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Abstract

We contribute to the literature on air pollution and health by assessing an additional channel, the effect of El Niño Southern Oscillation (ENSO) on health. Currently, there is a vast literature on the effects of urban pollution on health. Our research, unlike other studies, jointly investigates the effects of pollution, ENSO and local weather on health. On the one hand, ENSO manifests itself as an extreme climatic shock that follows certain seasonality and influences weather. It may also have an impact on floods, droughts and agriculture inducing changes in food markets or a loss of household income, which also affect health. On the other hand, health outcomes are affected by other factors which follow separate mechanisms to the previous ones. Therefore, pollutant impacts on health may be interpreted as separate effects from other shocks mediated through ENSO. Using a database from 1998 to 2015 on air quality and vital statistics for Bogotá, and ENSO information, we find that across several specifications, ENSO affects birth weight and the probability of low birth weight after separating pollution and classical local weather impacts. Interestingly, the effect on birth weight of ENSO are several times larger than the impacts of pollution. Being exposed to ENSO may decrease birth weight up to 1.3%, while an increase of 1 *ppb* of SO_2 or 1 $\mu g/m^3$ of PM_{25} might reduce birth weight up to 0.3% or 0.14%, respectively. From a policy point of view, these results are relevant because regardless of the measure of pollution that we employ, the amount of the impacts exhibited by climatic shocks via ENSO events dominate.

Keywords: climate change, health, ENSO Index, El Niño, La Niña, weather, pollution, Bogotá.
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1 Introduction

Two of the major climatic phenomena on Earth are El Niño Southern Oscillation (ENSO[1]) and the North Atlantic Oscillation (NAO). They create important fluctuations in weather in the surroundings of the Pacific Ocean and the North Atlantic, respectively. With regard to ENSO, the occurrence and impacts of its events have been extensively studied from the meteorological and geographical side (see for instance Stenseth et al. [2003]). Both the intensity and the frequency of El Niño have been forecasted to increase in the coming years (see chapter 3 of the report "Global Warming of 1.5 Celsius degrees" of the Intergovernmental Panel of Climate Change and Wang et al. [2017]). Despite this, studies that explore the impact of ENSO on socio-economic outcomes are rare. One of the first studies to do so was Hsiang et al. [2011], who find that the ENSO events affects one-fifth of all civil conflicts since 1950 in the tropics. They also show that El Niño may double the probability of having new civil conflicts with respect to La Niña events. More recently, Dingel et al. [2020] use ENSO as a natural experiment to show that when cereal productivity is more spatially correlated, more productive countries experience larger gains from trade than the less productive ones.

In addition to conflicts, ENSO also affects health. Caminade et al. [2016] assess the impact of El Niño on the Zika outbreak in Latin America. Also, Kovats et al. [2003] find a relationship between ENSO events and the spread of malaria in South America and South Asia and cholera in Bangladesh. Their findings suggest that high temperatures during El Niño in 2015-2016 fostered the disease transmission by the Aedes Aegypti mosquito. In Colombia, Brando and Santos [2015] explore the impact of the strong La Niña event in 2010-2011 on birth weight, finding that the climatic shock reduces birth weight. They also argue that households react to the shock by decreasing investment in education for children. When it comes to economic variables, in another study for Colombia, Abril-Salcedo et al. [2020] find that El Niño had a significant impact on consumer food prices during the strong event in 2015, by using a smooth transition nonlinear model. In that study, weather shocks are transitory and asymmetric, affecting inflation growth from five to nine months after the shock. This could be an example of the potential channel through which El Niño affects food prices and hence, consumption of households.

Another strand of the literature studies the impacts of climate change measured as temperature variability in general, but not ENSO in particular. Deschênes et al. [2009] find that extreme temperatures increase low birth weight probability and reduce birth weight. Similarly, Barreca and Schaller [2020] find that hot temperatures reduce gestational weeks. In the case of mortality, Barreca et al. [2015] show that high temperatures over the period 1900-2004 had an effect on deaths, but the effect was lower in places that often face high temperatures. Our article contributes to two strands of the literature: first, about the effects of climate variability on health by assessing the influence of ENSO on health variables; and second, regarding the effect

[1]The episodes of cold and warm weather are measured by the Oceanic Niño Index (ONI) that captures the El Niño Southern Oscillation (ENSO). For the case of Colombia, El Niño is associated with warm episodes and La Niña with cold episodes, but the same does not hold in other countries.

of air pollution on health adding the impact of climatic shocks.[2]

The ENSO phenomena may influence health outcomes through several channels: (1) ENSO manifests as a climatic shock affecting weather, hence, extreme weather may have an impact on health (see Barreca et al. [2015]). (2) ENSO affects air pollution, which may influence health. There is a vast literature on the effect of pollutants on health [Arceo et al., 2015, Knittel et al., 2016, Schlenker and Walker, 2016, Deschênes et al., 2017]. It becomes particularly relevant in areas where pollution levels are high, as it is the case of urban environments. (3) There might exist a direct impact of ENSO on health. Although one may hypothesize about the presence of this channel, it is difficult to find practical examples to cite in this regard, particularly considering that effects are mainly transmitted via changes in weather. (4) ENSO also affects the economy. For example, floods and droughts induce changes in agriculture and food prices (see Abril-Salcedo et al. [2020] for the effects of ENSO on prices in Colombia) that lead to a loss of household income and consumption or effects on other socioeconomic variables. As Hsiang et al. [2011] argue, ENSO may be seen as a mechanism that assembles economic shocks. Such economic impacts may be considered as a set of general equilibrium effects that may also influence health. In this article, we identify channels (1) and (2). We also believe that our approach partly captures channels (3) and (4) through the overall estimate of the effect of ENSO on health.

Our article investigates different mechanisms: the effect of local weather on health, the impact of ENSO on health, and the influence of pollution on health. Unlike previous studies, we jointly explore the effects of pollution, ENSO and local weather on birth weight, probability of low birth weight, and gestational length. In our approach, pollutant impacts on health may be interpreted as separate effects from other shocks mediated through ENSO. We conduct our analysis using data over the period 1998-2015 from Bogotá, one of the largest urban centers in Latin America. Pollution levels in the city reach annual means of 26 $\mu g/m^3$ for PM_{10} in areas of low exposition and 87 $\mu g/m^3$ in the most polluted places, which exceed the maximum value of 20 $\mu g/m^3$ recommended by the World Health Organization (WHO).[3] In the case of daily concentrations, pollution may increase to 160 $\mu g/m^3$, also surpassing the WHO's air quality standard of 50 $\mu g/m^3$ (see Secretary-Environment [2015]). Estimating the effect on health is complex because, in addition to the effects of local weather and ENSO, these factors may alter air pollutant concentrations. Apart from annual weather fluctuations (see Deschênes and Greenstone [2011]), no one seems to have investigated further the link between pollution and health, considering the interaction it has with climatic shocks as ENSO events. El Niño or La Niña might exacerbate pollution. The intuition behind this is that a higher intensity or steeper trend of ENSO events could induce temperature and rainfall changes that favor higher concentrations.[4] On our data, we find that ENSO events may affect some pollutants. Similar results are shown by Grundström et al. [2011] in the North-West of Europe indicating that climate shifts of the NAO affect air pollution. Our analysis for ENSO indicates that intraday

[2]Only recently, Elorreaga et al. [2020] found that the ENSO phenomenon could have increased childhood stunting on the coast of Piura in Peru.

[3]Mobile sources account for more than 50% of air pollution in the city.

[4]See Watson et al. [1988] for the difference in meaning between concentration, exposure and dose.

variation matters, which motivates us to suggest maximum and peak hour concentrations as pollutant exposure measures on health besides the classical daily average.

Another challenge in assessing the effect of air pollution on health is that pollution is endogenous due to omitted variables and unobserved confounders. Therefore, our empirical strategy is based on a two stage approach. In a first stage, we estimate pollution as a function of local weather and ENSO shocks exploiting exogenous variation of wind direction as an instrument. Wind direction is included as a set of indicator variables and interactions with wind speed. As an extra set of instruments, we use changes in driving restrictions over time. In the second stage, we regress health outcomes on instrumented pollution, ENSO shocks and local weather. We aim to capture size and length of pollutant exposure and strong climatic variability exposure *in utero* by computing measures for each of the three gestational quarters. Note that ENSO shocks represent effects of strong climatic variability (or nonlinear transmission effects) through channels different from pollution exposure. Thus, the estimates of the extreme climate variability effects in our specifications provide a measure of the aggregated impacts from channels (1) and (2), and partially from channels (3) and (4). The lack of information about food prices and household consumption during the entire period of our sample prevent us to separate economic shocks from other channels.

In the review of the state of the art for pollution and individual well-being by Graff Zivin and Neidell [2013], they acknowledge the use of quasi-experimental techniques to study causal estimates of pollution and the role of avoidance behaviour to reduce the effect of pollutants on health. However, they consider that such studies should expand to focus toward the effects of pollution on human capital. Lately, the literature is heading from studying labor supply outcomes (see Graff Zivin and Neidell [2013]) to cognitive formation and performance (see Hanna and Oliva [2015]). Recently, de la Mata and Gaviria [2019] studied the effects of air pollution on health for the case of Bogotá, using a smaller sample of children born in the city and attending kinder-gardens between 2010 to 2014. These studies highlight the importance of human capital for economic growth, in the sense that negative shocks from pollution on health should affect labor productivity (see Graff Zivin and Neidell [2012]).

Our study thus sheds light on the magnitude of extreme climate variability and pollution on birth outcomes, as an indicator of human capital. It is relevant since better health at birth has been linked with lower health-care costs after birth and later in life (see Almond et al. [2005]). As has been pointed out by Almond and Currie [2011a], different early life conditions, particularly before the age of five, can have persistent and profound impacts on later life, affecting educational outcomes and future earnings. In fact, health at birth is a crucial component of human capital development and the evidence discussed by Almond and Currie [2011a] suggest that the period *in utero* is one of the most important stages for children's later development. With respect to educational attainment, Conley et al. [2001] find that a low birth weight child who spent 6 years at the poverty line is less likely to graduate from high school compared to a normal birth weight child who spent 6 years at the poverty line. In addition, Conley et al. [2006] find that increases in birth weight might lead to decreases in infant and neonatal mortality. In a wider perspective, Almond and Currie [2011b] review the literature of the "fetal origins" hypothesis which establishes that the effects of fetal conditions are persistent and that the intrauterine environment can lead to future disease (diabetes, overweight, cardiovascular diseases), and affect future earnings. In more economical terms, their later-life impacts can extend to "bread and butter" economic outcomes, educational attainment and wages. Taken together, this could imply that in addition to interventions implemented at young age, children might also need to be targeted during pregnancy, as early life conditions can have long-term impacts in the accumulation of human capital.

The article is organized as follows: Section 2 discusses the importance of analyzing health outcomes and air pollution in Bogotá, Section 3 describes the data-sets, some stylized facts that motivate the study of the relationship between ENSO, local weather and pollution in Bogotá, and the descriptive statistics. Section 4 discusses the empirical strategy while section 5 presents the main results of the effects of pollution and ENSO events on health. Finally, Section 6 concludes.

2 The importance of health, air pollution and ENSO in Bogotá

According to a report in 2017 of the National Department of Planning DNP [2017], the health costs of the environmental degradation in Colombia are COP $20.7 billions, equivalent to 2.6% of the GDP in 2015. Of that, the costs associated to urban air pollution correspond to 75%. For the particular case of Bogotá, pollution is one of the most important environmental problems, getting more attention in the media. DNP [2017] indicates that 10.5% (3.219) of the total deaths in the city are attributed to air pollution, with an estimated cost of COP $4.2 billions (2.5% of the city's GDP). Pollution in Bogotá reach under certain conditions levels of cities like Delhi. According to the Real-time Air Quality Index[5] from the World Air Quality Index Project, Bogotá showed a value of 141 in the index on March 8th of 2019 (very harmful for the individuals). For the same day, the index had a value of 151 (unhealthy) in Delhi that contrasted with a value of 23 (good) for Paris; this gives a picture of the dimension of the problem in the city.

In 2011, the Decennial Pollution Abatement Plan in Bogotá conducted by Behrentz et al. [2010] (University of Los Andes and University of La Salle) for the Secretary of Environment of the city found that implementing the plan (by renewing the type of buses, introducing diesel particle filters, among other measures) could avoid 27,500 hospitalizations for respiratory diseases among the population of children, 75,000 case entries to emergency rooms and around 7,500 in intensive care. In the base scenario without measures, infant deaths could reach 3,700 for the period 2010 to 2020, but with the implementation of the plan this number could have declined in 1,500 potential deaths during the same years. For adults, the plan could have avoided 14,000 deaths, 40,000 cases in emergency rooms and 11,000 cases of hospitalizations for respiratory diseases. Although the cost of the plan could have reached COP $1.7 billions, the benefits

[5]The index takes into account different pollutants emitted locally.

would have totaled COP $16 billions. Despite the benefits of the plan would exceed its costs, the plan only implemented few of its reduction measures. It motivated to re-build the plan in the first quarter of 2021.

These reports make evident the large costs that air pollution can cause on health, for both children and adults. However, they do not consider the effects of ENSO on health as our article is one of the first addressing it. As we show in the results section, ENSO effects on birth weight are several times larger than the impacts coming from pollution. As we argue, ENSO might have an impact on health but can also affect health through the effects it has on pollution, through the effect on weather and then on health, or through the distortions it generates in the economy which can affect health. If the environmental degradation from air pollution already has a huge cost for the city, considering the ENSO impact on health could add an extra cost that has not been taken into account, which is important from a policy perspective.

In this article we will focus only on children during gestation because first, it allows us to capture more instantaneous effects during the nine months of gestation, and second, we do not have to control for unobserved factors more common in adults, such as whether or not the individual smokes, the habits of eating healthy food, exercising and having a healthy life in general. By choosing children in gestation time, we should be less prone to this type of bias in our results. Additionally, using children during a short period of time should also permit to capture exposure to ENSO events (El Niño-La Niña) more immediately.

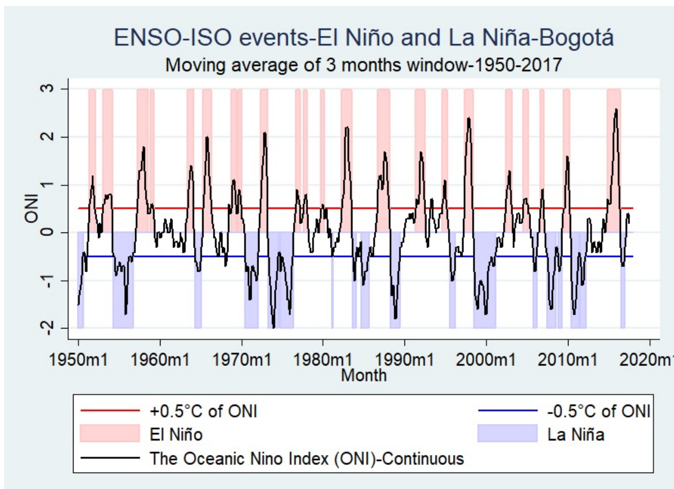
3 Data and stylized facts

We employ a rich database collected from several sources. Information on ENSO is taken from The National Oceanic and Atmospheric Administration (NOAA). El Niño and La Niña data are available from 1950 to 2017. Episodes are reported on a monthly basis in two ways. The first is a continuous variable named The Oceanic El Niño Index (ONI). It is calculated as a three-month moving average of the Sea Surface Temperature (SST) in the tropical Pacific. The second is a discrete variable that indicates if the ONI lies within specific bands that describe El Niño and La Niña events or normal status. Periods above 0.5 or below -0.5 of ONI for a minimum of 5 consecutive overlapping months (colored in red and blue) define El Niño or La Niña events, respectively. The past 30 years (i.e. 1986-2015) are used to compute the departure from the SST average.

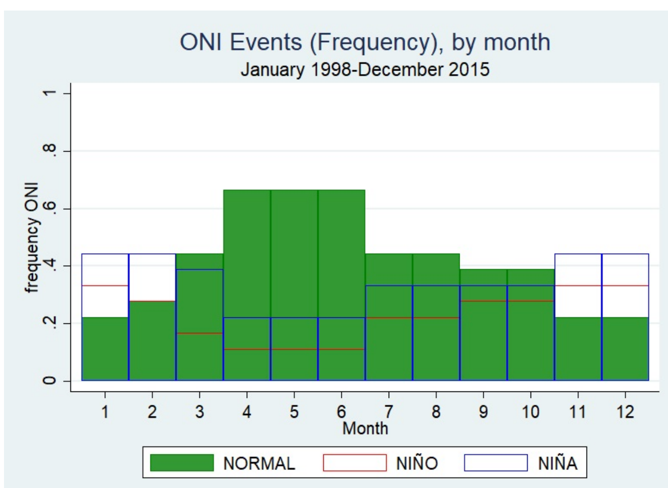
Figure 1 (a) depicts the ONI index since 1950. The graph shows two important characteristics. In the last 20 years, La Niña (in blue) is more frequent and El Niño (in red) reaches much higher values over time. The latter fact coincides with the climate model forecasts indicating that the extreme El Niño frequency will increase linearly with the Global Mean Temperature (GMT) towards a doubling of 1.5 Celsius degrees on warming (Wang et al. [2017]). Moreover, Figure 1 (b) displays the percentage of months exhibiting Normal, El Niño, and La Niña episodes between 1998 and 2015 (percentage with respect to last 18 years). For instance, 44% of the months of January between 1998 and 2015 faced La Niña, 33% El Niño, while 22% were normal months. It suggests that ENSO events usually occur between November and February, while normal months are frequent between April and June. This kind of seasonality is considered in our analysis when we assign exposure to children *in utero*.

Figure 1: ONI Index-ENSO events and Frequency

(a)



(b)



Source: The National Oceanic and Atmospheric Administration (NOAA)

Weather variables come from the Air Quality Monitoring Network of Bogotá (RMCAB). It covers from twelve to twenty one monitoring stations. Figure 2 shows the spatial distribution of RMCAB in the city. Hourly data exist from August 1st of 1997 to December 31st of 2015.[6] We exclude the stations of Usme, Vitelma and Bolivia because of lack of observations.

[6]Although information may exhibit missing values due to blackouts or failures of the monitoring platform, the missing patterns seem to be random and reports for most stations have a large valid data representation.

Available variables are wind speed (WS), wind direction (WD), solar radiation (SR), temperature (TMP), barometric pressure (BPR), rainfall ($RAIN$), and relative humidity (RH). For our analysis, we use rainfall, temperature and wind variables to describe local weather conditions. In the case of wind direction, we convert degree units to a set of indicator variables that correspond to the standard eight-azimuth bearings.[7] Figure 3 displays the average intraday variation of local weather conditions such as rain and temperature under ENSO conditions.

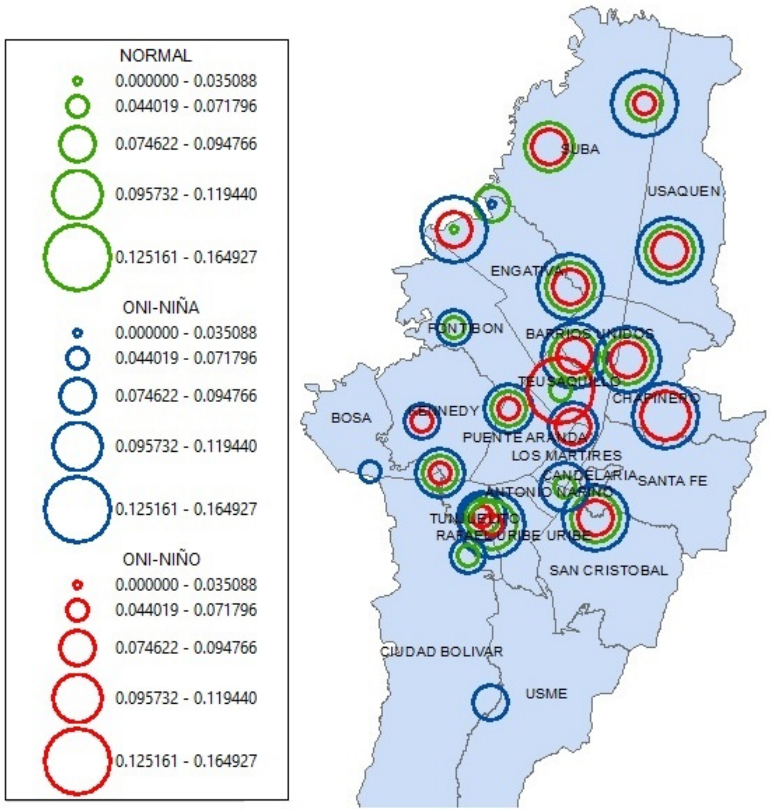
ENSO events also manifest in different ways, depending on the country. For Bogotá, we observe that El Niño is associated with less rain and higher temperature, while La Niña does the opposite, bringing more rain and lower temperature (see Figure 3). This pattern holds across the city. Figure 2 shows levels of rain for each monitoring station, where the size and color of the circles illustrate magnitude and ENSO condition. In addition, Figure 3 shows the rainfall (rain) and temperature (tmp) pattern for the 24 hours schedule for business days (Monday to Friday). It is evident that rainfall tends to be higher during La Niña episodes, particularly during the afternoon. These results are also confirmed in the Appendix 2B based on an additional regression analysis.

Air Quality information is also provided by RMCAB for similar monitoring stations of weather data.[8] The network registers hourly readings and consists of four to ten monitoring stations depending on the air pollutant measured. The data spans the same period as the weather variables (August 1997 to December 2015). In many cases stations monitoring weather also measure pollutants. The list of pollutants includes particulate matter with a diameter less than 10 micrometers (PM_{10}), particulate matter with a diameter less than 2.5 micrometers ($PM_{2.5}$), carbon monoxide (CO), sulfur dioxide (SO_2), and nitrogen oxides (NO_x). As pollution may be affected by local weather and ENSO, in Appendix 2B we analyze how sensitive pollutant concentrations are to climatic conditions. This analysis suggests that not all the pollutants are affected in the same way. For instance, particles tend to be affected by extreme rain, whereas gases such as NO_x may respond to extreme temperature. It is consistent with what other studies suggest regarding the relationship between pollutants and weather, for instance rainfall helps to washout particles (see Guo et al. [2016]), while ambient temperature plays an important role in NO_x formation in urban environments (see Ko et al. [2019]). Those effects tend to occur in rush hours, periods where the population is more exposed to pollution because individuals are going to work or returning home. Therefore, we explore a set of different intraday pollutant exposure measures in the subsequent analysis.

[7] Wind Direction Rose: 1 "WD: N 337.5-22.5" 2 "WD: NE 22.5-67.5" 3 "WD: E 67.5-112.5" 4 "WD: SE 112.5-157.5" 5 "WD: S 157.5-202.5" 6 "WD: SW 202.5-247.5" 7 "WD: W 247.5-292.5" 8 "WD: NW 292.5-337.5"

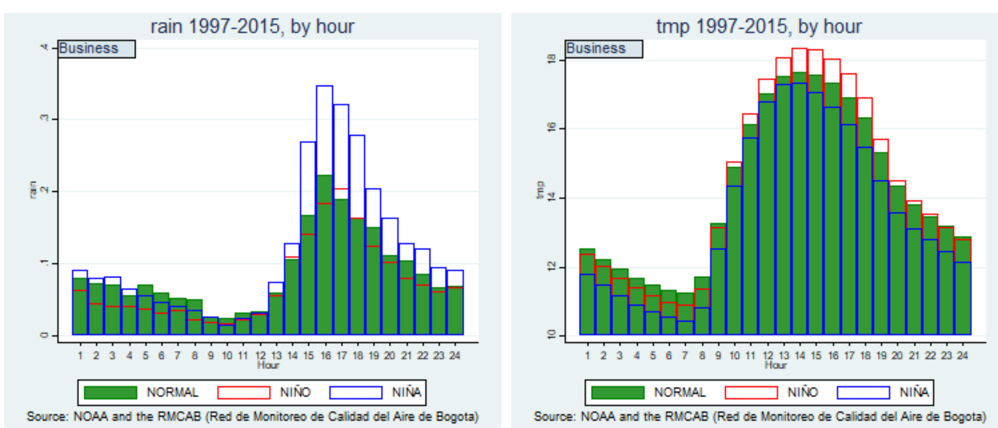
[8] List of monitoring stations for the RMCAB: Usaquén, Carvajal, Tunal, Simón Bolívar, Ferias, Cazuca, Guaymaral, Kennedy, Chicó-Lago, Suba, Cade- Energía, Puente Aranda, Fontibón, San Cristobal, Olaya y OPSIS, Universidad Nacional, Engativa and Central de Mezclas. All the stations capture traffic pollution. Background pollution is also captured in all the stations, except for Ferias, Guaymaral, Cade- Energía, Puente Aranda and Central de Mezclas. Industry stations are Carvajal, Cazuca, Puente Aranda and Fontibón. The classification given by type of monitoring stations are for year 2009 and they seem to capture similar type for air pollution (see (link document)).

