase in the level of pollution exposure. Robust standard error in parenthesis; ([a]): 8hrs-max average; ([b]): gender, smoked or cohabitated with a smoker during pregnancy, house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic, mobility, poverty rate, level of education (the rate of completed secondary school studies for people under the age of 20), and proportion of people with health insurance (last three characteristics were taken from the EMB for 2007, 2011, and 2014); these variables are extracted from the EMB for 2007, 2011, and 2014. *** $p \leq 0.01, **p \leq 0.05, *p \leq 0.1$.

Table 16: Estimates of Low Birth Weight for CO, Pm10, and O3, During Pregnancy for Each Month of Pregnancy

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	lhp	lhp	lhp	lhp	lhp	lhp
	Panel A. Levels of CO([a])		Panel B. Levels of Pm10([a])		Panel C. Levels of O3([a1])	
Month 1	-0.0318	-0.103	0.00838	0.00894	0.0299	0.121***
	(0.0521)	(0.0720)	(0.0264)	(0.0344)	(0.0224)	(0.0431)
Month 2	0.0583	0.0507	0.00871	-0.0391	-0.00112	0.0149
	(0.0505)	(0.0653)	(0.0264)	(0.0402)	(0.0247)	(0.0457)
Month 3	0.121**	0.0444	0.0439**	0.00325	0.0241	0.0148
	(0.0590)	(0.0715)	(0.0206)	(0.0362)	(0.0228)	(0.0456)
Month 4	0.0381	0.0729	0.0289	-0.00717	0.0345	-0.0641
	(0.0555)	(0.0713)	(0.0191)	(0.0327)	(0.0220)	(0.0461)
Month 5	0.0716	0.0531	0.0393**	-0.00231	0.0555***	0.0705*
	(0.0547)	(0.0674)	(0.0189)	(0.0282)	(0.0206)	(0.0420)
Month 6	0.0693	0.0868	0.0113	-0.00907	0.0396*	0.0506
	(0.0460)	(0.0639)	(0.0171)	(0.0279)	(0.0215)	(0.0448)
Month 7	0.0354	0.129*	0.0103	0.0236	0.00292	0.00877
	(0.0552)	(0.0758)	(0.0173)	(0.0269)	(0.0201)	(0.0436)
Month 8	-0.0193	-0.107	-0.00666	0.00360	-0.0101	-0.0543
	(0.0599)	(0.103)	(0.0192)	(0.0322)	(0.0233)	(0.0530)
Month 9	0.0113	0.0249	-0.00466	-0.0189	-0.0420*	-0.0280
	(0.0559)	(0.0803)	(0.0194)	(0.0278)	(0.0223)	(0.0506)
All controls		X		X		X
Observations	807	801	1,383	1,367	801	791

Note: Precipitation and levels of CO, Pm10, and O3 are quadratic; all pollution measures are standardized by subtracting the average pollution (2002-2014) and dividing it by the standard deviation (2002-2014); table reports marginal effects (dy/dx) of a one standard deviation increase in the level of pollution exposure. Robust standard error in parenthesis; ([a]): daily average; ([a1]): 8hrs-max average; ([b]): gender, smoked or cohabitated with a smoker during pregnancy, house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic, mobility, poverty rate, level of education (the rate of completed secondary school studies for people under the age of 20), and proportion of people with health insurance (last three characteristics were taken from the EMB for 2007, 2011, and 2014); These variables are extracted from the EMB 2007, 2011, and 2014. *** $p \leq 0.01, **p \leq 0.05, *p \leq 0.1$.