Figure 2: Localities and Monitoring Stations in Bogotá



Source: Authors' elaboration based on data from the Air Quality Monitoring Network in Bogotá (RMCAB)

Figure 3: Weather variables-24hour schedule



Source: Authors' elaboration based on data from the Air Quality Monitoring Network in Bogotá (RMCAB)

Information on health outcomes comes from the Vital Statistics Registrations gathered by the National Administrative Department of Statistics of Colombia (DANE). It provides data for each child born in the city over the period 1997-2015 on month of birth, birth weight, gestation length, gender, parents' characteristics, health care institution attending the birth, among others. Using birth weight (in grams) and gestation length (in weeks), we construct indicator variables for low birth weight and premature birth of the child. A child has low birth weight if its weight is less than 2500 grams. A gestation length lower than 38 weeks is considered as premature birth (see Knittel et al. [2016]).[9]

The databases described above are merged with information of geographical location of Health Service Providers (IPS). We follow an algorithm to match address and names of IPS listed in the Ministry of Health with health reports of DANE and computed all the variables at the IPS level. The procedure conducted to assign air pollutant concentrations to each child is explained in detail in the empirical strategy section.

3.1 Descriptive statistics

In Table 1 and Table 2, we present the descriptive statistics for the variables collected. In Table 1, we observe that, on average, health centers attend to 18% of premature births and 11% of births with low weight. The average child's weight at birth in an IPS is 3016 grams. Table 1 also shows high levels of pollutants during peak hours. The maximum average temperature is around 19° Celsius (Table 2). Although, Table 10 in Appendix 2A presents all the eight categories of the Wind Direction Rose, only five are relevant for the sample (Table 2). Interestingly, wind blows mainly from south, south-east and south west, with differences across the city that play an important role in pollution transport. Mothers, on average, are 26 years old and have two children. 62% of mothers are married and 71% have secondary education. 66% of births are spontaneous deliveries and almost 50% of children are females (Table 2). The last panel of Table 2 also shows different transport measures implemented in the city during the last years.

[9] Gestation length has four categories: 1=less than 22 weeks, 2=from 22 to 27 weeks, 3=from 28 to 37 weeks, 4= from 38 to 41 weeks and 5=from 42 or more. We used categories 1, 2 and 3 to define premature birth.

Table 1: Descriptive Statistics for children (health outcomes and pollution)

	Observations	Mean	SD	Min	Max
ave-birth-weight (gr)	11655	3016.13	226.03	750.00	4750.00
ave-birth-height (cm)	11647	50.00	2.16	24.50	54.50
ave-weeks-ges (weeks)	11655	38.22	1.33	21.50	42.50
premature (% per IPS)	11655	0.18	0.17	0.00	1.00
weeks-ges-premature	10426	32.35	0.56	21.50	32.50
low-birth-weight (% per IPS)	11655	0.11	0.13	0.00	1.00
premature-low-birth-weight (% per IPS)	11655	0.08	0.12	0.00	1.00
weight-low-birth-weight	9898	2069.78	167.98	750.00	2250.00
apgar1 Index (1-10)	11651	5.43	2.61	1.00	10.00
apgar2 Index (1-10)	11650	6.05	3.21	1.00	10.00
Male to Female ratio in IPS	11110	1.05	0.51	0.00	9.78
pm10-peakm ($\mu g/m^3$)	15092	75.70	26.59	23.29	176.41
pm10-peaka ($\mu g/m^3$)	15092	54.91	17.88	15.55	131.24
pm10-max ($\mu g/m^3$)	15092	113.25	34.04	36.53	267.37
pm10-avma7 ($\mu g/m^3$)	15092	56.61	18.38	18.66	124.53
pm10-ave ($\mu g/m^3$)	15092	56.22	18.34	17.68	121.83
pm25-peakm ($\mu g/m^3$)	8139	36.16	12.48	7.43	68.83
pm25-peaka ($\mu g/m^3$)	8139	22.77	6.14	5.94	44.70
pm25-max ($\mu g/m^3$)	8152	53.41	16.11	12.96	92.03
pm25-avma7 ($\mu g/m^3$)	8144	26.31	8.62	5.42	48.84
pm25-ave ($\mu g/m^3$)	8152	26.06	8.69	5.67	48.99
o3-peakm (ppb)	14527	9.46	4.16	2.33	30.03
o3-peaka (ppb)	14526	12.91	3.95	2.30	43.76
o3-max (ppb)	14529	29.60	12.36	4.99	81.17
o3-avma7 (ppb)	14453	12.67	3.76	2.32	36.35
o3-ave (ppb)	14529	12.57	3.78	2.64	35.36
co-peakm (ppm)	14573	1.98	1.18	0.36	6.68
co-peaka (ppm)	14552	1.48	0.88	0.24	5.33
co-max (ppm)	14647	2.81	1.48	0.39	9.03
co-avma7 (ppm)	14329	1.42	0.85	0.22	4.77
co-ave (ppm)	14647	1.43	0.84	0.23	4.80
so2-peakm (ppb)	15092	9.84	6.92	0.66	47.24
so2-peaka (ppb)	15092	6.69	5.27	0.45	38.06
so2-max (ppb)	15092	13.91	10.93	0.93	94.08
so2-avma7 (ppb)	15080	7.12	5.16	0.47	34.01
so2-ave (ppb)	15092	7.06	5.14	0.47	32.71
no-peakm (ppb)	14577	45.51	20.02	3.30	120.15
no-peaka (ppb)	14577	18.24	11.46	2.03	135.68
no-max (ppb)	14578	71.70	30.36	3.70	166.48
no-avma7 (ppb)	14339	22.89	10.46	3.85	89.86
no-ave (ppb)	14578	22.70	10.82	3.23	91.81
no2-peakm (ppb)	14567	22.16	8.56	1.97	74.27
no2-peaka (ppb)	14567	18.20	5.85	1.36	49.77
no2-max (ppb)	14567	31.83	11.25	2.47	95.35
no2-avma7 (ppb)	14352	17.22	5.35	1.70	47.28
no2-ave (ppb)	14567	17.01	5.53	1.38	47.97
nox-peakm (ppb)	11521	64.85	27.02	4.83	169.26
nox-peaka (ppb)	11521	35.65	15.30	5.97	144.14
nox-max (ppb)	11522	91.65	36.94	6.54	213.54
nox-avma7 (ppb)	11283	38.90	14.48	8.52	109.04
nox-ave (ppb)	11522	38.43	15.20	5.24	115.47

Source: based on the Air Quality Monitoring Network Data for Bogotá (RMCAB) and Vital Statistics from DANE, aggregated by the Health Service Providers (IPS). Micrograms per cubic meter ($\mu g/m^3$), parts per million (*ppm*) and parts per billion (*ppb*). For particulate matter, sizes are expressed in micron or micrometer.

Table 2: Descriptive statistics for socio-economic variables, weather, ENSO events and other controls

	Observations	Mean	SD	Min	Max
rain-sum (ml)	15092	2.28	1.14	0.14	10.15
rain-suma7 (ml)	15092	2.30	1.14	0.08	8.34
rain-peakm (ml)	15092	0.03	0.02	0.00	0.29
rain-peaka (ml)	15092	0.17	0.12	0.01	1.19
rain-max (ml)	15092	1.30	0.63	0.08	4.35
tmp-peakm (celsius)	15013	13.11	1.06	8.74	16.38
tmp-peaka (celsius)	15013	15.30	1.13	11.39	18.59
tmp-min (celsius)	15034	10.45	1.28	5.20	13.91
tmp-max (celsius)	15034	18.91	1.26	14.23	22.92
tmp-avma7 (celsius)	15031	14.10	1.04	10.35	16.98
tmp-ave (celsius)	15034	14.11	1.05	10.34	17.05
ws-peakm (meters/second)	15092	1.15	0.42	0.18	3.44
ws-peaka (meters/second)	15092	2.06	0.69	0.37	4.60
ws-max (meters/second)	15092	3.52	1.08	1.07	9.00
ws-avma7 (meters/second)	15092	1.57	0.53	0.37	3.46
ws-ave (meters/second)	15092	1.57	0.54	0.37	4.23
wd-rose==NE: 22.5-67.5	15092	0.00	0.04	0.00	1.00
wd-rose==E: 67.5-112.5	15092	0.01	0.11	0.00	1.00
wd-rose==SE: 112.5-157.5	15092	0.24	0.43	0.00	1.00
wd-rose==S: 157.5-202.5	15092	0.59	0.49	0.00	1.00
wd-rose==SW: 202.5-247.5	15092	0.15	0.36	0.00	1.00
numconsul	11576	5.98	2.07	0.00	30.00
N. Pregnancies	11642	2.14	0.53	1.00	12.00
N. children	11639	1.94	0.49	1.00	11.00
father-age	11593	29.54	3.46	14.00	60.00
max-mother-age	11653	27.78	3.31	14.00	49.00
min-mother-age	11653	23.78	3.31	10.00	45.00
ave-mother-age	11653	25.78	3.31	12.00	47.00
Type delivery-spontaneous	11650	0.66	0.25	0.00	1.00
Type delivery-cesarea	11650	0.31	0.23	0.00	1.00
Type delivery-instrumented	11650	0.03	0.05	0.00	1.00
More deliveries (2-3-4)	11627	0.02	0.04	0.00	1.00
Partner's marital status	11628	0.62	0.27	0.00	1.00
seg-social-contributive	11611	0.48	0.46	0.00	1.00
seg-social-subsidized	11611	0.28	0.32	0.00	1.00
seg-social-others	11611	0.16	0.27	0.00	1.00
seg-social-uninsured	11611	0.07	0.17	0.00	1.00
Father's edu.-none	11568	0.00	0.04	0.00	1.00
Father's edu.-primary	11568	0.12	0.14	0.00	1.00
Father's edu.-secondary	11568	0.67	0.22	0.00	1.00
Father's edu.-terciary	11568	0.20	0.22	0.00	1.00
Mother's edu.-none	11627	0.00	0.03	0.00	1.00
Mother's edu.-primary	11627	0.11	0.14	0.00	1.00
Mother's edu.-secondary	11627	0.71	0.23	0.00	1.00
Mother's edu.-terciary	11627	0.18	0.24	0.00	1.00
female	11655	0.49	0.17	0.00	1.00
male	11655	0.51	0.17	0.00	1.00
Min dist. IPS to station	46872	1.97	1.30	0.06	9.41
No-car-day during the quarter	15198	0.08	0.15	0.00	0.67
Transmilenio Phase I	15198	0.16	0.36	0.00	1.00
Transmilenio Phase II	15198	0.51	0.50	0.00	1.00
Transmilenio Phase III	15198	0.18	0.38	0.00	1.00
Peak-and-plate change I	15198	0.61	0.48	0.00	1.00
Peak-and-plate change II	15198	0.19	0.38	0.00	1.00
Peak-and-plate change III	15198	0.18	0.38	0.00	1.00
nino	15198	0.22	0.39	0.00	1.00
nina	15198	0.35	0.45	0.00	1.00

Source: based on the Air Quality Monitoring Network Data for Bogotá (RMCAB) and Vital Statistics from DANE, aggregated by the Health Service Providers (IPS).

4 Method and empirical strategy

The identification procedure uses a system of equations to evaluate first, the effect of pollution on health using an instrumental variable approach and second, estimate the impact of ONI (Niño-Niña) on weather variables, on pollution and on health outcomes. We divide the analysis in two parts: 1) an hourly analysis (Appendix 2B) of the ONI index, as well as El Niño and La Niña dummy variables by monitoring station for weather and pollution variables; 2) a quarterly analysis (subsection 4.1) by health center, matching weather and pollution variables with health data (our main estimation). Although secondary, the hourly analysis provides guidance for the second part. Hence, the main focus of our study is the quarterly analysis, which is shown below in subsection 4.1.

4.1 Identification of health effects

The analysis uses the administrative registers of all births observed in the city from 1998 to 2015. This enables us to capture a long period of time and many different events (NIÑO-NIÑA). All the weather and pollution variables are aggregated at the level of health center and by quarter, grouping children that were born in the same month of the year. This allows us to separate the effects of the levels of pollution during each quarter of gestation of the child. We will proceed by first, describing how we assign pollution to each childbirth and then, discuss the identification we propose.

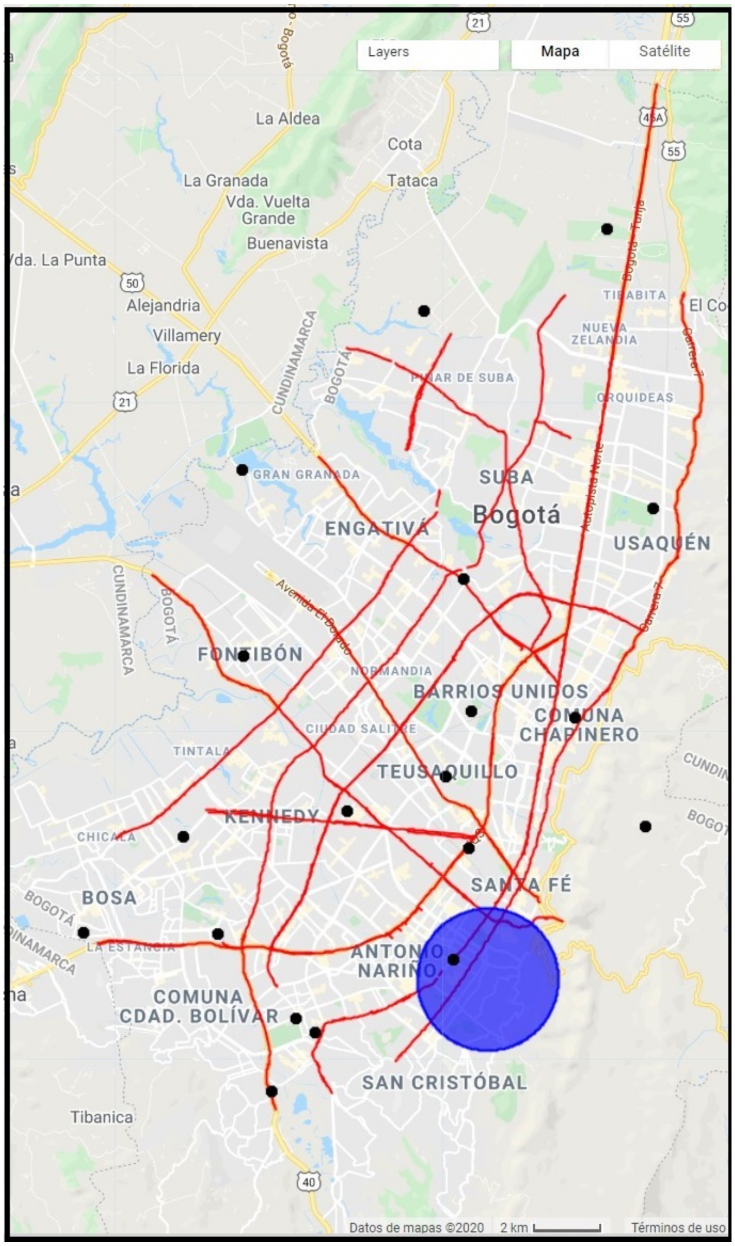
4.1.1 Assigning pollution and weather to each childbirth

Assigning the pollution and weather to health outcomes constitutes a challenge. To start, weather and pollution are aggregated for each monitoring station, and then by: average by day, average during the morning peak by day (7am-9am), average during afternoon peak by day (5pm-7pm), maximum during the day and average in the last seven days. The analysis of the effects of Niño-Niña on pollution and on weather in Appendix 2B allows us to understand in which period of the day the variables were more affected by the phenomena and aggregate the variables in similar way. For rainfall, we use the cumulative sum instead of the average by day.

We then have a daily panel of monitoring stations. The data-set is imported to Google Earth Engine and it uses the inverse distance weighting interpolation to estimate the levels of pollution and weather for the whole area of Bogotá and for each month of the data-set. This data-intensive procedure creates for example, a map of PM_{10} in January 2000, another map for February 2000 and so on.

As observed by Graff Zivin and Neidell [2013], assigning climatic variables and air pollutants to individuals' health outcomes according to the nearest monitoring station, could lead to measurement error, since it assumes that people are affected by pollution of that station, and that pollutants spread homogeneously over space. This justifies the use of the inverse distance weighting interpolation, since it allows us to use as much daily information as possible, in order

Figure 4: Map to assign weather and pollution to each health center



Note: 15 main roads (in red) in the city and health centers' addresses. This is an example for one health center (the blue dot), making a buffer of 2 km to give an idea about the area imputed. The black dots correspond to the location of the monitoring stations.

to create monthly maps of the city.[10]

As a next step, ideally, we should assign pollution and weather of the monthly maps to the

[10]Kriging or other techniques of spatial forecasting based on the monitoring stations information are alternatives to the inverse distance weighting interpolation.

child's mother's address. Unfortunately, access to this was denied and we have to use another strategy, by using the address of the IPS health center where the mother was giving birth.[11] As the average minimum distance of health centers to the monitoring stations is 2km (see Figure 4), we designed a buffer of 2km around each health center. For instance, we take the health center in the blue dot in the map and create a 2km buffer, and intersect it with the monthly maps of pollution and weather. This data-set is then matched to each child according to the health center, their respective month-year in which they were born and the specific months of gestation (time of gestation varies per child and it is accounted for).[12] The data-set is then collapsed by running quarter of gestation and IPS, to create a quarterly panel of health centers from 1998 to 2015 (see the next section for the details about the running quarter).

Although this methodology assumes that individuals move or live inside the buffer of 2km, which could be a strong assumption given the mobility of people in Bogotá, aggregating by health center can circumvent in some way this issue, by allowing us to express the health outcomes on average for the children that were born in that health center. We consider this as the best alternative, given the restriction of not having access to the exact address of the mother giving birth. We test the robustness of the results to this aspect by changing the buffer size to 4km in a later section.

4.1.2 Identification strategy

The identification relies on the variation in weather, pollution and NIÑO-NIÑA events at the quarterly level, which allows us to disentangle in which quarter of gestation the effects are more critical and can affect more the children. It also permits to capture concentration and time of exposure to the concentration of pollutants, in the sense that mothers might face similar levels of pollution and NIÑO-NIÑA events, but the time exposure (and doses of pollution) can affect

[11] We use the sample of IPS health centers from the Integrated System of information for the Social Protection (SISPRO) for the city. After cleaning the data-set for repeated names of health centers with the same address, etc., we ended up with 1268 health centers. As not all the health centers attend births, only 217 match with our sample of health centers of administrative registers of births in the city for which we have the location. However, the registers of birth in those 217 health centers correspond to 87.7% of the total sample of births from 1998 to 2015. As the data of health centers represent a census of all the births during the period in the city, attrition could come from two sources: attrition for reason one, for children not being delivered at the health center and attrition for reason two, for children born in a health center but for which we could not recover the address. Figure 10 in Appendix 2C shows the percentage of attrition of both sources by month. We observe first, that attrition for reason one is very low and second, the total number of attrition for reason two is stable by month and around 10%.

[12] As the exact day of childbirth was not provided (only month and year), the birth of the child it is set as the 15th of that month. Also, as the variable weeks of gestation is recorded in brackets (22-27 weeks, 28-37 weeks, 38-41 weeks, etc.), the average in the bracket is used to determine the months of gestation. For instance, a child was born on the 15th of September of 2004 with 38-41 weeks of gestation, so she had on average 39.5 weeks of gestation, or 39.5*7=276.5 days of gestation. We can subtract that from the day of birth and infer the first day of gestation, which is the 13th of December of 2003. The period between the first day of gestation and the birthday gives approximately nine months of gestation in total. This allows us to take into account that some children can have less than nine months of gestation. As a next step, we create a panel for each child and her months of gestation, and match it with the respective month in which pollution and weather affected the child contemporaneously.

more the baby during some particular quarters of gestation. As such, the system identifies not only the effects of ENSO events on pollution and health, but also the total effects of pollution on health during normal days, which is very relevant from a policy-maker's perspective. Hence, the system of equations for pollution ($P_{j,t-k}$) and health ($H_{j,t}$), aggregated by health center j is:

$$\begin{aligned} P_{j,t-k} = \quad & \alpha_0 + \textstyle\sum_{q=0,3,6} \left(\alpha_{1,q} NI\tilde{N}O_{t-q} + \alpha_{2,q} NI\tilde{N}A_{t-q} + \alpha_{3,q} WR_{j,t-q}\right) \\ & + \textstyle\sum_{q=0,3,6} \left(\alpha_{4,q} WS_{j,t-q} + \alpha_{5,q} WS_{j,t-q} \times WD^{rose}_{t-q} + \kappa_{WD^{rose}_{t-q}}\right) \\ & + \eta_1 X^{hh}_{j,t-k} + \eta_2 X^{fe}_{t-k} + \eta_{3,q} \textstyle\sum_{q=0,3,6} T_{t-q} + \epsilon_{j,t-k} \quad \forall k = 0,3,6 \qquad (1) \\ H_{j,t} = \quad & \theta_0 + \textstyle\sum_{k=0,3,6} \theta_{1,k} P_{j,t-k} + \textstyle\sum_{q=0,3,6} \left(\theta_{2,q} NI\tilde{N}O_{t-q} + \theta_{3,q} NI\tilde{N}A_{t-q}\right) \\ & + \textstyle\sum_{q=0,3,6} \left(\theta_{4,q} WR_{j,t-q} + \theta_{5,q} WS_{j,t-q}\right) + \lambda_1 X^{hh}_{j,t} + \lambda_2 X^{fe}_{t} + \varepsilon_{j,t} \end{aligned}$$

where $P_{j,t-k}$ corresponds to the different variables of pollution averaged for each health center j at running quarter t, with $k = 0, 3, 6$, which corresponds to the third, second and first quarter of gestation, Q3, Q2, Q1, respectively.[13] $WR_{j,t-q}$ are the different variables of rain and temperature constructed previously at health center j and quarter q (rain and temperature included at the same time); $NI\tilde{N}O_{t-q}$ ($NI\tilde{N}A_{t-q}$) capture the percentage of months of *niño* (*niña*) during the quarter (3/3, 2/3, 1/3, 0); $WS_{j,t-q}$ is the wind speed for the quarter and $\kappa_{WD^{rose}_{t-q}}$ a rose of wind direction fixed effects, the instruments for the pollution equation;[14] $X^{hh}_{j,t-k}$ is a vector of household characteristics (father's and mother's average age, father's and mother's dummies for education level, partner's marital status, type of delivery, multiple deliveries, number of previous pregnancies, number of children, number of consultations, and type of social security of the mother); X^{fe}_{t-k} a set of fixed effects ($locality \times year$, month, health center); and T_{t-q} a set of variables for transportation changes (3/3, 2/3 1/3, 0 for having no-car-day during the months of the quarter, for Transmilenio phases or for changes in the peak and plate measures). These transportation variables also enter in the system as instruments. $H_{j,t}$ are the average of the different health outcomes of the children born in the running quarter t, which are only observed at the moment of the birth. The channel of pollution on health was already found relevant for childbirth outcomes in previous studies (Currie et al. [2009] and Lavaine and Neidell

[13] t is constructed as a running quarter according to the month of birth of the children born in a specific month. If the children were born in March 2000, for instance, t corresponds to the average for January-February-March of 2000 (Q3 or last quarter of gestation), $t-1$ stands for December 1999-January 2000-February 2000. In the same way, $t-3$ corresponds to October-November-December of 1999 (Q2 or second quarter of gestation), and $t-6$ stands for July-August-September of 1999 (Q1 or first quarter of gestation). The aggregation of the data-set by running quarter and health center takes into account the children who were alive based on the months of gestation; if four children were born in health center j in March 2000, but two had gestation time of six months and the two other nine months, the variables in Q1 take into account only the children with nine months of gestation, while Q2 and Q3 takes into account all the four children.

[14] Table 10 in Appendix 2A shows the categories of the Wind Direction Rose. Only the categories in Table 2 are relevant for the estimation and in all the estimations, category two is the baseline wind direction.

[2017], among others).

Notice that ENSO events might influence health outcomes through different channels in our context: (1) ENSO affects weather, which may affect health; (2) ENSO influences air pollution, which may affect health; (3) there may be a direct effect of ENSO on health; and (4) ENSO affects the economy through changes in food markets inducing variations in household income and consumption, or other economic variables, which also may affect health. In this sense, we consider that the system of equations we propose is able to identify several of those channels. The coefficient of ENSO events in the second stage of equation 1 might be interpreted as an overall estimate of the effects from channel (1), and partial effects from channels (3) and (4), while the coefficient of pollutant variables measure the impact of pollution exposure. We argue that ENSO events coefficients might reflect partial effects of economics shocks because we are not able to structurally separate such shocks from other channels. Furthermore, in order to capture the total compounded effect of the four different channels of ENSO events on health, we proceed by estimating a reduced-form version of equation 1 without including pollution, or weather factors. The section of results discusses further the reduced-form estimations, and then, moves towards the estimation of the different channels of ENSO events on health through the IV approach.

In practical terms, the system of equations 1 could be estimated through a model of simultaneous equations, by using a General Structural Equation Modelling (Eleftherios and Oznur [2016]), by using mediation analysis (Laffan [2018], Barrett et al. [2017]), or by using an instrumental variables approach, with the rose of wind direction as the instrument for the endogenous variable of pollution (see Deryugina et al. [2019] and Schlenker and Walker [2016] for articles instrumenting pollution with wind direction). Our estimations follow the latter approach, and use standard errors robust to heteroscedasticity and autocorrelated cross-panel disturbances (see Driscoll and Kraay [1998]). Notice also that the variables of transportation changes T_{t-q} are only included in the pollution equation and as such, they also enter in the system as instrumental variables. However, our identification strategy relies more on the variation coming from wind direction, as it can be seen in Appendix 2D. Appendix 2D shows that there is not only cross-section variation in wind direction and wind speed but also variation over the years. In the map of Appendix 2D, we can see that the wind blows from the east (mountains), towards the west and the south.[15]

Importantly, the system captures the lagged effect on health of the exposure to pollution, $NI\tilde{N}O$ and $NI\tilde{N}A$, during the three quarters of gestation. The first stage of the IV approach is estimated for three endogenous variables $P_{j,t}$, $P_{j,t-3}$, $P_{j,t-6}$, one for the exposure during each quarter of gestation. According to the literature, it is important to consider pollution and weather during the different quarter of gestation, e.g., Currie et al. [2009] who use CO and PM_{10} and by Barreca et al. [2015] and Deschênes et al. [2009], who use the temperature of the different quarters. We use both in the same estimation and add the effect of ENSO during the

[15] An alternative to the rose of wind direction in some studies consist of using a dummy variable for upwind or downwind direction.

different quarters of gestation.

The previous system also allows us to capture the effect of El Niño and La Niña events, directly in the equation of pollution and health, considering them as exogenous global phenomena (see Hsiang et al. [2011] and Dingel et al. [2020]). Although they could disturb weather conditions, affecting the levels of pollution, they could also affect, for instance, food prices or other economic variables, which might impact the health of pregnant mothers, and hence, their children. As such, ENSO events do not change with respect to location as they are considered as global phenomena, affecting several countries like Colombia. Therefore, there is no spatial variation across locations in Bogotá of the ENSO events captured here (see Figure 1). Once we control for the set of fixed effects ($locality \times year$, month, health center), the identification of ENSO events in our main equation relies more on the time variation of what we define as running-quarter. This is an advantage that we have in the data, varying over 1998-2015 by quarter of gestation of the children and by month of birth (cohort). In studies such as Dingel et al. [2020], the identification of ENSO events also relies on the variation over time but the impacts on trade depend on the latitude-longitude of the location and are spatially correlated.

The system also includes the effect of classical local weather on health as it could be that higher levels of rainfall or temperature affect negatively the health of the pregnant mother and hence, the infant [Knittel et al., 2016, Barreca and Schaller, 2020]. They find an impact of high temperatures on delivery timing and gestational lengths at the level of county in the United States. The argument is that heat increases the levels of oxytocin, the hormone regulating the onset of delivery; alternatively, extreme heat might also cause earlier deliveries via cardiovascular stress (see for instance Hampel et al. [2011]). Some interesting heterogeneous effects are found by Barreca and Schaller [2020], so the cumulative effects are particularly higher in cold counties while hot counties might be more accustomed to extreme heat and can adapt better. In the context of India, high temperature should also affect directly and indirectly (via pollution) health outcomes. Although in Bogotá temperatures does not reach such extreme values, it might be that pregnant mothers are affected by extreme rainfall, which is more likely during La *Niña*.

4.2 Potential threats to identification

In the literature, studies such as Hanna and Oliva [2015] and Anderson [2014] analyze the effects of pollution on health by using a single shock to an emission source like an industry strike or a plant closure. Also, Knittel et al. [2016] assign pollution of the nearest station to particular individuals, and solve the issue of measurement errors by instrumenting pollution with weekly shocks to traffic, including weather conditions as additional confounders. Our strategy relies more on the use of wind direction to instrument pollution and exploit NIÑO-NIÑA as exogenous sources of variation. The problem of using a single shock such as a plant closure or unexpected changes in traffic, is that it could affect multiple pollutants, putting some threats to the identification, unless some extra assumptions are considered (see Graff Zivin and Neidell [2013]). This justifies the use of weather variables as additional confounders that help in identifying the effects of different air pollutants.

Currie et al. [2009] study the effect of pollution on infant health in New Jersey. They assign the closest air quality monitoring station variables to the mother's location and finds a negative impact of exposure to carbon monoxide (CO) during and after birth, with larger effects for the group of smokers and older mothers. By analyzing infants, they can capture a causal effect more immediately; we follow their approach in this article.

Residential sorting could be a potential problem (see Graff Zivin and Neidell [2013]) as families might try to locate to areas where air quality is less contaminated, with better education and health care access, leading us to underestimate the effects of pollution. Currie et al. [2009] propose to solve this issue through fixed effects for mothers and station. For this reason, our system of equations also control for a rich set of parents' characteristics. However, individuals move in Bogotá mainly after experiencing income shocks, and hence, moving to areas with less pollution should be uniquely a secondary aspect to consider in relocation decisions after an income shock (see Table 22 in Appendix 2G). Locations can also differ in terms of access to Primary Care Physician, income, access to transport, etc., and to that aim, the system of equations 1 also includes health center fixed effects and locality $\times$ year fixed effects. In addition, we explore the residential sorting issue in more detail in subsection 5.3.

A more important challenge for the empirical strategy is the assignment of pollution and weather variables to the children based on the health center's location using a radius of 2km. Unfortunately, mothers' addresses were not provided and we consider much better to aggregate the data-set at the level of health center. We explore some robustness checks using a larger radius, or aggregating the data-set at the level of locality instead of health center in Appendix 2I and Appendix 2N, respectively. By using a larger buffer or aggregating at locality level, we give a decreasing weight to the farthest measurement stations, and increase the likelihood that the measure better characterizes the air pollution level in the area where the mother is supposed to live/work/sleep during pregnancy.

Another point with respect to the implicit assumption that women live close to the health centers is how mothers choose the place of birth. Mothers can choose the health center to give birth in two ways: by planning and by not planning. In the first case, mothers can organize the delivery in advance. As this is a risky situation for both, mother and baby, they might try to avoid choosing a health center very far from where they live. It is well known that the traffic in Bogotá is very complicated and they might want to avoid risking the baby's life on the day of delivery by choosing something not too far, and closer to where they live. Although the second situation is possible, it would be surprising to see that this happens in the majority of the deliveries in the city, but still, the mother could try to go to the planned health center of delivery. In both cases, mothers try to avoid unnecessary movements around the city in the last weeks of gestation and might try to stay in an area not far from where they live, and probably, closer to the planned place of delivery. Another potential threat is that the mother's exposure could be different at home, or work, etc.. However, this is less a concern in our case as pregnant women tend to move less in the city. It would have been a more important threat in the case of estimating effects of pollution on individuals that move more.

Finally, there is another issue with respect to the temporal scale. Graff Zivin and Neidell [2013] mention that some air pollutants like ozone have nearly immediate effects after 1-2 hours, some have incubation periods and others could have both immediate and delayed effects. For this reason, we aggregate the pollution variables as a running quarter, split the effects by quarter and analyse several different pollutants.

5 Results and robustness checks

The section of results is organized in the following way. We start by estimating the total compounded effect of ENSO on health in a reduced-form style and describe the mechanisms we aim to capture. This will give a better understanding of the main contribution of the article, the estimate of the El Niño/La Niña impacts on birth outcomes. Then, we proceed with the instrumental variable approach, starting with the first stage. As air pollution is endogenous and affects health outcomes at birth, we instrument it with wind variables. This is followed by the discussion of the main effects we capture on health in the second stage, coming directly from ENSO events and from pollution. The next subsections present some robustness checks, discuss some threats to the identification, show some additional tests, heterogeneous effects, and check effects on additional health outcomes.

5.1 Total ENSO effect on health

In order to assess the total compounded effect of ENSO events on health, we proceed by making a reduced-form estimation of equation 1 without including pollution or weather factors to capture the total composed effect of ENSO. As we argue, ENSO might affect health outcomes through different channels (in our context) and the reduced-form estimations capture the four different channels as a compounded effect of ENSO on health.

Table 3 summarizes the results of these estimations. It shows that ENSO events increase the percentage of low weight at birth and decrease the average weight of the children at birth in the health centers. The results are different depending on the quarter, with statistically significant effects at conventional levels from El Niño during the first and third quarter of gestation, and from La Niña during the second quarter. However, there is no effect of ENSO on the other health outcomes considered. Using the rows NINO and NINA (cumulative effect) in Table 3, we can say that being exposed to El Niño (or La Niña) during pregnancy increases the percentage of children with low weight at birth in the health centers by 1 percentage points. This is an increase of 9.1% of low birth weight children delivered on average (from a base of 11 percentage points of low birth weight in the IPS-health centers). The result is bigger compared to Brando and Santos [2015] who use the Colombian panel survey ELCA. In their article, an average of nine more days of La Niña rainfall exposure *in utero* increases the probability of being a low birth weight baby by 2.92% (one standard deviation of 16.2 more days of exposure *in utero* increases the probability of being a low birth weight baby by 4.7%). Consequently, being exposed to El Niño during pregnancy (cumulative effect) decreases the average weight of children in the health centers by 23 grams, which is a decrease of 0.8% from a baseline average of 3016.1 grams (see Table 1). The cumulative effect of La Niña on birth weight is not statistically significant at conventional levels, but statistically significant at the 5% significance level during the second quarter.

Table 3: REDUCED FORM: ENSO EFFECTS ON HEALTH

	RF (ENSO)			
	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)
Niño-Q3	0.008	0.009*	-0.061	-23.443***
	(0.005)	(0.005)	(0.039)	(7.658)
Niño-Q2	-0.005	-0.004	0.034	8.008
	(0.006)	(0.004)	(0.045)	(7.114)
Niño-Q1	0.003	0.008*	0.016	-7.670
	(0.006)	(0.005)	(0.044)	(7.977)
Niña-Q3	0.004	-0.000	-0.004	2.060
	(0.006)	(0.004)	(0.043)	(7.684)
Niña-Q2	0.001	0.011***	-0.020	-20.784**
	(0.006)	(0.004)	(0.042)	(8.758)
Niña-Q1	-0.006	-0.002	0.061	5.253
	(0.008)	(0.005)	(0.058)	(8.816)
Observations	11193	11193	11193	11193
NINO	0.01	0.01	-0.01	-23.10
P_NINO	0.36	0.01	0.84	0.01
NINA	-0.00	0.01	0.04	-13.47
P_NINA	0.92	0.21	0.63	0.14
r2_a	0.37	0.31	0.36	0.34

* p<0.05> , ** p<0.01, *** p<0.001

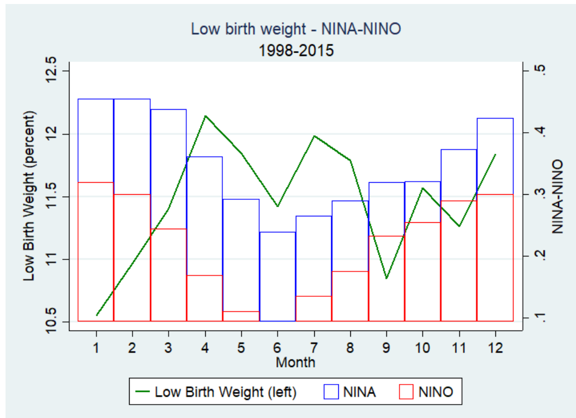
Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics mentioned in section 4.1.2. $NINO$, $NINA$ correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño and for La Niña, while P_NINO, P_NINA are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

In Figure 5, we show the relationship between ENSO and the different pollutants with health. Panel a) shows the relation of ENSO with low weight at birth, aggregating by the different months of the year. ENSO events are more frequently observed at the end and beginning of the years. We also notice a lagged effects in the sense that once ENSO events become more frequent after the months of September, there is an increase in the children born with low weight. This also happens from January to March. In addition, ENSO events are less persistent from April to September, which coincides with a decrease of the low birth weight variable (with increases in some months). It is worthwhile to notice that ENSO can have not only an effect manifested as extreme climatic shocks on health, but also, an effect mediated through pollution. The relationship described in panel a) of the figure includes both aspects. In fact, the reduced-form estimations presented allow to understand better the total compounded effect of ENSO events on health outcomes (the sum of the four different channels discussed).

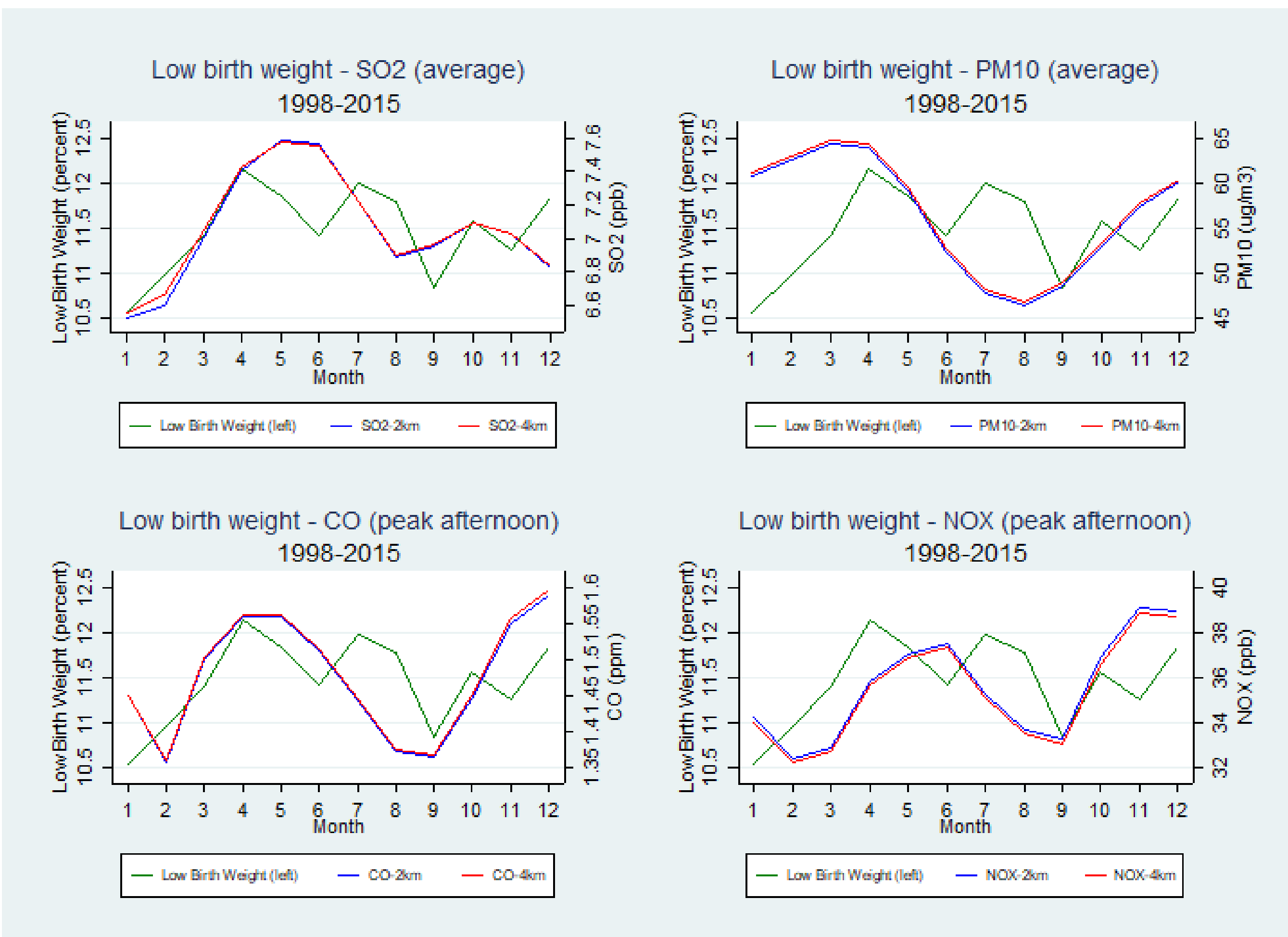
We can see the important effect of air pollution on health by relating the different pollutants with the variable of low birth weight in panel b) of Figure 5. It shows a positive correlation of air pollution with the low birth weight variable across the different months. The relationship is much clearer for CO, so months with higher emissions of CO such as April, go together with increases in the low weight at birth, and reductions of CO emissions in September coincide with lower values for the variables of low weight at birth. This pattern is also observed for PM_{10} and to a lesser extent for NO_X and SO_2. Low birth weight tends to move more contemporaneously with air pollution, but more in a lagged manner with respect to ENSO events. This confirms that lagged terms should be included in the estimations.

Figure 5: ENSO and Pollutants effect on Low Birth Weight

(a) ENSO



(b) Pollutants

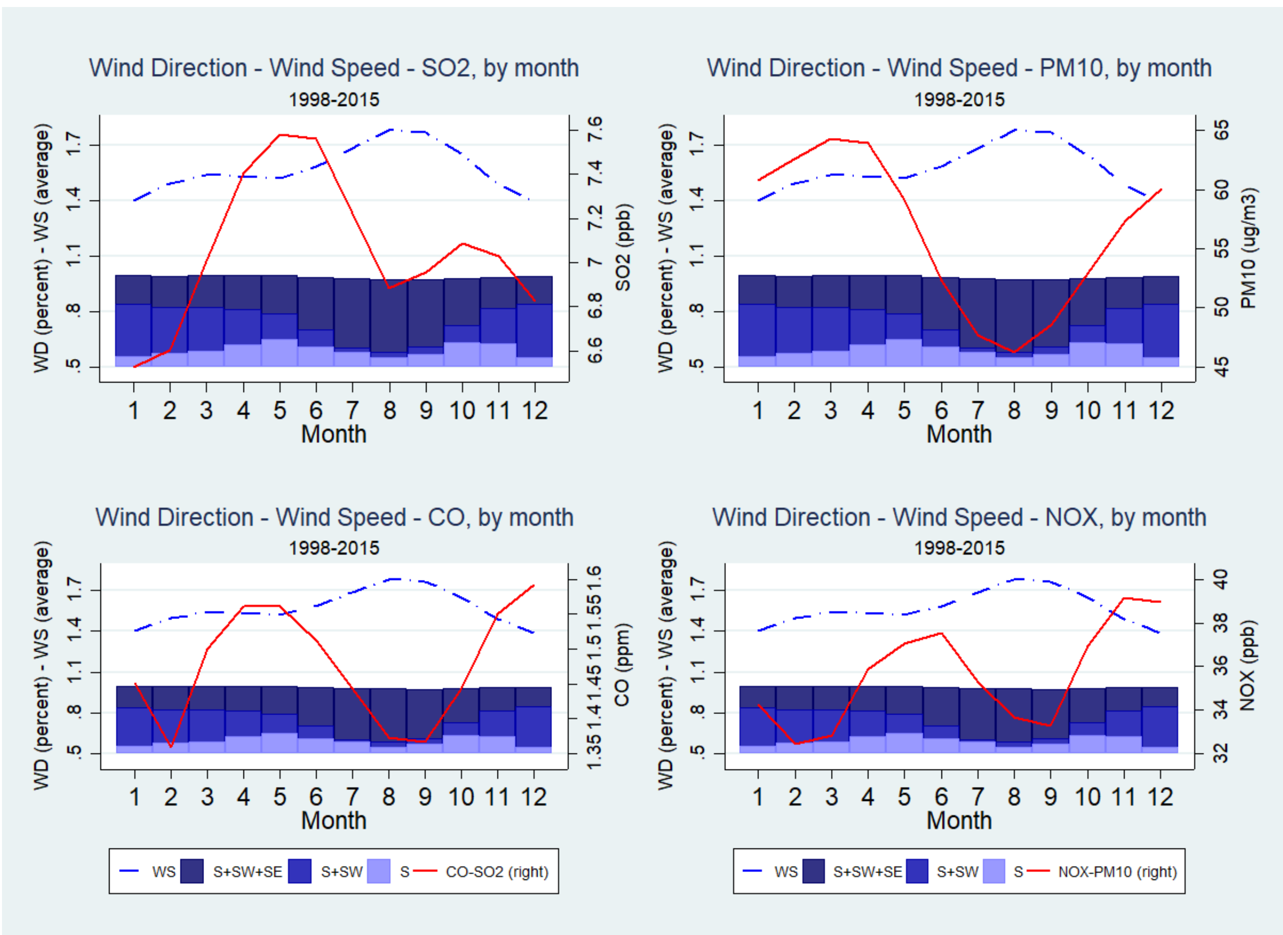


Source: based on the Air Quality Monitoring Network Data for Bogotá (RMCAB) .

5.2 The Instrumental Variable approach: how ENSO affects health

After discussing the total compounded effect of ENSO events on health in the previous subsection, we move to the instrumental variable approach for the system of equations 1 using wind variables as instruments. Figure 6 describes this relationship between wind variables and four of the pollutants used, over the year.

Figure 6: Wind Direction (WD) and Wind Speed (WS) on Pollutants



Source: based on the Air Quality Monitoring Network Data for Bogotá (RMCAB). S: percentage of wind blowing from the south; S+SW: percentage of wind blowing from the south and the south-west; S+SW+SE: percentage of wind blowing from the south, the south-west and from the south-east.

During periods of high wind speed (WS) like July, August and September, the levels of pollution tend to decrease across the four pollutants in the figure.[16] For PM_{10}, and to a lesser

[16] August in fact, is the most preferred month for flying kites for the Bogotanos (demonym for the people

extent for CO and NO_X, lower levels of wind speed in April to May and October to December come in hand with higher levels of pollution.

Figure 6 also shows the cumulative percentage when wind blows from the south (S), from the south and the south-west (S+SW) and from the south, the south-west and the south-east (S+SW+SE) between 1998 to 2015. These are the main directions from which wind blows in the city. As observed, when wind direction is predominantly from the south and the south-west, the levels of pollution tend to be lower. Similarly to wind speed, for the period between July to September, wind blows less from the south and the south-west. Once wind blows more from these directions, the levels of pollution tend to increase (April to May and October to December).

This discussion shows the importance of using the interactions between wind speed and the wind direction variables for the identification strategy, in order to have a richer set of instruments for pollution. We proceed by estimating the system of equations 1 using the instrumental variable approach. Tables 4 and 5 present the first-stage estimates that support the statistical correlation between the wind direction instruments with pollutant concentrations (interactions of the wind direction rose with wind speed not shown to save space). We estimate several exposure measures of pollution, but for ease of presentation we select exposure measures grouped by pollutants for which the results are statistically relevant. In the case of Table 4, we use average daily pollution to analyze impacts of SO_2, PM_{10} and $PM_{2.5}$, while in Table 5, we employ pollutant concentrations during evening peak hours for CO, and NO_x. The second stage estimations presented later on are consistent with the same aggregation of pollutant that are used in the first stage. Almost all coefficients of the set of instruments are statistically different from zero at conventional significance levels. Additionally, the adjusted R-squared of the first stage accounts for the importance of the pollution variability explained by the wind variables and the exogenous variables (from 6% to 34%). The F-statistics across the majority of the first stage results are larger than ten, exceeding the rule of thumb cutoff for weak instruments proposed by Staiger and Stock [1997].

Note that each regression of the health outcomes (second-stage) has three equations in the first stage, one for each quarter of gestation, and corresponds to the set of three columns shown in the tables of the first stage for each pollutant. In fact, the three equations estimated in the first stage are the same for the four health outcomes presented in the second stage. For instance, the first four columns of Table 6 (for SO_2) share the same equations in the first stage, and we present only once the results of the first stage (first three columns of Table 4). The same holds for the other pollutants.

from Bogotá) because of the very strong winds and better weather conditions. This is a common practice with several kites festival during the month.