Table 17: Estimates of Low Birth Weight for CO, Pm10, and O3, During Pregnancy for Each Month of Pregnancy. Combined Pollutants

	(1)	(2)		(3)	(4)		(5)	(6)
Variables	LRD	LRD	Variables	LRD	LRD	Variables	LRD	LRD
Panel A. CO & Pm10			Panel B. O3 & Pm10			Panel C. CO & O3		
CO month 1([a])	-0.0701	-0.0772	O3 month 1([a1])	0.147***	0.131***	CO month 1	0.0280	0.0482
	(0.0724)	(0.0734)		(0.0460)	(0.0463)		(0.121)	(0.130)
Pm10 month 1([a])	0.0123	-0.0354	Pm10 month 1	0.0267	0.00216	O3max month 1	0.175***	0.200***
	(0.0694)	(0.0714)		(0.0631)	(0.0656)		(0.0615)	(0.0683)
CO month 2	0.0205	0.0485	O3max month 2	0.0233	0.00622	CO month 2	0.0933	0.0760
	(0.0731)	(0.0710)		(0.0427)	(0.0461)		(0.123)	(0.127)
Pm10 month 2	-0.0170	0.0250	Pm10 month 2	0.0493	0.0745	O3max month 2	0.0417	0.0525
	(0.0756)	(0.0745)		(0.0806)	(0.0865)		(0.0705)	(0.0727)
CO month 3	0.0303	0.0435	O3max month 3	0.0336	0.0159	CO month 3	-0.0610	-0.0296
	(0.0731)	(0.0713)		(0.0442)	(0.0472)		(0.113)	(0.129)
Pm10 month 3	0.155**	0.200**	Pm10 month 3	0.0308	0.0171	O3max month 3	-0.0141	-0.0441
	(0.0713)	(0.0797)		(0.0548)	(0.0608)		(0.0868)	(0.0904)
CO month 4	0.0521	0.0645	O3max month 4	-0.0312	-0.0604	CO month 4	0.0172	-0.0136
	(0.0724)	(0.0701)		(0.0472)	(0.0465)		(0.142)	(0.148)
Pm10 month 4	0.101	0.146**	Pm10 month 4	-0.0177	0.0192	O3max month 4	-0.0693	-0.0571
	(0.0701)	(0.0703)		(0.0637)	(0.0692)		(0.0925)	(0.116)
CO month 5	0.0456	0.0469	O3max month 5	0.0832*	0.0674	CO month 5	-0.0322	-0.00749
	(0.0610)	(0.0679)		(0.0449)	(0.0432)		(0.0987)	(0.119)
Pm10 month 5	0.134**	0.157**	Pm10 month 5	0.0922*	0.123**	O3max month 5	0.0431	0.0221
	(0.0678)	(0.0790)		(0.0516)	(0.0546)		(0.103)	(0.0952)
CO month 6	0.0927	0.0858	O3max month 6	0.0617	0.0650	CO month 6	0.0743	0.0355
	(0.0643)	(0.0642)		(0.0430)	(0.0452)		(0.128)	(0.133)
Pm10 month 6	0.0600	0.0660	Pm10 month 6	0.125**	0.145**	O3max month 6	0.146*	0.162*
	(0.0634)	(0.0700)		(0.0572)	(0.0607)		(0.0852)	(0.0977)
CO month 7	0.110	0.101	O3max month 7	0.0366	0.0439	CO month 7	0.129	0.168
	(0.0801)	(0.0766)		(0.0378)	(0.0401)		(0.114)	(0.119)
Pm10 month 7	0.0551	0.0492	Pm10 month 7	0.147***	0.167***	O3max month 7	0.102*	0.154**
	(0.0575)	(0.0626)		(0.0517)	(0.0541)		(0.0525)	(0.0655)
CO month 8	-0.0664	-0.102	O3max month 8	-0.0311	-0.0327	CO month 8	0.0217	0.0895
	(0.0979)	(0.106)		(0.0497)	(0.0506)		(0.120)	(0.120)
Pm10 month 8	-0.0143	0.0460	Pm10 month 8	-0.0382	-0.0277	O3max month 8	0.0501	0.138*
	(0.0778)	(0.0927)		(0.0692)	(0.0693)		(0.0769)	(0.0783)
CO month 9	0.0422	0.0441	O3max month 9	-0.0512	-0.0217	CO month 9	0.178	0.140
	(0.0737)	(0.0832)		(0.0492)	(0.0537)		(0.137)	(0.145)
Pm10 month 9	-0.121*	-0.109	Pm10 month 9	-0.0115	-0.0304	O3max month 9	-0.0751	-0.137
	(0.0656)	(0.0678)		(0.0727)	(0.0694)		(0.0769)	(0.0904)
All controls		X	All controls		X	All controls		X
Observations	788	782	Observations	790	780	Observations	523	523