Table 4: IV FIRST STAGE: IV ON SO_2 PM_{10} $PM_{2.5}$ (average)

	SO2 (average)			PM10 (average)			PM2.5 (average)		
	Q3-gest.	Q2-gest.	Q1-gest.	Q3-gest.	Q2-gest.	Q1-gest.	Q3-gest.	Q2-gest.	Q1-gest.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Niño-Q3	0.119	0.868	-0.384	-3.260	0.528	1.552	0.718	-3.239***	-1.117
	(0.352)	(0.536)	(0.368)	(2.012)	(1.247)	(1.446)	(1.662)	(0.992)	(1.741)
Niño-Q2	-1.438***	0.194	1.211***	-3.341*	-5.029***	-1.261	2.091	-3.801***	2.538*
	(0.384)	(0.578)	(0.409)	(1.838)	(1.597)	(1.054)	(1.646)	(1.219)	(1.302)
Niño-Q1	0.074	-1.377**	-0.580	2.100	0.044	-2.789	-0.814	-0.268	2.013
	(0.452)	(0.538)	(0.464)	(1.663)	(2.009)	(2.278)	(1.273)	(1.291)	(1.230)
Niña-Q3	0.443	-0.507	0.147	-2.280	0.141	0.615	0.301	-2.297	9.584***
	(0.381)	(0.543)	(0.336)	(1.984)	(1.566)	(1.948)	(1.745)	(2.180)	(2.033)
Niña-Q2	-0.038	0.127	-0.233	-4.828***	-2.146	-0.572	-2.892	-1.780	-4.144
	(0.562)	(0.565)	(0.609)	(1.798)	(2.855)	(1.917)	(2.000)	(1.792)	(2.561)
Niña-Q1	1.769***	-0.617	1.459***	-0.429	-5.473***	-3.067*	0.870	-5.882***	5.408**
	(0.471)	(0.627)	(0.511)	(1.966)	(1.735)	(1.856)	(1.844)	(1.401)	(2.272)
ws_ave-Q3	-4.957*	1.195	-1.350	2.333	14.378***	2.177	15.899	-4.300	-18.063
	(2.605)	(1.079)	(1.061)	(5.475)	(4.422)	(8.037)	(10.518)	(10.620)	(14.735)
ws_ave-Q2	-3.922**	-3.605	1.114	1.991	3.743	17.605***	-13.113	12.678	24.149
	(1.889)	(2.315)	(1.143)	(9.466)	(6.526)	(3.123)	(9.182)	(10.061)	(17.825)
ws_ave-Q1	1.772	-3.231	-4.848**	-16.790**	2.981	3.737	5.767*	-3.998	-1.329
	(1.337)	(2.617)	(2.268)	(6.749)	(5.190)	(10.034)	(3.416)	(3.202)	(2.869)
wd_rose_Cat3-Q3	-3.003	1.743	-1.891	1.295	6.169	-9.134	15.832	-8.628	-15.790
	(2.510)	(1.357)	(1.263)	(5.124)	(5.259)	(8.182)	(12.189)	(12.356)	(17.510)
wd_rose_Cat4-Q3	-4.922*	1.650	-2.041	0.883	10.141*	-5.355	15.675	-5.879	-17.229
	(2.629)	(1.441)	(1.345)	(4.947)	(5.913)	(8.360)	(12.310)	(12.401)	(17.253)
wd_rose_Cat5-Q3	-4.998*	2.608**	-1.528	4.738	11.408*	-2.852	17.731	-5.484	-18.523
	(2.678)	(1.329)	(1.307)	(4.993)	(5.836)	(8.283)	(12.309)	(12.200)	(16.864)
wd_rose_Cat6-Q3	-6.195**	2.421	-1.818	11.906**	17.877***	-0.919	17.223	-4.814	-18.439
	(2.754)	(1.508)	(1.533)	(5.188)	(6.246)	(8.584)	(12.360)	(12.198)	(16.797)
wd_rose_Cat3-Q2	-4.513**	-0.309	1.825	6.067	2.004	8.100**	-12.853	10.488	24.630
	(2.070)	(2.354)	(1.379)	(10.611)	(6.374)	(3.667)	(10.769)	(11.502)	(20.658)
wd_rose_Cat4-Q2	-4.067*	-3.086	1.991	5.112	1.589	9.899***	-14.137	11.614	30.021
	(2.303)	(2.557)	(1.426)	(10.522)	(5.979)	(3.757)	(10.598)	(11.295)	(20.796)
wd_rose_Cat5-Q2	-3.343	-2.438	3.132**	8.649	4.587	8.358**	-14.965	14.576	28.003
	(2.225)	(2.498)	(1.393)	(10.484)	(6.337)	(3.628)	(10.494)	(11.447)	(20.676)
wd_rose_Cat6-Q2	-2.729	-3.330	2.778*	6.356	7.748	13.019***	-17.704*	13.193	29.860
	(2.310)	(2.610)	(1.454)	(10.631)	(6.448)	(4.183)	(10.669)	(11.032)	(20.864)
wd_rose_Cat3-Q1	2.111*	-1.803	-2.493	-20.433**	1.097	-2.094	8.834**	-3.140	-1.998
	(1.150)	(2.990)	(2.710)	(8.850)	(6.349)	(9.701)	(3.795)	(4.411)	(3.162)
wd_rose_Cat4-Q1	2.332*	-1.301	-5.172*	-22.081**	-0.374	-1.442	9.957**	-3.816	-1.369
	(1.273)	(3.291)	(2.786)	(8.608)	(6.332)	(9.757)	(4.234)	(4.301)	(3.293)
wd_rose_Cat5-Q1	2.808**	-0.251	-4.567*	-22.666**	2.198	2.150	9.593**	-3.843	0.495
	(1.287)	(3.225)	(2.766)	(8.840)	(6.399)	(9.785)	(4.310)	(4.278)	(3.318)
wd_rose_Cat6-Q1	2.263	0.182	-5.762**	-20.574**	0.137	4.978	11.836**	-7.329	1.070
	(1.418)	(3.310)	(2.797)	(9.245)	(6.496)	(10.026)	(4.684)	(4.606)	(3.708)
N	11027	11027	11027	11027	11027	11027	4413	4413	4413
R2_first_a	0.16	0.14	0.08	0.11	0.09	0.06	0.20	0.22	0.34
F_first_a	27.88	19.79	9.71	14.27	10.61	6.62	11.12	20.32	42.68

* p<0.05> , ** p<0.01, *** p<0.001

Note: Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. Each regression of the health outcomes has three equations in the first stage, one for each quarter of gestation. In this case, the three equations are the same for each set of four health outcomes presented in the second stage, for instance, the first four columns of Table 6 (for SO_2) share the same equations in the first stage, so we will only present once the results. The same holds for the other pollutants. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay). The interaction of the wind direction rose with wind speed not shown to save space.

Table 5: IV FIRST STAGE: IV ON CO NO_X (peak afternoon)

	CO (peak afternoon)			NOX (peak afternoon)		
	Q3-gest.	Q2-gest.	Q1-gest.	Q3-gest.	Q2-gest.	Q1-gest.
	(1)	(2)	(3)	(4)	(5)	(6)
Niño-Q3	0.064	-0.389***	0.163	-5.086*	-5.279***	-2.075
	(0.074)	(0.105)	(0.106)	(3.051)	(1.663)	(1.813)
Niño-Q2	-0.203*	0.049	-0.357***	2.015	-4.439**	-4.981***
	(0.118)	(0.111)	(0.131)	(3.153)	(1.991)	(1.732)
Niño-Q1	-0.102	-0.310	0.276**	0.553	-0.021	-6.844**
	(0.082)	(0.247)	(0.123)	(3.370)	(3.278)	(2.855)
Niña-Q3	-0.166*	-0.252**	0.347***	0.134	-4.478**	5.413**
	(0.089)	(0.099)	(0.116)	(2.148)	(1.895)	(2.506)
Niña-Q2	-0.058	-0.222	-0.115	4.218	-1.425	-2.630
	(0.071)	(0.139)	(0.109)	(2.775)	(1.953)	(2.818)
Niña-Q1	-0.487***	-0.124	-0.152	-6.105**	6.502**	2.797
	(0.096)	(0.092)	(0.096)	(2.766)	(3.093)	(2.259)
ws_peaka-Q3	-0.183	0.591	-0.207	8.137	-5.280	4.886
	(0.329)	(0.644)	(0.262)	(6.451)	(3.456)	(3.213)
ws_peaka-Q2	-1.098***	0.147	0.626*	7.704	-3.593	-8.537***
	(0.356)	(0.313)	(0.369)	(4.775)	(5.598)	(2.614)
ws_peaka-Q1	0.339	-0.447	0.587**	-6.140	-3.234	-10.109*
	(0.253)	(0.465)	(0.292)	(4.434)	(3.794)	(5.424)
wd_rose_Cat3-Q3	-0.126	0.279	0.026	8.104	-11.673	9.575*
	(0.524)	(0.840)	(0.338)	(9.230)	(7.115)	(5.178)
wd_rose_Cat4-Q3	0.289	0.571	-0.478	17.147*	-7.897	9.170*
	(0.490)	(1.016)	(0.370)	(9.004)	(6.761)	(5.126)
wd_rose_Cat5-Q3	0.245	0.559	-0.415	23.280**	-6.840	10.439*
	(0.506)	(1.015)	(0.383)	(9.551)	(6.963)	(5.380)
wd_rose_Cat6-Q3	0.213	0.698	-0.350	25.464***	-5.638	12.001*
	(0.515)	(1.027)	(0.411)	(9.450)	(7.202)	(6.489)
wd_rose_Cat3-Q2	-1.636***	0.681	0.382	13.423*	-1.398	-3.455
	(0.612)	(0.465)	(0.516)	(7.245)	(6.967)	(4.898)
wd_rose_Cat4-Q2	-1.575***	0.539	0.911	9.247	4.239	-9.334**
	(0.549)	(0.432)	(0.619)	(7.162)	(7.372)	(4.696)
wd_rose_Cat5-Q2	-1.746***	0.297	1.014	20.063***	6.942	-12.856**
	(0.536)	(0.409)	(0.635)	(7.498)	(7.526)	(5.284)
wd_rose_Cat6-Q2	-1.599***	0.362	1.204*	20.111***	7.605	-13.894**
	(0.542)	(0.419)	(0.635)	(7.512)	(7.884)	(6.104)
wd_rose_Cat3-Q1	0.012	-0.779	0.798*	-3.922	-0.979	2.114
	(0.520)	(0.694)	(0.420)	(5.908)	(4.973)	(7.162)
wd_rose_Cat4-Q1	0.506	-0.544	0.654*	-8.577	-4.279	1.483
	(0.387)	(0.729)	(0.369)	(5.751)	(4.675)	(7.051)
wd_rose_Cat5-Q1	0.725*	-0.813	0.478	-4.343	1.131	0.690
	(0.374)	(0.748)	(0.358)	(5.832)	(5.049)	(7.329)
wd_rose_Cat6-Q1	0.641*	-0.599	0.353	-6.334	2.975	-0.835
	(0.384)	(0.748)	(0.369)	(6.533)	(5.478)	(7.597)
N	9833	9833	9833	7683	7683	7683
R2_first_a	0.26	0.30	0.34	0.18	0.21	0.24
F_first_a	32.94	33.08	19.38	10.97	29.68	34.43

* $p<0.05>$, ** $p<0.01$, *** $p<0.001$

Note: Peak afternoon is the average pollution during the peak in the afternoon per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. Each regression of the health outcomes has three equations in the first stage, one for each quarter of gestation. In this case, the three equations are the same for each set of four health outcomes presented in the second stage, for instance, the first four columns of Table 6 (for SO_2) share the same equations in the first stage, so we will only present once the results. The same holds for the other pollutants. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay). The interaction of the wind direction rose with wind speed not shown to save space.

The first stage estimations show not only the importance of using the wind variables lagged according to the quarter of gestation of the children born in the health center, but also, the complexity of the relationships between pollution with wind variables and their interactions in our setting. This can be noticed in the results of the first stage where some signs of wind direction on pollutants might change according to the quarter of gestation. This can be due to the fact that the instruments of wind direction and wind speed present time variation during the period analysed. As shown in Figure 11 and Figure 12 of Appendix 2D, wind direction and wind speed change during the different quarters and years. For the city, the wind blows mainly from the south, the south-east and the south west, with some years like 2008 where wind blew more from the south-west (see Figure 11, panel a) of Appendix 2D). The time variation of wind direction and wind speed variables is more evident in Figure 12, panel a) of Appendix 2D. The figure uses quarterly variation, much closer to the variation we exploit for the identification. As such, the data-set was constructed as a panel of health centers and running quarters according to the specific month in which the children were born (see subsection 4.1.2). Therefore, some children might be more or less affected by the levels of pollution, which in fact, depends on the delivery month. While a child born in December 2005 could have benefited from the lower levels of pollution and higher levels of wind speed and wind from the south and the south-west during the second quarter of gestation (July-August-September 2005), a child born in March 2006 might have being exposed to higher levels of pollution and less wind speed and wind from the south during the second quarter of gestation (October-November-December 2005).

Similar studies disaggregating the effect of pollution on newborns by quarter of gestation have also found a change in the sign of the effects of pollution and weather depending on the quarter [Lavaine and Neidell, 2017, Currie et al., 2009], and variability with respect to the pollutant. For this reason, we present in the second stage the cumulative effects (sum of the coefficients of the three quarters) of pollution and ENSO on health, to have a better approximation of total effects during pregnancy.

Tables 6, 7 and 8 show the main results of the second stage of the effects of ENSO and pollution on health outcomes. They are consistent with the estimations of the first stage presented before. In the case of Table 6 and 7, we use average daily pollution to analyze impacts of SO_2, PM_{10} and $PM_{2.5}$, while in Table 8, we employ pollutant concentrations during evening peak hours for CO, and NO_x. Reduced form specifications of health outcomes on weather and ENSO events are shown in Tables 14, 15 and 16 of Appendix 2D. Appendix 2F, also displays the results using exposure measures of pollution such as the mean of the moving average of the last 7 days and the mean of the daily maximum concentrations. Those results are qualitatively similar to those presented in Tables 6, 7 and 8, and constitute a robustness check for the estimations.

Regarding ENSO impacts, for specifications when pollutants SO_2, PM_{10} and $PM_{2.5}$ are analyzed, El Niño and La Niña episodes reduce birth weight when exposure takes place in the last quarter (Q3-gestation), when the mother is close to give birth. The effect ranges from 19 to 45 grams relative to normal conditions. These results manifest that climatic shocks via ENSO are not negligible. Cumulative impacts over the entire gestational length tend to be statistically significant different from zero for El Niño but not significant for La Niña (rows $NINO$, $NINA$,

Table 6: IV SECOND STAGE: SO_2 (average) ON HEALTH

	SO2 (average)			
	Premature (1)	Low Weight (2)	Weeks Gest. (3)	Birth Weight (4)
Niño-Q3	0.010*	0.014***	-0.081*	-31.838***
	(0.006)	(0.005)	(0.049)	(8.321)
Niño-Q2	-0.007	-0.012**	0.050	15.396*
	(0.007)	(0.005)	(0.053)	(8.353)
Niño-Q1	0.007	0.011*	-0.016	-14.291
	(0.006)	(0.006)	(0.044)	(8.929)
Niña-Q3	0.003	0.007	0.004	2.196
	(0.006)	(0.004)	(0.046)	(7.555)
Niña-Q2	-0.002	0.012***	0.004	-19.659***
	(0.006)	(0.004)	(0.045)	(7.370)
Niña-Q1	-0.013	-0.004	0.111*	8.564
	(0.008)	(0.006)	(0.059)	(10.535)
so2_ave-Q3	-0.000	-0.002	-0.000	-0.412
	(0.001)	(0.001)	(0.012)	(2.473)
so2_ave-Q2	-0.002	0.001	0.017	-2.306
	(0.002)	(0.002)	(0.013)	(3.138)
so2_ave-Q1	0.005**	0.003**	-0.038**	-6.386**
	(0.002)	(0.001)	(0.017)	(2.706)
Observations	11027	11027	11027	11027
NINO	0.01	0.01	-0.05	-30.73
P_NINO	0.08	0.01	0.29	0.00
NINA	-0.01	0.01	0.12	-8.90
P_NINA	0.27	0.07	0.12	0.48
POL	0.00	0.00	-0.02	-9.10
P_POL	0.25	0.07	0.21	0.00
r2_a	0.36	0.30	0.35	0.34

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

P_NINO and P_NINA of Table 6 and Table 7).

When it comes to pollutant effects, our findings indicate that exposure *in utero* to average SO_2 concentrations in the first and third quarter of gestation influences health outcomes at birth. An increase of 10 *ppb* in SO_2 in the first quarter of gestation raises the probability of premature birth by 5 percentage points, while 1 *ppb* extra of SO_2 may cause a loss of 6.4 grams in weight at birth. In a similar study, Lavaine and Neidell [2017] find that a refinery strike in France decreased the SO_2 emissions, which could have increased the birth weight of infants living close to the refineries, particularly during the first and the third quarter of gestation. In their article, a decrease of 1 $\mu g/m^3$ of SO_2 (2.62 $\mu g/m^3$=1 *ppb*) for one month, increases the birth weight in the third quarter by 6.62 grams. Qualitatively, the results are similar to our findings, but larger.

In the case of particles, $PM_{2.5}$ exposure during the third quarter of gestation also increases the probability of being premature. The effect of an increase of 10 $\mu g/m^3$ of $PM_{2.5}$ is almost equivalent to a 6 percentage points increase in the likelihood of being premature. PM_{10} appears to decrease birth weight when exposure occurs in the second quarter of gestation. For the low weight outcome variable the sign of the PM_{10} effects differs across quarters, but when we sum the coefficients of the three quarters, the cumulative impact is not significant and statistically equal to zero (rows POL and P_POL of Table 7) (see Currie et al. [2009] and Lavaine and Neidell [2017] for references about the differences of the effect of air pollution on health by quarter of gestation). In fact, among this set of specifications, SO_2 is the only pollutant that has a negative cumulative effect during total gestational length on birth weight at conventional significance levels. Our results show a negative impact of pollution on low birth weight and premature birth. Such effects could be long-lasting, as Knittel et al. [2016] show that premature and low birth weight infants could be at higher risk of mortality in later stages of their development, when exposed to air pollution.

Although there is no statistical evidence that CO concentrations during evening peak hours affect birth weight, CO exposure seems to increase the probability of having low birth weight, being premature and decrease the weeks of gestation. This impact particularly arises if the exposure occurs in the third quarter of gestation. 1 *ppm* increase in CO raises the probability of low weight at birth by 1.5 percentage points. This is an increase of 13.6% of low birth weight children delivered on average (from a base of 11 percentage points of low birth weight in the IPS-health centers). The results are high but in line with effects of previous studies. For example, Currie et al. [2009] find that one unit change in CO would lead to an increase in low birth weight of 0.0083 (from a base of 0.106) for the second quarter of gestation, an 8% increase of the incidence of low birth weight. Aggregate coefficients (rows POL and P_POL of Table 8) of CO impacts on low birth weight are statistically different from zero at the 5% significance level. In the case of NO_X, the results indicate that this pollutant does not affect birth weight, although the coefficient is estimated with low precision.

In the set of specifications for CO and NO_X, the separate effects of ENSO show that El Niño and La Niña episodes increase the likelihood of having low weight at birth, and reduce birth weight. For El Niño events, exposure in the first and third quarter are relevant, whereas for La Niña episodes only exposure in the second quarter seems to matter. Quarter impacts of ENSO may decrease a child's birth weight from 18 to 26 grams compared to normal conditions. Cumulative ENSO effects across gestational quarters are more often statistically different from zero at the 5% of significance level for El Niño, but less for La Niña events (rows $NINO$, $NINA$, P_NINO and P_NINA of Table 8). Although some studies have already shown an effect of extreme temperature on health, we consider the impact of climatic shocks via ENSO events on health as a new channel that has not been explored in the literature yet. For example, Deschênes et al. [2009] show that exposure to extreme temperatures (particularly hot) during pregnancy leads to lower birth weight, especially during the second and third quarter of gestation (see also Barreca et al. [2015] for the effects on child mortality). For the case of Colombia, El Niño brings higher temperatures, while La Niña brings more rain. As local weather factors are already controlled for in our specifications, the ENSO events capture a more global distortion such as extreme climatic shocks.

Table 7: IV SECOND STAGE: PM_{10}-$PM_{2.5}$ (average) ON HEALTH

	PM10 (average)				PM2.5 (average)			
	Premature (1)	Low Weight (2)	Weeks Gest. (3)	Birth Weight (4)	Premature (5)	Low Weight (6)	Weeks Gest. (7)	Birth Weight (8)
Niño-Q3	0.005	0.003	-0.040	-20.068**	0.005	0.000	-0.028	-10.391
	(0.006)	(0.005)	(0.042)	(7.977)	(0.010)	(0.006)	(0.078)	(11.916)
Niño-Q2	0.002	-0.002	-0.011	-0.264	0.004	0.003	-0.025	-7.072
	(0.006)	(0.005)	(0.046)	(8.199)	(0.010)	(0.007)	(0.071)	(9.997)
Niño-Q1	0.007	0.011*	-0.017	-12.449	0.014	0.016**	-0.065	-20.121*
	(0.006)	(0.006)	(0.046)	(9.983)	(0.010)	(0.006)	(0.070)	(11.107)
Niña-Q3	0.001	-0.000	0.017	7.275	-0.034**	-0.020**	0.272**	19.773
	(0.006)	(0.005)	(0.042)	(9.285)	(0.016)	(0.009)	(0.122)	(17.348)
Niña-Q2	-0.000	0.008	-0.002	-19.390*	0.039***	0.033***	-0.260***	-44.379***
	(0.006)	(0.006)	(0.045)	(10.742)	(0.012)	(0.008)	(0.094)	(11.263)
Niña-Q1	-0.003	-0.000	0.044	-3.750	-0.001	0.002	0.029	-0.052
	(0.007)	(0.006)	(0.057)	(10.756)	(0.012)	(0.009)	(0.094)	(13.184)
pm10_ave-Q3	0.000	-0.001***	-0.001	1.195				
	(0.001)	(0.001)	(0.005)	(0.804)				
pm10_ave-Q2	0.001	0.001*	-0.003	-1.871*				
	(0.001)	(0.001)	(0.005)	(0.971)				
pm10_ave-Q1	0.000	0.001	-0.002	-0.915				
	(0.001)	(0.001)	(0.006)	(1.235)				
pm25_ave-Q3					0.006***	0.002	-0.039**	-1.632
					(0.002)	(0.001)	(0.015)	(1.992)
pm25_ave-Q2					-0.002	0.002	0.011	-2.172
					(0.002)	(0.001)	(0.014)	(2.205)
pm25_ave-Q1					0.001	0.001	-0.004	-0.421
					(0.001)	(0.001)	(0.008)	(1.307)
Observations	11027	11027	11027	11027	4413	4413	4413	4413
NINO	0.01	0.01	-0.07	-32.78	0.02	0.02	-0.12	-37.58
P_NINO	0.05	0.07	0.20	0.01	0.13	0.04	0.31	0.02
NINA	-0.00	0.01	0.06	-15.87	0.00	0.02	0.04	-24.66
P_NINA	0.83	0.38	0.43	0.22	0.86	0.23	0.79	0.21
POL	0.00	0.00	-0.01	-1.59	0.00	0.00	-0.03	-4.23
P_POL	0.25	0.55	0.40	0.27	0.32	0.09	0.29	0.29
r2_a	0.36	0.30	0.35	0.34	0.35	0.32	0.35	0.36

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

In addition, the reduced-form estimations in Appendix 2E show that ENSO shocks, weather factors and the instruments used, such as wind direction, explain around 30 to 40% (using the adjusted R^2) of the variation in the health outcomes used. As our estimations use a large set of instruments with their lags, we use the R^2 and adjusted R^2 as a measure of the total significance of the exogenous variables on health outcomes. The reduced-form results for $PM_{2.5}$ (Table 15 in Appendix 2E) give larger effects for the different instruments used and the effects of the instruments and exogenous variables are more often statistically significant at 10% level for birth weight. In many of the reduced-form estimations, there is a significant and negative effect of El Niño (Q3-gestation) on the birth weight of children, at the 5% significance level.

Table 8: IV SECOND STAGE: CO-NO_X (peak afternoon) ON HEALTH

	CO (peak afternoon)				NOX (peak afternoon)			
	Premature	Low Weight	Weeks Gest.	Birth Weight	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niño-Q3	0.003	0.011**	-0.025	-22.746***	-0.000	0.008	-0.009	-25.653***
	(0.006)	(0.006)	(0.042)	(8.249)	(0.006)	(0.006)	(0.048)	(9.667)
Niño-Q2	-0.007	-0.002	0.045	10.171	-0.005	-0.008	0.042	8.255
	(0.008)	(0.005)	(0.062)	(9.183)	(0.007)	(0.005)	(0.051)	(9.045)
Niño-Q1	0.006	0.013**	-0.013	-14.216	0.007	0.019***	-0.016	-22.639**
	(0.007)	(0.005)	(0.049)	(9.109)	(0.006)	(0.005)	(0.048)	(9.421)
Niña-Q3	0.003	0.007*	0.001	0.861	-0.002	-0.001	0.049	15.045
	(0.006)	(0.004)	(0.042)	(8.362)	(0.006)	(0.005)	(0.048)	(9.826)
Niña-Q2	-0.004	0.012***	0.020	-19.123**	-0.009	0.011**	0.052	-17.768*
	(0.005)	(0.004)	(0.038)	(8.218)	(0.007)	(0.005)	(0.053)	(9.129)
Niña-Q1	-0.003	0.002	0.043	5.939	-0.009	-0.008	0.089*	11.571
	(0.007)	(0.006)	(0.054)	(9.782)	(0.007)	(0.007)	(0.054)	(10.476)
co_peaka-Q3	0.014*	0.015**	-0.103*	2.462				
	(0.008)	(0.007)	(0.060)	(12.977)				
co_peaka-Q2	-0.004	0.010	0.010	9.545				
	(0.006)	(0.006)	(0.047)	(10.793)				
co_peaka-Q1	-0.001	0.003	-0.002	6.531				
	(0.005)	(0.004)	(0.036)	(8.242)				
nox_peaka-Q3					0.000	0.000	0.000	-0.293
					(0.000)	(0.000)	(0.003)	(0.559)
nox_peaka-Q2					-0.000	0.000	0.000	-0.753
					(0.000)	(0.000)	(0.002)	(0.505)
nox_peaka-Q1					-0.000	0.000	0.002	-0.620
					(0.000)	(0.000)	(0.002)	(0.429)
Observations	9833	9833	9833	9833	7683	7683	7683	7683
NINO	0.00	0.02	0.01	-26.79	0.00	0.02	0.02	-40.04
P_NINO	0.81	0.00	0.93	0.02	0.85	0.01	0.79	0.01
NINA	-0.00	0.02	0.06	-12.32	-0.02	0.00	0.19	8.85
P_NINA	0.67	0.00	0.38	0.31	0.07	0.88	0.02	0.53
POL	0.01	0.03	-0.10	18.54	-0.00	0.00	0.00	-1.67
P_POL	0.51	0.02	0.38	0.46	0.64	0.44	0.66	0.19
r2_a	0.37	0.30	0.35	0.34	0.38	0.33	0.36	0.37

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Peak afternoon is the average pollution during the peak in the afternoon per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Overall, the compelling message of our results is that across all specifications ENSO affects birth weight and the probability of low birth weight after separating pollution and classical local weather impacts. In addition, the semi-elasticity computations using column 4) of Table 6 shows that being exposed to a Niño event during gestation decreases birth weight by 1.02%, while an increase of one unit of *ppb* of SO_2, on average, decreases birth weight in the health centers by 0.3% (being exposed to a Niña event during gestation decreases birth weight by 0.3%).[17]

[17]The semi-elasticities are calculated for the cumulative effect (sum of the effects) for the three quarters of gestation.

Similar semi-elasticities calculated using column 8) of Table 7 show that being exposed to a Niño event during gestation decreases birth weight by 1.26%, while an increase in one $\mu g/m^3$ of $PM_{2.5}$ (average) decreases birth weight in the health centers by 0.14% (being exposed to a Niña event during gestation decreases birth weight by 0.82%). These results lead us to conclude that the ENSO effects on birth weight are several times larger than the impacts coming from pollution. It is very relevant from the policy point of view, because regardless of the measure of pollution that we employ, the amount of the impacts exhibited by climatic shocks via ENSO events dominate. If ENSO conditions may be accurately predicted by meteorologists, our article suggests that policymakers might anticipate and consider in their planning strategies to avoid health impacts caused by extreme climatic variability.

5.3 Spatial variation and residential sorting

Some potential threats to identification were discussed in subsection 4.2 and we investigate them here in more detail. Table 20 of Appendix 2G calculates the Moran Index of spatial correlation for the main weather variables and pollutants, year by year and for a spatial distance of 2km (the distance used to construct the buffers around each health center). The table shows that pollutants such as SO_2, for instance, have a positive spatial correlation but the correlations tend to change over time, with some values much smaller than in other years. This pattern holds for the different pollutants analyzed. Similar results can be seen for rainfall, temperature and wind speed. There is not only cross-section but also yearly variation for the different locations around the city. There may be a concern if the variation was driven mainly from the cross-section, and some areas tend to have more pollution than others. However, we also observe variation along time for the different locations of the IPS health center.

Another issue was that changes in air quality may result in residential sorting, for instance, if wealthier or more educated parents decide to move to cleaner neighborhoods, generating a bias in our results. To this aim, Hanna and Oliva [2015] analyze the effects of pollution on health by using the closure of a large refinery in Mexico city as a single shock, and check the problem of residential sorting by testing if migration and other demographic characteristics change in the areas analyzed before and after the shock (the instrument). We follow this approach in three steps, first by checking if our instruments affect the demographic characteristics, second, using another data-set to verify if some socioeconomic characteristics vary by locality during the years, and third, by restricting the sample to the South-West of the city.

For the first step, Table 21 of Appendix 2G shows the coefficient estimates of wind direction and wind speed (our instrumental variables for pollution) and NIÑO-NIÑA on some key socioeconomic characteristics of the running-quarter analysis. All variables are averaged at health center by running-quarter. Many variables such as parents' age, marital status, the percentage of female births in the health center and the mother's education are not affected by our instruments. In addition, the effect on the type of social security of the mother and father's education is small. Although this confirms that those factors should be controlled for in the identification, it is less likely that individuals decide to locate based on whether the wind blows pollution to some areas more than others.

For the second step, the economic factors tend to be more important in location decisions than the fact that the wind blows pollution from the south, as we observe in part b) of Table 22. Part a) of the table shows the movement of individuals between localities in the city, which tends to be stable for the years of the Multipurpose Survey for Bogotá. The last two columns of part a) of the table shows the test comparing the proportion of migration in each locality between 2011 and 2014. We fail to reject the null hypothesis that the difference in the percentage of migration between 2011 and 2014 was equal to zero (except for the locality of Engativa). Part b) of Table 22 shows the different reasons for moving between localities in the city. It shows that economic, family factors and education are the main reasons why individuals decide to move inside the city and health factors account only for around 2% of them. Part b) of the table shows the test comparing if the proportion of individuals moving for economic reasons is larger than the proportion of those moving for health reasons. We fail to reject the null hypothesis that the economic reasons for moving is larger than the health reasons for moving at the conventional levels, and by the different years.

Additionally, Table 23 presents how some socioeconomic characteristics vary for the years of the survey and by locality. We do not see large changes in the socioeconomic variables between the different years. Migration is very low by locality and the percentage of women by locality is rather stable. Although there is an increasing trend in the years of education and age, this is a general aspect similar along the localities. By including year times locality fixed effects in our estimations, the general trend should be controlled for already. The results of part b) in Table 23 show that there is no statistically significant differences in the average of the socioeconomic characteristics along the years. At least for the period we have data on, we do not have evidence to assert the presence of a residential sorting problem in terms of these variables, as they do not change drastically during the years of the sample.

With respect to the third step, residential sorting may occur from the south to the north in the city. It is common knowledge that individuals who have the economic possibilities tend to locate more towards the north and less to the south, in order to have access to better economic conditions, live in more secure areas with better amenities and probably, less pollution. For this reason, Appendix 2H and the next section show the results restricting the sample for the South-West of the city, which tends to be poorer and more polluted. The results are qualitatively similar to the ones found for the entire city with some coefficients slightly higher. This shows that the potential residential sorting from the south to the north might be less important here. If it exists, we should expect very different coefficients in the estimations using only the South-West of the city.

Another issue of residential sorting could arise if parents caring for their children may prefer some less polluted areas and also pay more attention to the mother's health during pregnancy. That is to say, a self-selection of less polluted places of residence positively correlated with the quality of the attention paid to health during pregnancy. This should be less a concern here for three reasons: 1) wind direction is exogenous, it should control for this kind of sorting problem; also, wind direction tends to change during the years, there is not only cross-section but also time variation of wind, which helps in the identification (see Appendix 2D); 2) Panel b) of Table 22 in Appendix 2G shows that individuals in fact move inside the city mainly for economic reasons, then for family or education reasons, while health aspect accounts for just 2% of those permanent movements; 3) even if some mothers pay attention to the levels of pollution during pregnancy, it would not be economically feasible for many mothers to relocate to areas of less pollution only during the specific time of pregnancy in an urban city like Bogotá; this re-settlement would be very costly for just the months of the pregnancy.

5.4 Restricting the sample to the South-West of the city, aggregating by localities and using a bigger buffer

Appendix 2H shows a robustness check by restricting the sample only to the localities of Bosa, Ciudad Bolivar, Engativa, Fontibon, Kennedy, Puente Aranda and Tunjuelito, located in the South-West of the city. These localities tend to be poorer and to present higher levels of pollution than other areas of the city. Also, as it is shown in the map of wind direction and wind speed in Appendix 2D, the wind blows towards the south-west of the city. The second stage tables (Table 25 and Table 26) are qualitatively similar to the ones presented in subsection 5.2, and give evidence that the results are not driven only by localities with higher pollution and lower income. However, some of the coefficients for El Niño as well as for PM_{10} and $PM_{2.5}$ are slightly larger than before. For the south-west of the city, we find that the cumulative effect (sum of the three coefficients) is statistically significant at the 10% level less often than with the baseline sample for PM_{10} and $PM_{2.5}$. In line with the baseline sample, the first-stage estimates of Appendix 2H show the presence of statistical correlation between the instruments of wind direction with pollutant concentrations (Table 27 and Table 28).

As an additional robustness check, Appendix 2I presents the results aggregating the sample by locality. Although we lose precision in assigning pollution and weather variables to a whole locality, the results follow a similar pattern for some of the pollutants presented in subsection 5.2. Table 29, Table 30 and Table 31 give the results for the second stage estimations. Regarding ENSO events, the quarterly coefficients and the cumulative effects follow a similar pattern as in the baseline estimation for CO, PM_{10} and $PM_{2.5}$ in general and for NO_X, but mainly for birth weight. The results are less intuitive in the estimation involving SO_2, which could be due to the lack of precision while aggregating the sample at the locality level. The effects of PM_{10} and CO by quarter are qualitatively similar to those obtained when aggregating by IPS health centers. Interestingly, the quarterly coefficients are less often statistically significant at conventional levels in comparison to the main baseline results. However, the cumulative effect is very similar for CO, PM_{10} and $PM_{2.5}$ with more statistically significant results and in the expected direction for NO_X (not for SO_2). The first-stage estimates of Appendix 2I confirm the statistical correlation between the instruments of wind direction with pollutant concentrations (Table 32 and Table 33).

We carry out an additional robustness check by changing the size of the buffer around each health center to investigate the sensitivity of the results. As the spatial correlation between the place of residence and the health center location is certainly positive (but not necessarily high) and we do not know where the mother actually live, we prefer to use a larger buffer of 4km. By increasing the buffer and giving a decreasing weight to the farthest measurement stations, we increase the likelihood that the measure better characterizes the air pollution level in the area where the mother is supposed to live / work / sleep during pregnancy. The results of ENSO and pollution on health outcomes using the buffer of 4km (see Appendix 2J) are qualitatively and quantitatively very similar to the baseline results using a buffer of 2km (see Table 6, Table 7 and Table 7), with a few coefficients of the ENSO effect on health outcomes with the 4km buffer being slightly smaller. In this regard, the results are very robust with respect to changes in the buffer size and the concern that air pollution might not be correctly assigned to where the mother lives seems to be less of an issue here.

Another potential concern is whether the pollution monitoring stations that underlie the computation of the weighted average concentration around each health center are of the same type (roadside, urban, industrial, near city background), and could affect the results. Although using health center fixed effects should control for this, the robustness check changing the 2km buffer when assigning pollution data to the health centers helps also to deal with the differences in the type of monitoring station. As mentioned previously, the results are very robust to the use of a bigger buffer of 4km and the differences in the type of monitoring station should be of less concern in the estimations.

5.5 Direction of the OLS bias

Appendix 2K has the OLS estimations of the effects of ENSO and pollution on the main variables of health without the instruments. This exercise allows us to understand better the direction of the bias, by comparing the IV results of the 2nd stage with this table. Across the majority of the estimations, the negative effect of ENSO and pollution on health is underestimated. For example, columns 3) and 4) of Table 6 and Table 7 show a higher negative effect of ENSO on weeks of gestation and on birth weight, compared to the coefficients in Table 37, columns 3, 4, 7 and 8. With respect to pollution, the majority of the coefficients in Table 37 are not statistically significant, but once we adjust the estimations in the IV regressions, we find the negative effect of pollution on the health variables used. Not solving the endogeneity problem in the estimations could lead us to neglect the negative effect of the pollutants on health and underestimate the negative impact of ENSO.

5.6 Heterogeneous effects, additional health outcomes and air pollution index

We explore heterogeneity with respect to the educational level of the mother. In the estimations, the variables representing the mother's education variables are defined as the percentage of mothers delivering in the IPS-health center with primary education, secondary education or tertiary education. We use the interaction of the tertiary education variable with ENSO events as we are more interested in the effects of these shocks on human capital and consumption, particularly for mothers with higher education (see Appendix 2L). Stunningly, the negative effect of ENSO events on health outcomes at birth is driven by mothers without tertiary education (primary or secondary education), with a positive effect from ENSO for the mothers with tertiary education. This pattern is found across all the different estimations using the different pollutants (Table 38, Table 39 and Table 40). For instance, the effect of having an El Niño episode during the three quarters of gestation if the mother had primary or secondary education is a reduction in the birth weight of the child of 19.42 grams, while a La Niña episode entails a reduction in the birth weight of the child of 30.81 grams (cumulative impact, rows $NINO$-$NINA$ of column 4, Table 38 in Appendix 2L). However, the cumulative effect of having an El Niño episode for a child with a mother with tertiary education is an increase in the birth weight of 32.9 grams, while having a La Niña episode for a child with a mother with tertiary education is an increase in the birth weight of 106.05 grams (cumulative impact, rows $NINO\_EDU$-$NINA\_EDU$ of column 4), Table 38 in Appendix 2L). It is also compelling to find that the effects of pollution on health outcomes for the estimations interacting ENSO events with tertiary education are robust and similar to the ones found in Table 6, Table 7 and Table 8.

In Appendix 2M, we explore if ENSO events and pollution can also affect three additional health outcomes. First, the average Apgar score at one minute of birth (index 1-10) of the children born in the health center, which can help to assess the health of the newborn at birth. Second, we combine low weight at birth and prematurity in a single indicator to better characterize the most adverse health effects. And third, we construct the sex-ratio as the percentage of boys over the percentage of girls for the children born in that health center (see Lichtenfels et al. [2007] for evidence of the change of male to female ratio due to pollution). With respect to the second additional outcome, it is possible that low birth weight is observed at term, or that premature newborns have a reasonable weight, which could weaken the detection of adverse health effects from air pollution exposure. Despite that, a newborn with low weight and prematurity is more likely to reflect the effects of exposure to harmful conditions during pregnancy. Economically speaking, this would also involve higher medical costs, educational costs during childhood or opportunity losses in future earnings (see for example Almond and Currie [2011a] and Almond et al. [2005]).

We do not find statistically significant effects of ENSO on the Apgar score in Table 41 and Table 42 in Appendix 2M, with some mixed results from pollutants on the score (positive effect from quarter two and quarter three from SO_2 and negative impact from CO in the first quarter). Nonetheless, the separate effects of ENSO show that El Niño episodes (but not La Niña) increase the likelihood of having low weight and being premature at birth. Using the aggregate coefficients (rows $NINO$ and P_NINO of Table 41 and Table 42) the El Niño impact on having low weight and being premature at birth are statistically different from zero at the 5% significance level in the estimations using SO_2, CO and NO_X and at 10% significance level for PM_{10}. With respect to pollutants, only SO_2 and CO have a statistically significant effect at reasonable levels on the low birth weight and premature variable. In terms of magnitude, being exposed to El Niño during the three quarters of gestation increases the percentage of children with low weight and premature by 2 percentage points (baseline of 8% in Table 1). An increase of 1 *ppm* of CO also rises the percentage of children with low weight and prematurity by 2 percentage points during the three quarters.

With respect to the last outcome variable, being exposed to El Niño decreases the sex ratio (on average less boys are born), particularly during the second quarter of gestation (columns 3 and 6 of Table 41 and Table 42 in Appendix 2M), but the effect is the opposite during the first and third quarter of gestation. However, the net cumulative effect during the three quarters of gestation is null, and only statistically significant for El Niño at the 10% of significance level in one specification. There is no statistically significant effects from the cumulative effect from La Niña at reasonable levels across all the estimations and during the different quarters of gestation. Regarding the pollutant variables, only SO_2 has a statistically significant effect at the 5% significance level on the sex ratio variable.

Finally, we construct a quarterly index of pollution which gathers the level of exposure of the five main pollutants. Following Arceo et al. [2015], we apply principal component analysis (PCA) on the standardized version of the pollutants of the main specifications (SO_2, PM_{10}, $PM_{2.5}$ (average), CO, NO_X (peak afternoon). The estimations use the first principal component, which has an eigenvalue larger than one. As $PM_{2.5}$ has many missing values, PCA version A includes $PM_{2.5}$ (explained variation of 48.9%), while PCA version B does not include $PM_{2.5}$ (explained variation of 44.1%). Both indices are scaled to be between zero and one for an easier interpretation. Table 43 in Appendix 2N shows that PCA version A uses a very small sample of observations, which might not be large enough to capture the time variation of the effects of ENSO events. For a better interpretation, we use PCA version B of Table 43 in Appendix 2N. With this composite measure of pollution, being exposed to El Niño increases the percentage of children with low weight at birth in the IPS by 3 percentage points across the three quarters of gestation (cumulative effect), while an increase of 0.1 units in the index of pollution increases the percentage of children with low weight at birth in the IPS by 2 percentage points across the three quarters of gestation (cumulative effect). The effect of El Niño on weight at birth follows the same pattern, so being exposed to the phenomenon decreases the weight at birth by 40.1 grams (cumulative effect). The results for the cumulative effect on birth weight are not statistically significant at reasonable levels for the index of pollution, but qualitatively similar to the ones found using the pollutants separately.

6 Conclusions

This article contributes to the literature of air pollution and health by adding an additional channel, the effect of ENSO events (El Niño and La Niña) on health. Although there is a vast literature of the effects of air pollution on health [Graff Zivin and Neidell, 2013, Lavaine and Neidell, 2017, Arceo et al., 2015], our research, unlike other studies, investigates at the same time the effects of ENSO events, air pollution and local weather on health. Our argument is that ENSO not only manifests itself as an extreme climatic shock that influences weather, but that it also has an impact on agriculture inducing changes in food markets and household income and consumption, which influence health. Therefore, the impact of pollution on health can be seen as separate effects from the other shocks mediated through ENSO events. Although the effects of air pollution on health have already been studied in the literature using similar instrumental variables like the ones used here (wind direction), the channel of ENSO events on health has not been explored yet. Our approach relies on studies like Hsiang et al. [2011] and Dingel et al. [2020], where ENSO events are considered in a wide perspective as global effects, affecting not only weather factors, but also creating disturbances on economic variables and, in that manner, pregnant mothers and infant health. Our article links the literature on air pollution and health and the growing number of studies that assesses the impact of extreme temperatures on health (see Barreca et al. [2015], Deschênes et al. [2009], Deschênes and Greenstone [2011]).

We conduct the analysis using data for Bogotá from 1998 to 2015, a city with high levels of pollution. Our approach consists of creating a running-quarter panel of health centers, where the quarter corresponds to the quarter of gestation for the infants born at a specific time in the health center. The identification strategy relies on a two stage approach, where the first stage instruments the pollution equation by wind direction; the second stage establishes the relationship of pollution and ENSO on health, controlling for weather factors, among other controls. Importantly, the system has the advantage of capturing the lagged effect on health of the exposure to pollution and ENSO during the three quarters of gestation.

Regarding ENSO impacts, when estimations involve SO_2, PM_{10} and $PM_{2.5}$, El Niño and La Niña events reduce birth weight when exposure happens in the last quarter of gestation, the period in which the mother is close to deliver. In the estimations with CO and NO_X, the separate effects of ENSO show that El Niño (in the third and first quarter) and La Niña (in the second quarter) increase the likelihood of having low weight at birth, and reduce the birth weight. Independently of the pollutant used, the cumulative effect of ENSO across gestational quarters is more often statistically different from zero at conventional significance levels for El Niño, but less for La Niña episodes.

For the effects of pollution on health, we find that exposure *in utero* to average SO_2 concentrations in the first and third quarter of gestation influences several health outcomes at birth, while $PM_{2.5}$ exposure during the third quarter of gestation increases the probability of being premature. In addition, PM_{10} appears to decrease birth weight when exposure occurs in the second quarter of gestation, while CO exposure (in the second and particularly, in the third quarter) increases the probability of having low birth weight. When analysing the cumulative effect during the total gestational length, SO_2 and CO are the only pollutants that have a negative impact on birth weight at conventional significance levels.

In a nutshell, across all specifications our results indicate that after including the channels of pollution and classical local weather, during some gestational quarters ENSO affects birth weight. Moreover, the size of this impact is much larger than the consequences of pollution exposure alone. Our article thus sheds light on the magnitude of the estimate of the overall effect of extreme climatic shocks on health at birth via ENSO. To the extent that accurate weather and ENSO forecasts are available, policymakers could design ex-ante measures to mitigate the impact of these shocks and implement policies to reduce the health effects induced by extreme climatic variability. As the *in utero* period is one of the most important stages for children's later development and a crucial component of human capital development (see Almond and Currie [2011a]), policy interventions should also be targeted during pregnancy.

References

Davinson S. Abril-Salcedo, Luis F. Melo-Velandia, and Daniel Parra-Amado. Nonlinear relationship between the weather phenomenon El Niño and Colombian food prices. *The Australian Journal of Agricultural and Resource Economics*, doi: 10.1111/1467-8489.12394(59): 1–28, 2020.

Douglas Almond and Janet Currie. Human capital development before age five. In David Card and Orley Ashenfelter, editors, *Handbook of Labor Economics*, volume 4 Part B Chapter 15, pages 1315–1486. Elsevier, 2011a.

Douglas Almond and Janet Currie. Killing me softly: The fetal origins hypothesis. *Journal of Economic Perspectives*, 25(3):153–172, 2011b.

Douglas Almond, Kenneth Chay, and David S. Lee. The costs of low birth weight. *Quarterly Journal of Economics*, 120(3):1031–1083, 2005.

Michael Anderson. Subways, strikes, and slowdowns: The impacts of public transit on traffic congestion. *American Economic Review*, 104(9):2763–2796, 2014.

Eva Arceo, Rema Hanna, and Paulina Oliva. Does the effect of pollution on infant mortality differ between developing and developed countries? Evidence from Mexico City. *The Economic Journal*, 126(1):257–280, 2015.

Alan Barreca and Jessamyn Schaller. The impact of high ambient temperatures on delivery timing and gestational length. *Nature Climate Change*, 10:77–82, 2020.

Alan Barreca, Karen Clay, Olivier Deschênes, Michael Greenstone, and Joseph J. Shapiro. Convergence in adaptation to climate change: Evidence from high temperatures and mortality, 1900-2004. *American Economic Review: Papers and Proceedings*, 105(5):247–251, 2015.

Kimberly Barrett, Michael J. Lynch, Michael Long, and Paul B. Stretesky. Monetary penalties and noncompliance with environmental laws: a mediation analysis. *American Journal of Criminal Justice*, 43(3):530–550, 2017.

Eduardo Behrentz, Juan M. Benavides, Juan P. Bocarejo, Margarita Canal, Monica Espinosa, Natalia Franco, Ivan D. Lobo, Oscar A. Pardo, and Mauricio Sanchez. Decadal plan for air decontamination for Bogotá. *Report for the Secretary of Environment of Bogotá*, 1(1):1–324, 2010.