Note: LDR: Lung-Related Disease. Precipitation and levels of CO, Pm10, and O3 are quadratic; all pollution measures are standardized by subtracting the average pollution (2002-2014) and dividing it by the standard deviation (2002-2014); table reports marginal effects (dy/dx) of a one standard deviation increase in the level of pollution exposure. Robust standard error in parenthesis; ([a]): daily average; ([a1]): 8hrs-max average; ([b]): gender, smoked or cohabitated with a smoker during pregnancy, house is close to roads, or to any source of pollution (chimneys, industries, recycling centers, and restaurants with burners), heavy traffic, mobility, poverty rate, level of education (the rate of completed secondary school studies for people under the age of 20), and proportion of people with health insurance (last three characteristics were taken from the EMB for 2007, 2011, and 2014); these variables are extracted from the EMB for 2007, 2011, and 2014. *** $p \leq 0.01, **p \leq 0.05, *p \leq 0.1$.

Table 18: Effect of Exposure to Pollution During Pregnancy on Probability of Suffering from a Lung-related Disease (LRD), Controlling for Levels of Pollution During First Year of Child´s Life

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Levels of CO		Levels of Pm10		Levels of O3	
	Panel A. Controlling for level of CO first year					
Trim 1 (dy/dx)	0.074	0.070	0.007	-0.027	-0.089	0.065
	(0.122)	(0.136)	(0.058)	(0.061)	(0.089)	(0.095)
Trim 2 (dy/dx)	0.044	0.042	-0.019	-0.012	0.180***	0.169*
	(0.115)	(0.126)	(0.072)	(0.069)	(0.069)	(0.087)
Trim 3 (dy/dx)	-0.125	-0.142	0.107	0.090	0.192***	0.247***
	(0.132)	(0.140)	(0.106)	(0.111)	(0.071)	(0.083)
CO 1st year (dy/dx)	0.184	-0.169	-0.040	0.015	-0.089	-0.268
	(0.212)	(0.258)	(0.115)	(0.123)	(0.228)	(0.245)
Observations	638	638	874	874	481	481
	Panel B. Controlling for level of PM10 first year					
Trim 1 (dy/dx)	0.093	0.029	0.067	0.063	0.059	0.120**
	(0.105)	(0.115)	(0.045)	(0.046)	(0.058)	(0.060)
Trim 2 (dy/dx)	0.134	0.123	0.069	0.074*	0.120**	0.136**
	(0.109)	(0.116)	(0.046)	(0.045)	(0.054)	(0.060)
Trim 3 (dy/dx)	-0.105	-0.110	0.053	0.022	0.044	-0.001
	(0.112)	(0.128)	(0.061)	(0.068)	(0.074)	(0.077)
Pm10 1st year (dy/dx)	0.257*	0.159	-0.031	-0.011	-0.324*	-0.204
	(0.139)	(0.172)	(0.077)	(0.077)	(0.176)	(0.191)
Observations	689	689	1,166	1,166	642	642
	Panel B. Controlling for level of O3 first year					
Trim 1 (dy/dx)	0.408**	0.357	0.124*	0.129*	0.022	0.091
	(0.177)	(0.263)	(0.070)	(0.075)	(0.067)	(0.068)
Trim 2 (dy/dx)	-0.172	0.036	0.056	0.065	0.101**	0.115*
	(0.155)	(0.207)	(0.074)	(0.075)	(0.051)	(0.059)
Trim 3 (dy/dx)	-0.326*	-0.388*	0.082	0.027	0.052	0.007
	(0.179)	(0.230)	(0.070)	(0.079)	(0.073)	(0.073)
O3 1st year (dy/dx)	-0.224	-0.180	-0.057	-0.051	-0.115	-0.139
	(0.187)	(0.219)	(0.076)	(0.079)	(0.113)	(0.121)
Observations	451	451	754	754	641	641
All controls		X		X		X

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