Juan F. Brando and Rafael J. Santos. La niña y los niños: Effects of an unexpected winter on early life human capital and family responses. *Documents CEDE-Los Andes University*, 1 (013316):1–60, 2015.

Cyril Caminade, Joanne Turner, Soeren Metelmann, Jenny C. Hesson, Marcus S. C. Blagrove, Tom Solomon, Andrew P. Morse, and Matthew Baylisa. Global risk model for vector-borne transmission of Zika virus reveals the role of El Niño 2015. *PNAS-Proceedings of the National Academy of Sciences of the United States of America*, 114(1):119–124, 2016.

Dalton Conley, Kate W. Strully, and Neil G. Bennett. Birth weight and income: interactions across generations. *Journal of Health and Social Behavior*, 42(4):450âĂŞ465, 2001.

Dalton Conley, Kate W. Strully, and Neil G. Bennett. Twin differences in birth weight: the effects of genotype and prenatal environment on neonatal and post-natal mortality. *Economics and Human Biology*, 4(2):151–183, 2006.

Janet Currie, Mathew Neidell, and Johannes F. Schmieder. Air pollution and infant health: Lessons from New Jersey. *Journal of Health Economics*, 28:688–703, 2009.

Dolores de la Mata and Carlos F. Gaviria. Exposure to pollution and infant health: evidence from Colombia. *Working Paper CINCH Competence in competition + health*, 1(1):1–50, 2019.

Tatyana Deryugina, Garth Heutel, Nolan H. Miller, David Molitor, and Julian Reif. The mortality and medical costs of air pollution: evidence from changes in wind direction. *American Economic Review*, 109(12):4178–4219, 2019.

Olivier Deschênes and Michael Greenstone. Climate change, mortality, and adaptation: Evidence from annual fluctuations in weather in the US. *American Economic Journal: Applied Economics*, 3(4):152–185, 2011.

Olivier Deschênes, Michael Greenstone, and Jonathan Guryan. Climate change and birth weight. *American Economic Review: Papers and Proceedings*, 99(2):211–217, 2009.

Olivier Deschênes, Michael Greenstone, and Joseph J. Shapiro. Defensive investments and the demand for air quality: evidence from the NOx budget program. *American Economic Review*, 107(10):2958–2989, 2017.

Jonathan I. Dingel, Solomon Hsiang, and Kyle Meng. Spatial correlation, trade, and inequality: Evidence from the global climate. *NBER WP*, DOI 10.3386/w25447(25447), 2020.

DNP. Costs on health associated with the environmental degradation in Colombia. *Report of the National Department of Planning of Colombia*, 1(1), 2017.

John Driscoll and Aart Kraay. Consistent covariance matrix estimation with spatially dependent panel data. *The Review of Economics and Statistics*, 80(4):549–560, 1998.

Giovanis Eleftherios and Ozdamar Oznur. Structural equation modelling and the causal effect of permanent income on life satisfaction: the case of air pollution in Switzerland. *Journal of Economic Survey*, 30(3):430–459, 2016.

Olivier A. Elorreaga, Luis Huicho, and Andres G. Lescano. El niño/southern oscillation (enso) and stunting in children under 5 years in Peru: a double-difference analysis. *The Lancet*, 8 Special Issue(29):29–29, 2020.

Joshua Graff Zivin and Matthew Neidell. The impact of pollution on worker productivity. *American Economic Review*, 102(7):3652–3673, 2012.

Joshua Graff Zivin and Matthew Neidell. Environment, health and human capital. *Journal of Economic Literature*, 51(3):689–730, 2013.

Maria Grundström, Hans W. Linderholm, Jenny Klingberg, and Pleijel Håkan. Urban NO2 and NO pollution in relation to the North Atlantic oscillation NAO. *Atmospheric Environment*, 45:883–888, 2011.

Ling-Chuan Guo, Yonghui Zhang, Hualiang Lin, Weilin Zeng, Tao Liu, Jianpeng Xiao, Shannon Rutherford, Jing You, and Wenjun Ma. The washout effects of rainfall on atmospheric particulate pollution in two Chinese cities. *Environmental Pollution*, 215(1):195–202, 2016.

Regina Hampel, Johanna Lepeule, Alexandra Schneider, Sébastien Bottagisi, Marie-Aline Charles, Pierre Ducimetière, Annette Peters, and Rémy Slamab. Short-term impact of ambient air pollution and air temperature on blood pressure among pregnant women. *Journal of Epidemiology*, 22:671–679, 2011.

Rema Hanna and Paulina Oliva. The effect of pollution on labor supply: Evidence from a natural experiment in Mexico City. *Journal of Public Economics*, 122:68–79, 2015.

Solomon Hsiang, Kyle Meng, and Mark Cane. Civil conflicts are associated with the global climate. *Letter Research Nature*, 476:438–441, 2011.

Christopher Knittel, Douglas Miller, and Nicholas Sanders. Caution, drivers! children present: traffic, pollution, and infant health. *Review of Economics and Statistics*, 98(2):350–366, 2016.

Jinyoung Ko, Cha-Lee Myung, and Simsoo Park. Impacts of ambient temperature, DPF regeneration, and traffic congestion on NO_x emissions from a Euro 6-compliant diesel vehicle equipped with an LNT under real-world driving conditions. *Atmospheric Environment*, 200 (1):1–14, 2019.

Sari Kovats, Menno J. Bouma, Shakoor Hajat, Eve Worrall, and Andy Haines. El Niño and health. *The Lancet*, 362(9394):1481–1489, 2003.

Kate Laffan. Every breath you take, every move you make: Visits to the outdoors and physical activity help to explain the relationship between air pollution and subjective wellbeing. *Ecological Economics*, 147:96–113, 2018.

Emmanuelle Lavaine and Matthew Neidell. Energy production and health externalities: Evidence from oil refinery strikes in France. *Journal of the Association of Environmental and Resource Economists*, 4(2):1–31, 2017.

Ana Julia F. C. Lichtenfels, Joabner B. Gomes, Patricia C. Pieri, Simone G. El Khouri Miraglia, Jorge Hallak, and Paulo H. N. Saldiva. Increased levels of air pollution and a decrease in the human and mouse male-to-female ratio in São Paulo, Brazil. *Fertility and Sterility*, 87(1): 230–232, 2007.

Wolfram Schlenker and W. Reed Walker. Airports, air pollution, and contemporaneous health. *The Review of Economic Studies*, 83(2):768–809, 2016.

District Secretary-Environment. Annual report of air quality in Bogotá. *Report RMCAB*, 1: 1–181, 2015.

Douglas Staiger and James H. Stock. Instrumental variables regression with weak instruments. *Econometrica*, 65(3):557–586, 1997.

Nils Chr. Stenseth, Geir Ottersen, James W. Hurrell, Atle Mysterud, Mauricio Lima, Kung-Sik Chan, Nigel G. Yoccoz, and Bjørn Alandsvik. Studying climate effects on ecology through the use of climate indices: the North Atlantic Oscillation, El Niño Southern Oscillation and beyond. *The Royal Society Review Paper*, 270:2087–2096, 2003.

Guojian Wang, Wenju Cai, Bolan Gan, Lixin Wu, Agus Santoso, Xiaopei Lin, Zhaohui Chen, and Michael J. McPhaden. Continued increase of extreme El Niño frequency long after 1.5 Celsius degrees warming stabilization. *Nature Climate Change*, 7:568–572, 2017.

Ann Watson, Richard Bates, and Donald Kennedy (Editors). *Air Pollution, the Automobile, and Public Health.* National Academies Press (US), 1988.

Appendices

2A Appendix Summary Traffic Policies - Wind Direction

Table 9: Traffic Policies

No Car Days		
February 4, 2000	February 1, 2001	February 7, 2002
February 6, 2003	September 22, 2003	February 5, 2004
February 3, 2005	February 2, 2006	February 1, 2007
February 7, 2008	February 5, 2009	February 4, 2010
February 3, 2011	February 2, 2012	February 7, 2013
February 6, 2014	February 5, 2015	April 22, 2015

Transmilenio Phases		
	Starting in	**Ending in**
Phase I	December 4, 2000	September 26, 2003
Phase II	September 27, 2003	June 8, 2012
Phase III	June 9, 2012	Still in place

Peak and Plate Changes		
	Starting in	**Ending in**
Peak and Plate 1	August 18, 1998	February 5, 2009
Peak and Plate 2	February 6, 2009	July 2, 2012
Peak and Plate 3	July 3, 2012	Still in place

Table 10: Wind Direction (Categories)

Categories	Wind Direction	Degrees Range
1	**North**	337.5° - 22.5°
2	**North-East**	22.5° - 67.5°
3	**East**	67.5° - 112.5°
4	**South-East**	112.5° - 157.5°
5	**South**	157.5° - 202.5°
6	**South-West**	202.5° - 247.5°
7	**West**	247.5° - 292.5°
8	**North-West**	292.5° - 337.5°

2B Identification of the effects on Weather and Pollution Hourly Analysis

2B.1 ONI Index

As ENSO events bring more extreme weather events, the first equation to estimate is:

$$\begin{aligned} Weather_{i,h,t} &= \beta_0 + \beta_1 \times ONI_t + \gamma_i + \theta_i \times t \\ &+\nu_{month} + \varepsilon_{i,h,t} \quad for \quad h = 1, 2, ..., 24 \end{aligned} \tag{2}$$

where ONI is the continuous monthly index as described previously. γ_i and $\theta_i \times t$ are station-specific fixed effects and station trends to account for unobserved time-invariant differences and trends across i. Equation 2 also includes ν_{month} as fixed effects for the month of the year, which should control for seasonal effects on weather.
The coefficient of interest is β_1.[18] It measures the effect of a unit increase in the monthly ONI index on weather in time t for each specific hour $h = 1, 2, ..., 24$. This allows to capture easily the effect of a unit increase in the ONI index on weather for the first hour, for the second hour, and so on. $\varepsilon_{i,h,t}$ are the standard errors, which are clustered at the i station level in the estimation.

In a second step, we estimate the effects of ONI on pollutants:

$$\begin{aligned} Pollution_{i,h,t} &= \alpha_0 + \alpha_1 \times ONI_t + \Gamma_i + \omega_i \times t + \eta_{dow} + \mu_{month} \\ &+\alpha_2 \times WS + \alpha_3 \times WS^2 + \kappa_{wd} + \psi_{no-car} + \phi_{Transmilenio} \\ &+\delta_{peak-plate} + \epsilon_{i,h,t} \quad for \quad h = 1, 2, ..., 24 \end{aligned} \tag{3}$$

[18] As an alternative to equation 2 that captures the ONI effect for each hour separately (24 regressions), we estimate a model of the ONI effect for all the 24 hours (by interacting the ONI index with each hour in a more parsimonious way), controlling for hourly fixed effects, and the same set of fixed effects as in equation 2. However, the article only presents the empirical strategy hour by hour, that we consider more conservative. For illustrative purposes, the results of this alternative model are shown in the Appendix 2B.5 and Appendix 2B.6 as MODEL B. MODEL J is the baseline presented here.

This relates the monthly effect of the ONI index on pollutants for station i and hourly time t. As previously, the effect is evaluated hour by hour so it creates a set of twenty-four regressions per pollutant. Equation 3 follows a similar structure as Equation 2, except that it includes η_{dow} as fixed effects of the day of the week. It is expected that traffic patterns change depending on the day of the week, particularly during Saturdays and Sundays.

Equation 3 also includes other weather factors such as wind speed (WS) in a quadratic way and a set of dummy variables of wind direction (8 categories, see Appendix 2A, and Appendix 2D for a detailed description). The inclusion of additional weather factors such as wind speed and wind direction have been well documented in the literature and not including them would lead to omitted variable bias (see Knittel et al. [2016] or Hanna and Oliva [2015]). Weather factors should have a relation with pollution, but it might be that during El Niño or La Niña events, the interaction changes and affects the levels of pollution. This could increase the levels of pollution or even reduce them, depending on the type of pollutant.

In terms of traffic policies, equation 3 includes a dummy for the no-car-day measure, a set of dummies for three different Transmilenio[19] Phases implemented in the city and a set of dummies for three changes in the peak-and-plate measures to reduce traffic congestion (See Appendix 2A). $\epsilon_{i,h,t}$ are the standard errors as usual. In the estimations, the errors are clustered at the monitoring station or i level.

2B.2 Separating the effects of NIÑO and NIÑA

To complement the analysis and understand better the effects of El Niño versus La Niña, we estimate a variant of equation 2 in which we replace the ONI index by dummies of El Niño and La Niña. This allows to compare the effect of both events with normal months (or months with no events).

As before, the first equation to estimate is:

$$\begin{aligned} Weather_{i,h,t} = \beta_0' + \beta_1' \times NI\tilde{N}O_t + \beta_2' \times NI\tilde{N}A_t + \gamma_i' + \theta_i' \times t \\ + \nu_{month}' + \varepsilon_{i,h,t}' \quad for \quad h = 1, 2, ..., 24 \end{aligned} \tag{4}$$

The coefficients of interest are β_1 and β_2.[20] Here, NIÑO and NIÑA are discrete dummies to account for periods when the events happened. As in the case of ONI (equation 2), γ_i' and $\theta_i' \times t$ are station-specific fixed effects and station trends to account for unobserved time-invariant differences and trends across i stations and ν_{month}' are fixed effects for the month of the year, to

[19] Transmilenio is the massive transportation system currently working in the city and it was implemented in three phases.

[20] Like for equation 2, equation 4 is also estimated for an alternative model of the ONI effect for all the 24 hours (by interacting the NIÑO and NIÑA dummies with each hour in a more parsimonious way), controlling for hourly fixed effects, the NIÑO and NIÑA dummies, and the same set of fixed effects as in equation 4. This section only presents the empirical strategy of the 24 hour by hour regressions, that we consider more conservative. For illustrative purposes, the results of this alternative model are shown in subsection 2B.5 and subsection 2B.6 as MODEL B. MODEL J is the baseline presented here.

control for seasonal effects on weather. Equation 4 estimates the monthly effect of NIÑO and NIÑA (with respect to normal months) on weather in time t for each specific hour $h = 1, 2, ..., 24$. $\varepsilon'_{i,h,t}$ are the standard errors, which are clustered at the i or station level in the estimation.

The second step will be to estimate the effects of NIÑO and NIÑA on pollutants:

$$\begin{aligned} Pollution_{i,h,t} = \alpha'_0 + \alpha'_1 \times NI\tilde{N}O_t + \alpha'_2 \times NI\tilde{N}A_t + \Gamma'_i + \omega'_i \times t + \eta'_{dow} + \mu'_{month} \\ + \alpha'_3 \times WS + \alpha'_4 \times WS^2 + \kappa'_{wd} + \psi'_{no-car} + \phi'_{Transmilenio} \\ + \delta'_{peak-plate} + \epsilon'_{i,h,t} \quad for \quad h = 1, 2, ..., 24 \end{aligned} \tag{5}$$

This relates the monthly effect of NIÑO and NIÑA (with respect to normal months) on pollutants for station i and hourly time t. As previously, the effect is evaluated hour by hour so it creates a set of twenty-four regressions per pollutant. Equation 5 includes identical controls as those used in equation 3. $\epsilon'_{i,h,t}$ are the standard errors, which are clustered at the i or station level in the estimations.

An alternative model was estimated including ONI events (and NIÑO-NIÑA) in a contemporaneous and in a lagged way (a month back). As the effects do not change a lot, they are not presented here.[21] In the case of NIÑO-NIÑA, a potential explanation is that by definition, the events are determined when the ONI index reaches five consecutive months above or below 0.5, hence, it already captures the impact from previous periods and there is no need to include lags for the ONI index or lags for NIÑO-NIÑA in the respective equations.

2B.3 Results of ONI-NIÑO-NIÑA on weather - Hourly Analysis

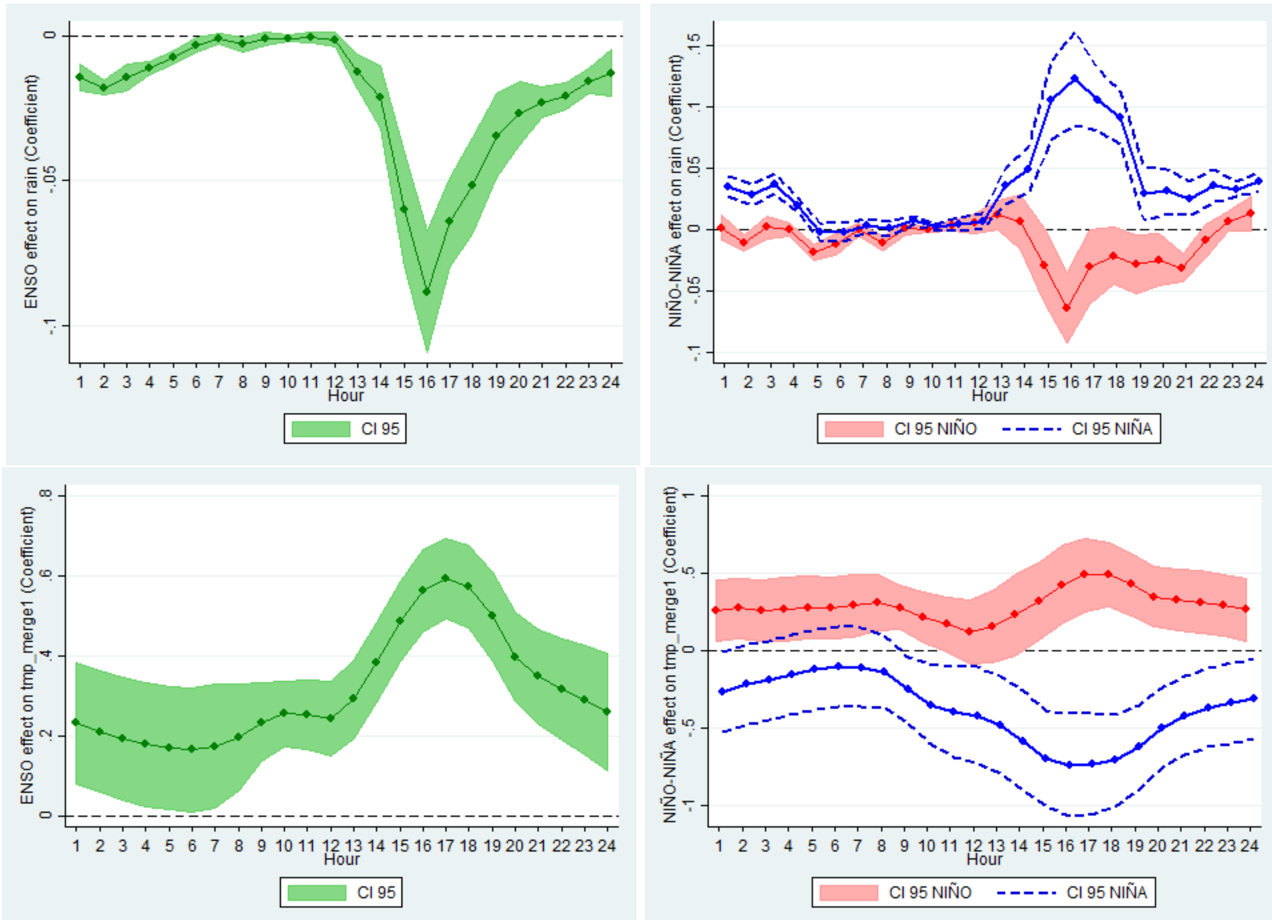
Figure 7 shows the ONI effect and NIÑO-NIÑA on rain and temperature (tmp), as described in the equations 2 and 4. The effects are estimated hour by hour and graphed with 95% confidence intervals. The ONI index tends to decrease rainfall, particularly after 1pm, reaching a minimum at 4pm, while it increases the temperature during all the 24 hours, reaching a maximum around 5pm.

As discussed in the introduction, El Niño is associated with less rain (in comparison with normal months), while La Niña comes with more (in comparison with normal months). In terms of temperature, it increases during the majority of the hours of El Niño, while it decreases during La Niña. Importantly, rain and temperature tend to be more affected by La Niña than by El Niño. Rain and temperature also reach the maximum and minimum around 4pm-5pm, time during which individuals are moving in the city. Also, temperature increases in 0.5 degrees Celsius during El Niño, while it decreases 0.7 degrees Celsius during La Niña. This shows the differences in magnitude that both ENSO events have in the city.

Additionally, the effect on weather is higher during the afternoon peak than during the morning peak. The results of these estimations can be found in Table 11 of Appendix 2B.5 as MODEL

[21] Results available upon request.

Figure 7: ONI-NIÑO-NIÑA on weather-24hours schedule



Source: based on the Air Quality Monitoring Network Data for Bogotá (RMCAB) ENSO(ONI) in green and NIÑO-NIÑA in red and blue respectively

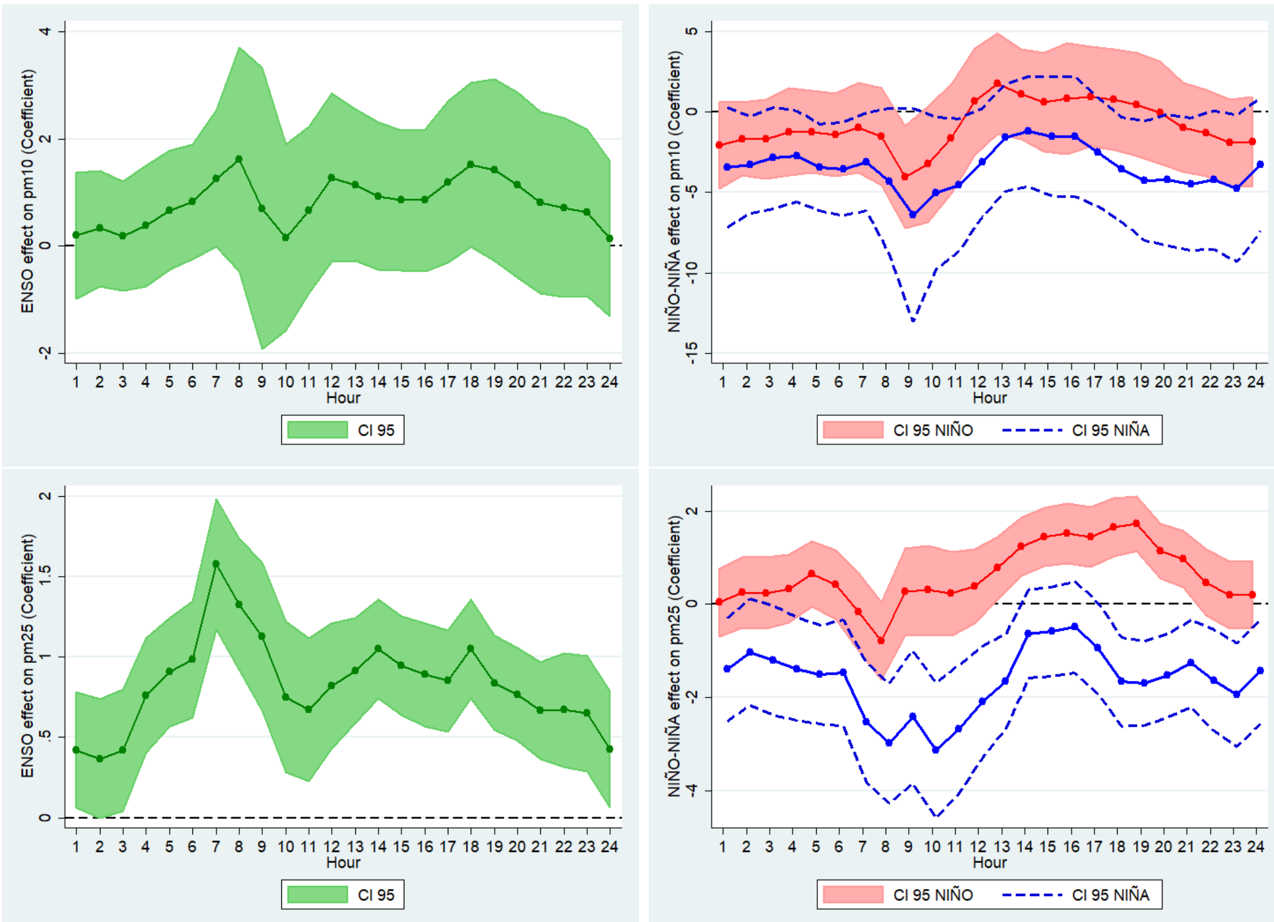
J; as explained, an alternative MODEL B was estimated, but it is shown only in the appendices for illustrative purposes.

In terms of weather, the Institute of Hydrology, Meteorology and Environmental Studies of Colombia (known by its acronym in Spanish, IDEAM) has conducted some studies of the effects of El Niño-La Niña on weather, but only on a monthly base. In this sense, this study provides a deeper analysis on an hourly basis for the city of Bogotá.

2B.4 Results of ONI-NIÑO-NIÑA on pollution - Hourly Analysis

Although information is available for different pollutants, the analysis will focus on four contaminants, particulate matters or PM_{10} and $PM_{2.5}$, Nitrogen Oxide NO_x and Carbon Monoxide CO. In the same way as for weather factors, figure 8 gives the estimated coefficients of ONI-NIÑO-NIÑA on particulate matters PM_{10} and $PM_{2.5}$ hour by hour that were described in equation 3 and equation 5.

Figure 8: ONI-NIÑO-NIÑA on Pollutants ($PM_{10} - PM_{2.5}$)-24hours schedule



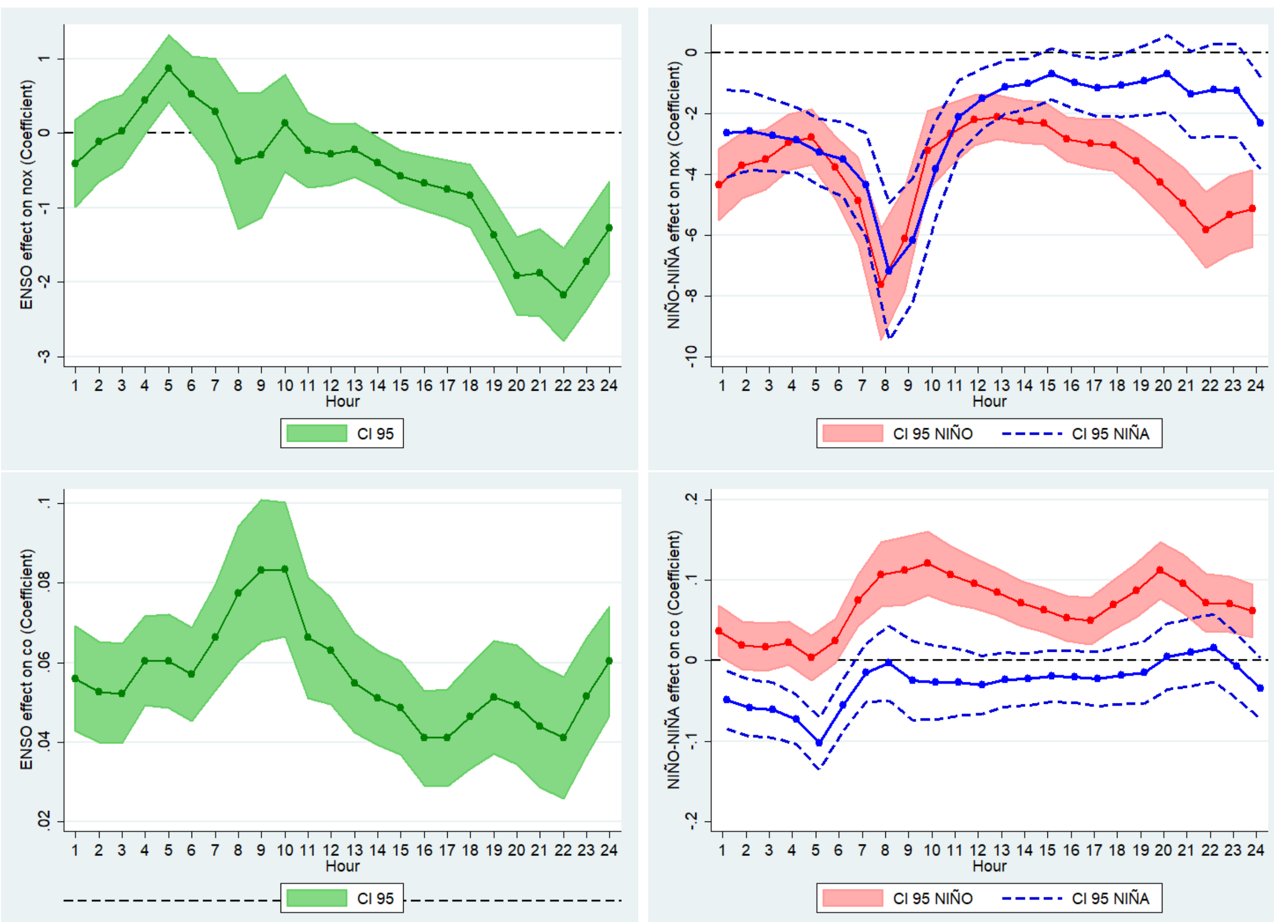
Source: based on the Air Quality Monitoring Network Data for Bogotá (RMCAB) ENSO(ONI) in green and NIÑO-NIÑA in red and blue respectively

The figure shows that the ONI index affects more PM_{10} than $PM_{2.5}$, with significant results for $PM_{2.5}$. In spite of that, both particulate matters follow similar patterns during the hourly schedule, increasing early in the morning and reaching a maximum peak at 8am-9am, decreasing and fluctuating around the same range of values later on. Interestingly, the peak in the afternoon is less pronounced.

If the ENSO events are isolated using equation 5, effects are found more of La Niña than El Niño on PM_{10}, but they are very small. La Niña effects are bigger for $PM_{2.5}$, reducing the concentration levels during the morning peak. It can reach a reduction of 0.3 micrograms per cubic meter on particulate matter at 10am with respect to an average of 31.38 micrograms per cubic meter during normal months at 10am (0.95% less). Although small during a particular hour, this reduction is not negligible when it is accumulated during a whole day or month. On the other hand, $PM_{2.5}$ concentrations tend to increase during the afternoon of Niño events, being higher around 5pm-7pm when individuals are returning home. Compared with normal days at the same hours, this corresponds to an increase of 1.1%-0.98%.

At first, we argue that ENSO events could affect pollution. Nonetheless, not all pollutants are affected in the same way and in some cases, they could decrease such as it happens during La Niña. A potential explanation could be the interaction with weather factors. For instance, NIÑA brings more rain as was shown before and this could help to reduce particulate matters. On the contrary, El Niño brings higher temperature and less rain, increasing particulate matters $PM_{2.5}$.

Figure 9: ONI-NIÑO-NIÑA on Pollutants ($NO_x - CO$)-24hour schedule



Source: based on the Air Quality Monitoring Network Data for Bogotá (RMCAB) ENSO(ONI) in green and NIÑO-NIÑA in red and blue respectively

Figure 9 shows the estimated coefficients of ONI-NIÑO-NIÑA on Nitrogen Oxide NO_x and

Carbon Monoxide CO hour by hour. With respect to the ONI index, it decreases NO_x concentrations. CO follows a similar pattern as the particulate matters, being more important in the morning peak and much less in the afternoon. In terms of the ENSO events, NO_x decreases less in La Niña than El Niño (in comparison to normal months), and in almost all the hours with significant results. Also, the peak of concentration is reached around 5am, with a large reduction after that hour for both ENSO events, reaching a maximum reduction at 8am. CO also has higher levels for El Niño than La Niña, but only significant during El Niño. In the last case, the concentration levels of CO tend to increase during the peaks of city's mobility.

To interpret these results, weather factors can help to give some hints. We find that pollution correlates positively with temperature and negatively with rain. As El Niño brings higher temperatures, pollutants such as particulate matter and CO increase during this event, in particular during peak hours. In addition, La Niña brings more rain which could help to wash out the levels of pollution. In terms of traffic, the city historically tends to exceed more the limits of particulate matters than the levels of Carbon Monoxide (CO). An explanation of this comes from the fact that vehicles are an important source of CO. For the case of Bogotá, the private car fleet is quite large. As new cars have been purchased in recent years, we should expect that they pollute less as they are better equipped with catalytic converters. The same does not hold for particulate matters, which are emitted mainly by buses and public transport that use diesel and tend to be older. It is then not a surprise that unfortunately, particulate matters exceed more frequently the recommended limits for Bogotá.

2B.5 Results: ONI-NIÑO-NIÑA on weather

Table 11: OLS Estimations on Weather Variables (24 hours schedule)

	ONI INDEX				NINO				NINA			
	RAIN		TEMPERATURE		RAIN		TEMPERATURE		RAIN		TEMPERATURE	
HOUR:	Model B	Model J	Model B	Model J	Model B	Model J	Model B	Model J	Model B	Model J	Model B	Model J
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
h1	-0.0146***	-0.0146***	0.220**	0.232**	-0.0134*	0.000951	0.0747	0.259**	0.0210***	0.0350***	-0.384*	-0.266*
	(0.00220)	(0.00217)	(0.0801)	(0.0722)	(0.00541)	(0.00497)	(0.110)	(0.0947)	(0.00373)	(0.00401)	(0.160)	(0.122)
h2	-0.0196***	-0.0180***	0.204*	0.211**	-0.0252***	-0.0108***	0.0657	0.271**	0.0173***	0.0282***	-0.361*	-0.219
	(0.00111)	(0.00125)	(0.0805)	(0.0720)	(0.00285)	(0.00323)	(0.109)	(0.0931)	(0.00364)	(0.00411)	(0.160)	(0.122)
h3	-0.0152***	-0.0145***	0.189*	0.192**	-0.0120*	0.00149	0.0352	0.257**	0.0245***	0.0371***	-0.355*	-0.193
	(0.00229)	(0.00224)	(0.0814)	(0.0729)	(0.00505)	(0.00430)	(0.110)	(0.0946)	(0.00448)	(0.00400)	(0.159)	(0.121)
h4	-0.0122***	-0.0111***	0.176*	0.178*	-0.00992**	-0.000606	0.0161	0.265**	0.0127***	0.0199***	-0.338*	-0.156
	(0.00131)	(0.00116)	(0.0827)	(0.0738)	(0.00371)	(0.00254)	(0.113)	(0.0972)	(0.00283)	(0.00271)	(0.158)	(0.121)
h5	-0.0103***	-0.00735***	0.169*	0.169*	-0.0288***	-0.0186***	-0.00120	0.276**	-0.00523	-0.00238	-0.331*	-0.123
	(0.00122)	(0.00111)	(0.0828)	(0.0728)	(0.00347)	(0.00328)	(0.111)	(0.0960)	(0.00272)	(0.00340)	(0.158)	(0.121)
h6	-0.00569***	-0.00320**	0.167*	0.165*	-0.0235***	-0.0125**	-0.0253	0.277**	-0.00834*	-0.00234	-0.336*	-0.104
	(0.00129)	(0.00111)	(0.0840)	(0.0733)	(0.00437)	(0.00417)	(0.111)	(0.0947)	(0.00336)	(0.00351)	(0.160)	(0.122)
h7	-0.00317**	-0.00121	0.180*	0.174*	-0.00874*	0.0000377	-0.0390	0.290**	-0.00217	0.00323	-0.369*	-0.108
	(0.00101)	(0.000845)	(0.0852)	(0.0739)	(0.00355)	(0.00254)	(0.111)	(0.0952)	(0.00311)	(0.00258)	(0.162)	(0.122)
h8	-0.00476***	-0.00315*	0.224**	0.197**	-0.0189***	-0.0114***	-0.0260	0.311***	-0.00439	0.000540	-0.441**	-0.137
	(0.00138)	(0.00126)	(0.0755)	(0.0635)	(0.00359)	(0.00283)	(0.0960)	(0.0857)	(0.00313)	(0.00299)	(0.147)	(0.111)
h9	-0.00297*	-0.00107	0.279***	0.234***	-0.00243	0.000391	0.185*	0.278***	0.00691***	0.00705***	-0.371***	-0.252*
	(0.00121)	(0.00110)	(0.0522)	(0.0463)	(0.00298)	(0.00215)	(0.0725)	(0.0678)	(0.00198)	(0.00164)	(0.105)	(0.100)
h10	-0.00242***	-0.000923	0.295***	0.256***	-0.00113	-0.000444	0.372***	0.216**	0.00268	0.00160	-0.248*	-0.350**
	(0.000733)	(0.000586)	(0.0408)	(0.0387)	(0.00202)	(0.00117)	(0.0980)	(0.0768)	(0.00226)	(0.00127)	(0.106)	(0.122)
h11	-0.00271*	-0.000602	0.282***	0.254***	-0.00151	0.00320	0.454***	0.169*	0.00348	0.00439	-0.162	-0.395**
	(0.00109)	(0.000933)	(0.0399)	(0.0408)	(0.00271)	(0.00222)	(0.102)	(0.0835)	(0.00349)	(0.00259)	(0.121)	(0.137)
h12	-0.00364**	-0.00139	0.261***	0.243***	-0.00227	0.00485	0.493***	0.117	0.00406	0.00663*	-0.0974	-0.419**
	(0.00116)	(0.00113)	(0.0449)	(0.0445)	(0.00399)	(0.00392)	(0.114)	(0.0984)	(0.00391)	(0.00297)	(0.139)	(0.148)
h13	-0.0128***	-0.0125***	0.302***	0.291***	-0.00694	0.0116*	0.589***	0.152	0.0180*	0.0351***	-0.102	-0.480**
	(0.00288)	(0.00290)	(0.0487)	(0.0473)	(0.00608)	(0.00568)	(0.123)	(0.110)	(0.00770)	(0.00704)	(0.142)	(0.148)
h14	-0.0190***	-0.0212***	0.392***	0.382***	-0.00910	0.00603	0.662***	0.228	0.0321***	0.0485***	-0.218	-0.582***
	(0.00515)	(0.00517)	(0.0494)	(0.0477)	(0.0115)	(0.0107)	(0.129)	(0.124)	(0.00713)	(0.00888)	(0.130)	(0.152)
h15	-0.0527***	-0.0602***	0.499***	0.487***	-0.0240*	-0.0296*	0.673***	0.315**	0.0965***	0.105***	-0.413***	-0.697***
	(0.00878)	(0.00956)	(0.0502)	(0.0474)	(0.0122)	(0.0144)	(0.121)	(0.118)	(0.0163)	(0.0154)	(0.118)	(0.145)
h16	-0.0811***	-0.0885***	0.591***	0.563***	-0.0225	-0.0638***	0.666***	0.423***	0.147***	0.123***	-0.588***	-0.736***
	(0.0103)	(0.0100)	(0.0531)	(0.0487)	(0.0152)	(0.0139)	(0.124)	(0.119)	(0.0228)	(0.0183)	(0.130)	(0.157)
h17	-0.0614***	-0.0645***	0.628***	0.592***	0.00730	-0.0303*	0.639***	0.488***	0.134***	0.105***	-0.683***	-0.731***
	(0.00778)	(0.00747)	(0.0532)	(0.0475)	(0.0133)	(0.0145)	(0.117)	(0.113)	(0.0151)	(0.0121)	(0.129)	(0.154)
h18	-0.0519***	-0.0518***	0.612***	0.573***	0.0119	-0.0215	0.565***	0.487***	0.122***	0.0904***	-0.730***	-0.709***
	(0.00803)	(0.00789)	(0.0539)	(0.0488)	(0.00831)	(0.0113)	(0.108)	(0.0976)	(0.0113)	(0.0100)	(0.119)	(0.139)
h19	-0.0355***	-0.0347***	0.527***	0.498***	-0.000157	-0.0288*	0.416***	0.428***	0.0628***	0.0293**	-0.703***	-0.624***
	(0.00708)	(0.00697)	(0.0531)	(0.0526)	(0.00913)	(0.0115)	(0.107)	(0.0959)	(0.0120)	(0.0107)	(0.119)	(0.129)
h20	-0.0248***	-0.0268***	0.403***	0.397***	-0.00831	-0.0247*	0.296**	0.347***	0.0451***	0.0307***	-0.562***	-0.498***
	(0.00536)	(0.00532)	(0.0548)	(0.0529)	(0.0111)	(0.00997)	(0.0999)	(0.0934)	(0.00927)	(0.00875)	(0.132)	(0.122)
h21	-0.0236***	-0.0231***	0.341***	0.348***	-0.0259***	-0.0313***	0.248*	0.325***	0.0318***	0.0250***	-0.472***	-0.418***
	(0.00241)	(0.00251)	(0.0595)	(0.0559)	(0.00643)	(0.00547)	(0.101)	(0.0950)	(0.00709)	(0.00668)	(0.141)	(0.120)
h22	-0.0213***	-0.0210***	0.300***	0.315***	-0.0136*	-0.00927	0.206*	0.313***	0.0301***	0.0352***	-0.427**	-0.367**
	(0.00215)	(0.00226)	(0.0652)	(0.0599)	(0.00569)	(0.00649)	(0.103)	(0.0945)	(0.00645)	(0.00652)	(0.149)	(0.120)
h23	-0.0168***	-0.0158***	0.272***	0.288***	-0.00306	0.00648	0.158	0.292**	0.0236***	0.0326***	-0.415**	-0.339**
	(0.00193)	(0.00213)	(0.0713)	(0.0648)	(0.00443)	(0.00391)	(0.105)	(0.0940)	(0.00406)	(0.00293)	(0.158)	(0.123)
h24	-0.0139***	-0.0129***	0.244**	0.259***	-0.00236	0.0125	0.102	0.262**	0.0245***	0.0386***	-0.408*	-0.312*
	(0.00377)	(0.00380)	(0.0762)	(0.0690)	(0.00750)	(0.00677)	(0.110)	(0.0957)	(0.00362)	(0.00401)	(0.160)	(0.122)

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

*Model B: Weather = f(ONI, HOUR fixed effects(h=1,...,24), ONI*HOUR(1,...,24)) taking h=1 as base. Hence, effect of h=1: ONI; effect h=2: ONI+ONI*HOUR(h=2); effect h=3: ONI+ONI*HOUR(h=3);...*

Model J: Weather = f(ONI(h)) if h=1,...,24

For NIÑO and NIÑA, both are included at the same time

Model B and Model J include Station fixed effects, Station-Trend fixed effects and month fixed effects

Standard Errors clustered at station level

2B.6 Results: ONI-NIÑO-NIÑA on pollution

Table 12: OLS Estimations on Pollutants (PM_{10}-$PM_{2.5}$) (24 hours schedule)

	ONI INDEX				NINO				NINA			
	PM10		PM2.5		PM10		PM2.5		PM10		PM2.5	
HOUR:	Model B (1)	Model J (2)	Model B (3)	Model J (4)	Model B (5)	Model J (6)	Model B (7)	Model J (8)	Model B (9)	Model J (10)	Model B (11)	Model J (12)
h1	0.322	0.196	0.580***	0.423*	-2.411	-2.091	0.745**	0.0395	-4.139*	-3.444	-0.237	-1.402*
	(0.561)	(0.557)	(0.127)	(0.183)	(1.379)	(1.277)	(0.278)	(0.371)	(1.607)	(1.760)	(0.394)	(0.567)
h2	0.510	0.325	0.837***	0.367	-1.910	-1.676	1.110***	0.257	-4.055**	-3.275*	-0.830*	-1.025
	(0.550)	(0.508)	(0.128)	(0.188)	(1.263)	(1.085)	(0.282)	(0.384)	(1.415)	(1.430)	(0.398)	(0.582)
h3	0.528	0.186	0.507***	0.422*	-1.923	-1.688	0.952***	0.242	-4.145**	-2.858	-0.126	-1.209*
	(0.579)	(0.485)	(0.129)	(0.193)	(1.311)	(1.168)	(0.280)	(0.389)	(1.472)	(1.495)	(0.402)	(0.597)
h4	0.711	0.380	0.820***	0.759***	-1.384	-1.234	1.171***	0.335	-3.957**	-2.753*	-0.485	-1.385*
	(0.634)	(0.533)	(0.128)	(0.182)	(1.350)	(1.281)	(0.280)	(0.372)	(1.400)	(1.346)	(0.398)	(0.568)
h5	0.957	0.665	0.767***	0.907***	-1.455	-1.241	1.220***	0.650	-4.591***	-3.456**	-0.189	-1.510**
	(0.621)	(0.528)	(0.128)	(0.172)	(1.396)	(1.206)	(0.280)	(0.353)	(1.373)	(1.275)	(0.397)	(0.539)
h6	1.233*	0.825	0.718***	0.984***	-1.253	-1.417	0.877**	0.426	-4.642***	-3.529*	-0.0676	-1.476*
	(0.558)	(0.509)	(0.128)	(0.185)	(1.343)	(1.226)	(0.280)	(0.379)	(1.405)	(1.380)	(0.396)	(0.581)
h7	1.376*	1.258*	1.243***	1.578***	-0.726	-0.969	0.698*	-0.171	-3.914**	-3.096*	-0.986*	-2.536***
	(0.601)	(0.603)	(0.128)	(0.207)	(1.425)	(1.319)	(0.278)	(0.425)	(1.433)	(1.440)	(0.396)	(0.655)
h8	1.416	1.614	0.482***	1.328***	-0.858	-1.530	-0.979***	-0.780	-4.064	-4.326*	-1.572***	-2.986***
	(0.914)	(0.987)	(0.127)	(0.208)	(1.583)	(1.429)	(0.277)	(0.424)	(2.318)	(2.149)	(0.395)	(0.657)
h9	0.370	0.698	-1.066***	1.127***	-2.680	-4.044**	-2.391***	0.266	-4.323	-6.423*	0.260	-2.420***
	(1.289)	(1.243)	(0.128)	(0.234)	(1.700)	(1.514)	(0.280)	(0.478)	(3.614)	(3.146)	(0.395)	(0.728)
h10	-0.487	0.154	-1.641***	0.750**	-1.592	-3.251	-2.551***	0.304	-1.773	-5.058*	1.242**	-3.138***
	(0.938)	(0.823)	(0.128)	(0.239)	(1.749)	(1.712)	(0.282)	(0.488)	(2.869)	(2.252)	(0.396)	(0.740)
h11	-0.239	0.666	-1.021***	0.672**	0.328	-1.628	-1.268***	0.227	0.128	-4.535*	1.444***	-2.683***
	(0.750)	(0.735)	(0.128)	(0.227)	(1.474)	(1.615)	(0.280)	(0.461)	(2.037)	(1.958)	(0.397)	(0.704)
h12	0.426	1.277	0.589***	0.819***	1.445	0.640	0.499	0.385	0.00357	-3.132	-0.522	-2.100***
	(0.712)	(0.741)	(0.129)	(0.198)	(1.221)	(1.563)	(0.282)	(0.401)	(1.635)	(1.600)	(0.400)	(0.613)
h13	0.836	1.139	1.179***	0.916***	0.976	1.748	0.386	0.774*	-1.508	-1.608	-2.929***	-1.667**
	(0.715)	(0.669)	(0.129)	(0.167)	(1.172)	(1.485)	(0.283)	(0.340)	(1.602)	(1.579)	(0.400)	(0.519)
h14	0.739	0.930	1.285***	1.052***	-0.436	1.105	0.446	1.237***	-2.495	-1.199	-3.353***	-0.634
	(0.701)	(0.650)	(0.129)	(0.157)	(1.051)	(1.331)	(0.285)	(0.319)	(1.688)	(1.620)	(0.400)	(0.486)
h15	0.409	0.851	1.305***	0.946***	-0.861	0.595	0.687*	1.442***	-2.349	-1.514	-3.589***	-0.582
	(0.648)	(0.622)	(0.129)	(0.158)	(1.233)	(1.453)	(0.284)	(0.320)	(1.772)	(1.757)	(0.400)	(0.486)
h16	0.637	0.854	1.606***	0.890***	0.289	0.834	1.269***	1.523***	-2.008	-1.512	-4.034***	-0.490
	(0.656)	(0.629)	(0.129)	(0.163)	(1.445)	(1.629)	(0.283)	(0.330)	(1.778)	(1.768)	(0.399)	(0.501)
h17	1.224	1.191	1.835***	0.852***	0.962	0.957	1.649***	1.446***	-2.751	-2.511	-4.372***	-0.944
	(0.749)	(0.714)	(0.129)	(0.161)	(1.409)	(1.475)	(0.282)	(0.326)	(1.728)	(1.597)	(0.398)	(0.500)
h18	1.590*	1.519*	2.317***	1.049***	0.312	0.772	1.988***	1.654***	-4.157*	-3.557*	-5.938***	-1.665***
	(0.809)	(0.725)	(0.128)	(0.157)	(1.452)	(1.478)	(0.281)	(0.318)	(1.835)	(1.544)	(0.396)	(0.485)
h19	1.647	1.420	2.109***	0.837***	-0.283	0.469	1.859***	1.726***	-5.141*	-4.264*	-5.957***	-1.697***
	(0.877)	(0.804)	(0.128)	(0.149)	(1.598)	(1.528)	(0.279)	(0.302)	(2.046)	(1.757)	(0.394)	(0.463)
h20	1.235	1.138	1.745***	0.767***	-0.886	-0.0313	1.379***	1.142***	-4.888*	-4.233*	-4.963***	-1.530***
	(0.875)	(0.820)	(0.128)	(0.147)	(1.557)	(1.506)	(0.277)	(0.295)	(2.099)	(1.932)	(0.394)	(0.455)
h21	0.860	0.812	1.269***	0.667***	-1.751	-0.967	1.228***	0.976**	-4.825*	-4.496*	-2.761***	-1.269**
	(0.819)	(0.805)	(0.128)	(0.154)	(1.383)	(1.313)	(0.278)	(0.310)	(1.984)	(1.949)	(0.393)	(0.476)
h22	0.737	0.718	0.877***	0.670***	-1.584	-1.303	0.995***	0.466	-4.093*	-4.226*	-1.112**	-1.635**
	(0.730)	(0.788)	(0.128)	(0.180)	(1.293)	(1.265)	(0.277)	(0.362)	(1.807)	(2.036)	(0.392)	(0.556)
h23	0.594	0.620	0.685***	0.649***	-2.097	-1.923	0.534	0.197	-4.390*	-4.756*	-1.264**	-1.951***
	(0.630)	(0.736)	(0.127)	(0.183)	(1.301)	(1.272)	(0.277)	(0.368)	(1.763)	(2.170)	(0.392)	(0.565)
h24	0.217	0.139	0.586***	0.427*	-2.288	-1.864	0.730**	0.200	-3.844*	-3.257	-0.416	-1.438*
	(0.608)	(0.685)	(0.128)	(0.184)	(1.384)	(1.318)	(0.277)	(0.372)	(1.708)	(1.971)	(0.393)	(0.571)

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

*Model B: Pollution = f(ONI, HOUR fixed effects(h=1,...,24), ONI*HOUR(1,...,24)) taking h=1 as base. Hence, effect of h=1: ONI; effect h=2: ONI+ONI*HOUR(h=2); effect h=3: ONI+ONI*HOUR(h=3);...*

Model J: pollution = f(ONI(h)) if h=1,...,24

For NIÑO and NIÑA, both are included at the same time

Model B and Model J include Station fixed effects, Station-Trend fixed effects, Day-of-the-week fixed effects, month fixed effects, Wind Speed, Wind Speed(squared), Dummies for 8 categories of Wind Direction, a Dummy for NO Car Day, Dummies for 3 phases of Transmilenio implementation and dummies for 3 changes in the Peak-and-Plate policy

Standard Errors clustered at station level

Table 13: OLS Estimations on Pollutants (NO_x-CO) (24 hours schedule)

	ONI INDEX				NINO				NINA			
	NOx		CO		NOx		CO		NOx		CO	
HOUR:	Model B (1)	Model J (2)	Model B (3)	Model J (4)	Model B (5)	Model J (6)	Model B (7)	Model J (8)	Model B (9)	Model J (10)	Model B (11)	Model J (12)
h1	-0.249	-0.409	0.0239***	0.0560***	-2.687***	-4.331***	-0.0138	0.0367*	-1.578***	-2.642***	-0.0389**	-0.0490**
	(0.185)	(0.299)	(0.00578)	(0.00677)	(0.475)	(0.606)	(0.0146)	(0.0159)	(0.475)	(0.731)	(0.0134)	(0.0186)
h2	-0.511**	-0.114	0.0373***	0.0526***	-2.897***	-3.715***	-0.0514***	0.0189	-1.230**	-2.568***	-0.122***	-0.0588***
	(0.185)	(0.269)	(0.00580)	(0.00646)	(0.477)	(0.547)	(0.0146)	(0.0152)	(0.477)	(0.658)	(0.0135)	(0.0179)
h3	-0.571**	0.0291	0.0509***	0.0522***	-3.043***	-3.497***	-0.0586***	0.0169	-1.236**	-2.704***	-0.172***	-0.0615***
	(0.186)	(0.248)	(0.00583)	(0.00636)	(0.479)	(0.504)	(0.0147)	(0.0149)	(0.478)	(0.605)	(0.0136)	(0.0175)
h4	-0.357	0.436	0.0627***	0.0604***	-2.812***	-2.938***	-0.0608***	0.0218	-1.592***	-2.862***	-0.204***	-0.0728***
	(0.186)	(0.227)	(0.00582)	(0.00574)	(0.480)	(0.462)	(0.0147)	(0.0135)	(0.478)	(0.554)	(0.0136)	(0.0158)
h5	0.797***	0.871***	0.0656***	0.0603***	-1.343**	-2.768***	-0.0808***	0.00332	-3.034***	-3.265***	-0.237***	-0.103***
	(0.187)	(0.229)	(0.00584)	(0.00600)	(0.481)	(0.466)	(0.0147)	(0.0142)	(0.480)	(0.558)	(0.0136)	(0.0165)
h6	2.395***	0.523*	0.0726***	0.0570***	0.339	-3.766***	-0.0544***	0.0246	-5.491***	-3.496***	-0.219***	-0.0553***
	(0.188)	(0.259)	(0.00583)	(0.00600)	(0.480)	(0.527)	(0.0147)	(0.0142)	(0.481)	(0.631)	(0.0136)	(0.0165)
h7	4.261***	0.293	0.0759***	0.0664***	3.735***	-4.861***	0.0495***	0.0748***	-6.779***	-4.344***	-0.0865***	-0.0150
	(0.186)	(0.358)	(0.00579)	(0.00676)	(0.479)	(0.726)	(0.0146)	(0.0160)	(0.477)	(0.875)	(0.0135)	(0.0187)
h8	3.213***	-0.376	0.0484***	0.0773***	0.825	-7.609***	0.174***	0.107***	-6.971***	-7.193***	0.154***	-0.00334
	(0.186)	(0.467)	(0.00578)	(0.00860)	(0.478)	(0.943)	(0.0146)	(0.0204)	(0.478)	(1.143)	(0.0134)	(0.0237)
h9	0.0188	-0.296	0.0626***	0.0831***	-2.646***	-6.117***	0.289***	0.112***	-2.278***	-6.179***	0.242***	-0.0245
	(0.186)	(0.428)	(0.00578)	(0.00911)	(0.477)	(0.865)	(0.0145)	(0.0215)	(0.477)	(1.046)	(0.0134)	(0.0250)
h10	-1.248***	0.131	0.0869***	0.0834***	-4.572***	-3.219***	0.272***	0.121***	-1.471**	-3.822***	0.135***	-0.0272
	(0.186)	(0.331)	(0.00578)	(0.00859)	(0.477)	(0.669)	(0.0146)	(0.0203)	(0.477)	(0.810)	(0.0134)	(0.0236)
h11	-1.854***	-0.230	0.0858***	0.0662***	-6.187***	-2.670***	0.171***	0.106***	-1.690***	-2.113***	0.00437	-0.0270
	(0.187)	(0.256)	(0.00581)	(0.00772)	(0.478)	(0.518)	(0.0146)	(0.0181)	(0.478)	(0.625)	(0.0135)	(0.0210)
h12	-1.376***	-0.281	0.0924***	0.0630***	-5.949***	-2.208***	0.104***	0.0962***	-2.654***	-1.500**	-0.0861***	-0.0299
	(0.188)	(0.208)	(0.00585)	(0.00682)	(0.480)	(0.419)	(0.0147)	(0.0159)	(0.480)	(0.506)	(0.0135)	(0.0185)
h13	-1.337***	-0.226	0.0846***	0.0548***	-6.155***	-2.104***	0.0731***	0.0853***	-2.757***	-1.121*	-0.100***	-0.0236
	(0.188)	(0.185)	(0.00586)	(0.00634)	(0.481)	(0.373)	(0.0147)	(0.0148)	(0.481)	(0.451)	(0.0135)	(0.0171)
h14	-1.714***	-0.395*	0.0740***	0.0511***	-6.283***	-2.256***	0.0469**	0.0715***	-2.017***	-1.017*	-0.105***	-0.0231
	(0.188)	(0.175)	(0.00585)	(0.00608)	(0.481)	(0.353)	(0.0147)	(0.0142)	(0.480)	(0.426)	(0.0135)	(0.0165)
h15	-1.879***	-0.581**	0.0691***	0.0487***	-5.945***	-2.323***	0.0480**	0.0631***	-1.255**	-0.683	-0.0909***	-0.0189
	(0.188)	(0.177)	(0.00584)	(0.00600)	(0.480)	(0.356)	(0.0147)	(0.0140)	(0.480)	(0.429)	(0.0135)	(0.0163)
h16	-1.900***	-0.668***	0.0633***	0.0410***	-6.020***	-2.831***	0.0487***	0.0527***	-1.189*	-0.965*	-0.0782***	-0.0200
	(0.188)	(0.186)	(0.00583)	(0.00603)	(0.479)	(0.374)	(0.0147)	(0.0142)	(0.480)	(0.453)	(0.0135)	(0.0164)
h17	-1.746***	-0.748***	0.0579***	0.0411***	-6.018***	-2.979***	0.0531***	0.0496***	-1.560**	-1.136*	-0.0554***	-0.0226
	(0.187)	(0.199)	(0.00581)	(0.00627)	(0.478)	(0.399)	(0.0147)	(0.0148)	(0.478)	(0.484)	(0.0134)	(0.0171)
h18	-1.533***	-0.840***	0.0568***	0.0464***	-5.535***	-3.038***	0.0781***	0.0690***	-1.510**	-1.073*	-0.0272*	-0.0186
	(0.186)	(0.213)	(0.00580)	(0.00662)	(0.476)	(0.430)	(0.0146)	(0.0156)	(0.476)	(0.520)	(0.0134)	(0.0180)
h19	-1.527***	-1.367***	0.0576***	0.0511***	-5.448***	-3.573***	0.109***	0.0874***	-1.477**	-0.905	0.00899	-0.0145
	(0.185)	(0.239)	(0.00578)	(0.00723)	(0.475)	(0.481)	(0.0146)	(0.0171)	(0.475)	(0.582)	(0.0134)	(0.0197)
h20	-1.319***	-1.916***	0.0609***	0.0493***	-5.027***	-4.247***	0.159***	0.112***	-1.686***	-0.677	0.0567***	0.00533
	(0.185)	(0.266)	(0.00576)	(0.00763)	(0.474)	(0.537)	(0.0145)	(0.0180)	(0.474)	(0.649)	(0.0133)	(0.0209)
h21	-1.104***	-1.874***	0.0418***	0.0439***	-4.985***	-4.951***	0.135***	0.0960***	-2.035***	-1.366	0.0963***	0.0102
	(0.185)	(0.297)	(0.00576)	(0.00782)	(0.473)	(0.600)	(0.0145)	(0.0184)	(0.473)	(0.726)	(0.0133)	(0.0214)
h22	-1.217***	-2.170***	0.0102	0.0410***	-4.617***	-5.825***	0.0787***	0.0718***	-1.134*	-1.219	0.128***	0.0155
	(0.185)	(0.316)	(0.00576)	(0.00785)	(0.473)	(0.639)	(0.0145)	(0.0184)	(0.473)	(0.773)	(0.0133)	(0.0215)
h23	-0.913***	-1.728***	0.0192***	0.0514***	-3.676***	-5.329***	0.0661***	0.0700***	-0.831	-1.245	0.0877***	-0.00703
	(0.185)	(0.322)	(0.00576)	(0.00751)	(0.474)	(0.650)	(0.0145)	(0.0176)	(0.474)	(0.787)	(0.0133)	(0.0206)
h24	-0.665***	-1.269***	0.0256***	0.0603***	-3.407***	-5.112***	0.0336*	0.0618***	-1.403**	-2.307**	0.0248	-0.0348
	(0.185)	(0.316)	(0.00577)	(0.00706)	(0.474)	(0.639)	(0.0145)	(0.0166)	(0.474)	(0.773)	(0.0134)	(0.0194)

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

*Model B: Pollution = f(ONI, HOUR fixed effects(h=1,...,24), ONI*HOUR(1,...,24)) taking h=1 as base. Hence, effect of h=1: ONI; effect h=2: ONI+ONI*HOUR(h=2); effect h=3: ONI+ONI*HOUR(h=3);...*

Model J: pollution = f(ONI(h)) if h=1,...,24

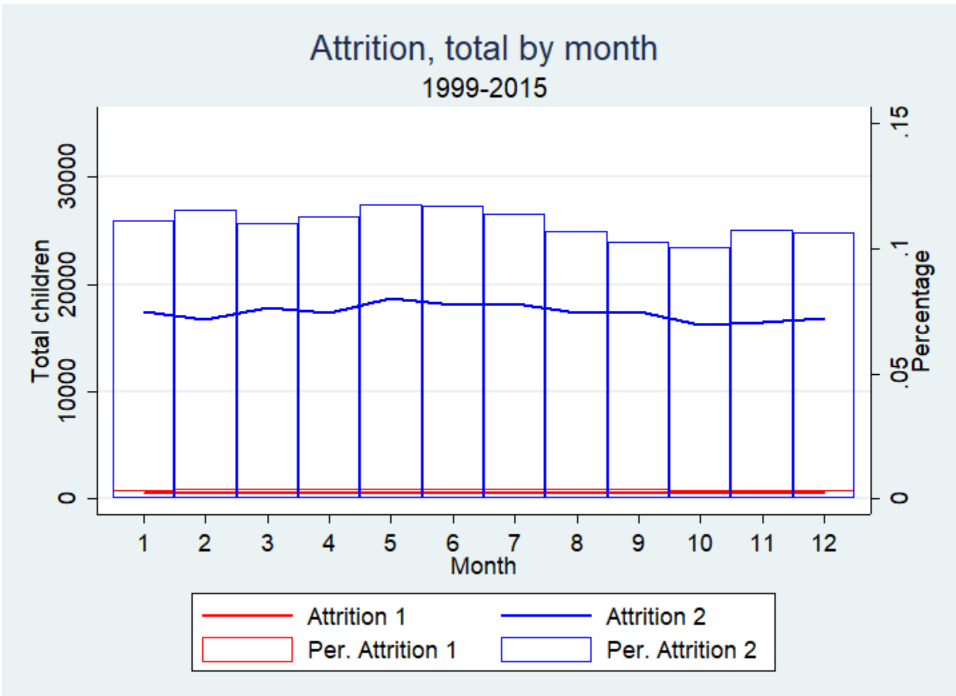
For NIÑO and NIÑA, both are included at the same time

Model B and Model J include Station fixed effects, Station-Trend fixed effects, Day-of-the-week fixed effects, month fixed effects, Wind Speed, Wind Speed(squared), Dummies for 8 categories of Wind Direction, a Dummy for NO Car Day, Dummies for 3 phases of Transmilenio implementation and dummies for 3 changes in the Peak-and-Plate policy

Standard Errors clustered at station level

2C Attrition in the sample

Figure 10: Type of attrition by month and source
Percentage and Total

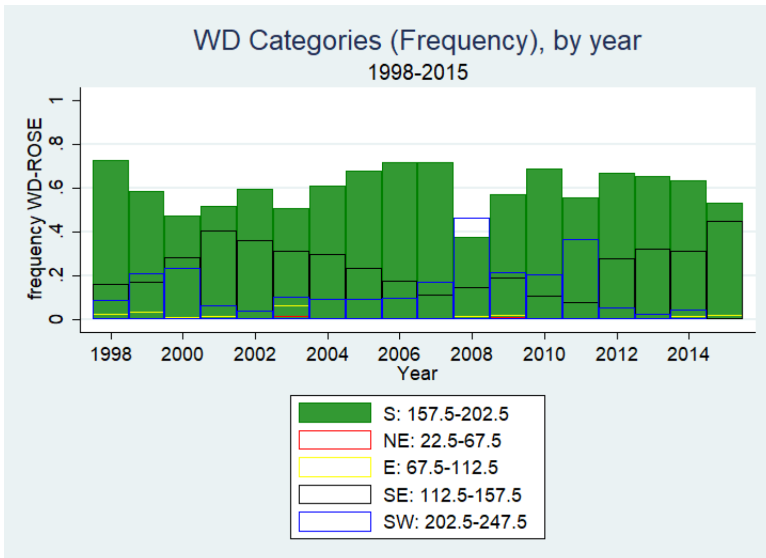


Source: based on the Air Quality Monitoring Network Data for Bogotá (RMCAB). Attrition could come from two sources: attrition for reason one, for children not being delivered at the health center and attrition for reason two, for children born in a health center but for which we could not recover the address.

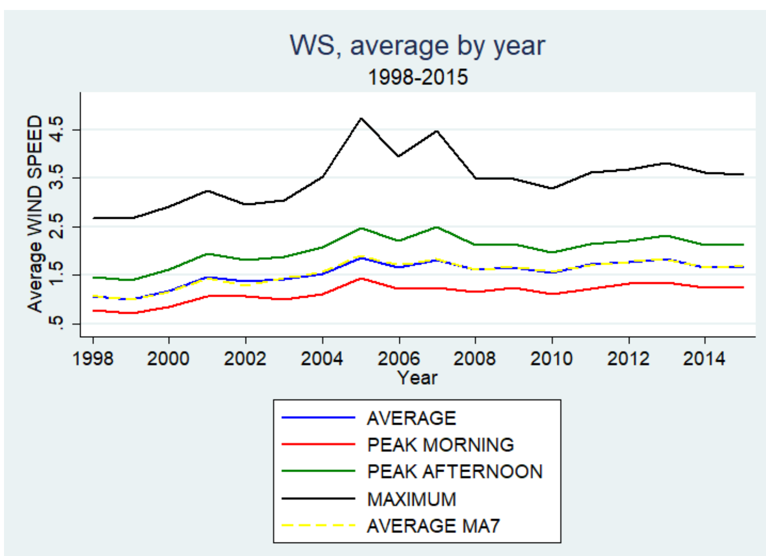
2D Wind-direction over year

Figure 11: Categories of wind direction and wind speed per year

(a) Wind-direction



(b) Wind-speed

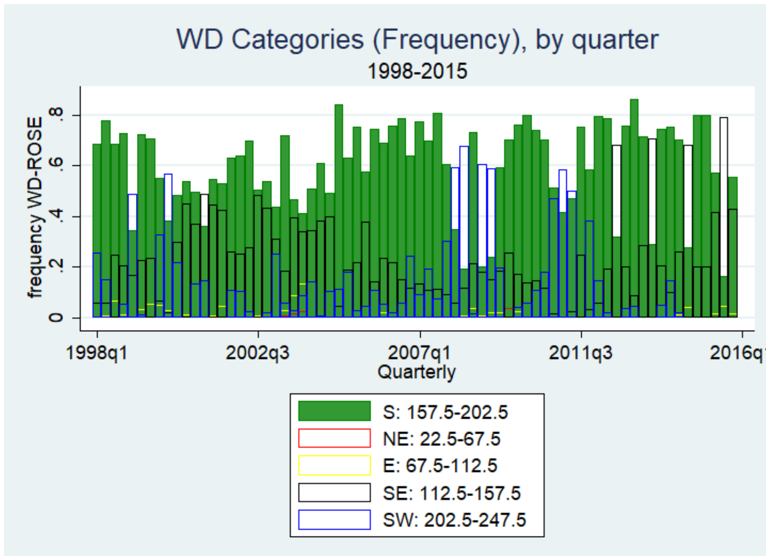


Source: based on the Air Quality Monitoring Network Data for Bogotá (RMCAB) .

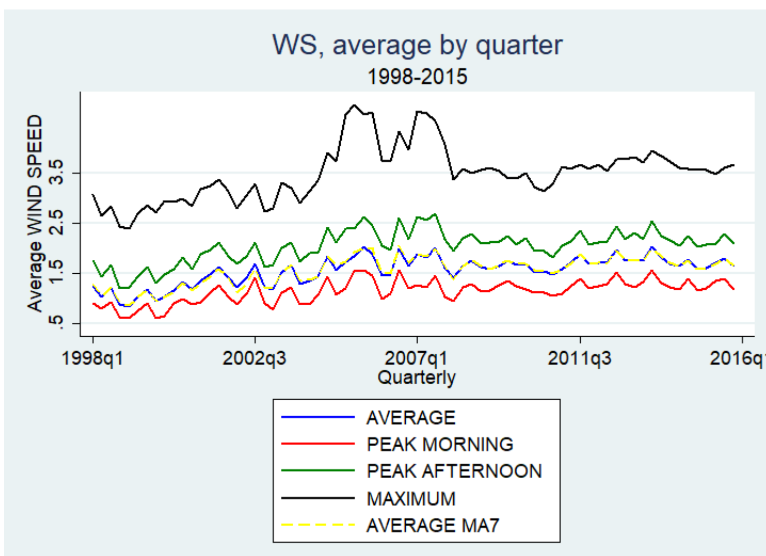
In figure 11 and figure 12, part a), we can see the yearly and quarterly frequency of the different wind direction categories, with the wind blowing from the south in almost 60% of the cases, followed by wind blowing to the south-east (SE) and south-west (SW). It is important to notice that there is not only cross-section variation, but also variation along the years. Part b) shows the average of the different variables used of wind speed by year and for all the health

Figure 12: Categories of wind direction and wind speed per quarter

(a) Wind-direction



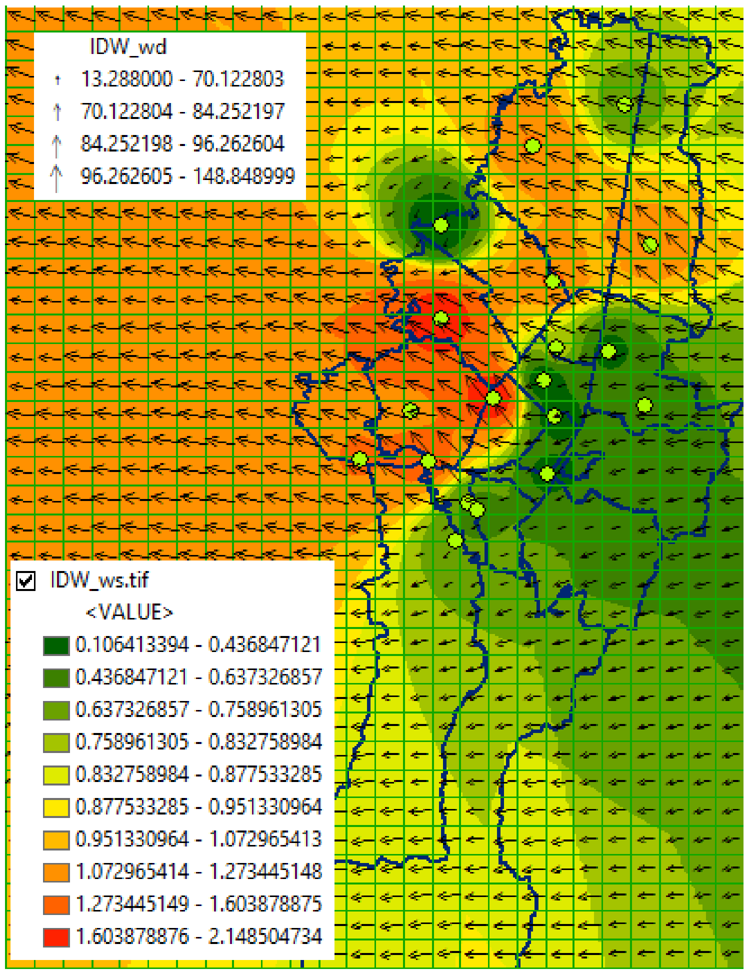
(b) Wind-speed



Source: based on the Air Quality Monitoring Network Data for Bogotá (RMCAB).

centers of the data-set. Here, we can also observe some variation along the years, with higher values around 2005-2007. The different time and cross-section variation in the data help in the identification strategy.

Figure 13: Map of wind direction (WD) and wind speed (WS) in the city



Source: based on the Air Quality Monitoring Network Data for Bogotá (RMCAB). WD in degrees and WS in meters/seconds. Map constructed using inverse distance weighting for the monitoring stations of the network. For WD, a value of 90 degrees corresponds to wind blowing from the east to the west. As can be seen in the map, the wind blows from the north and from the mountains that limit the city in the east, towards the south and west.

2E Reduced form results IV on health

Table 14: REDUCED FORM: IV ON HEALTH SO_2 (average)

	SO2 (average)			
	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)
Niño-Q3	0.004	0.007	-0.028	-25.230***
	(0.006)	(0.005)	(0.046)	(7.726)
Niño-Q2	0.005	-0.001	-0.038	2.211
	(0.006)	(0.004)	(0.044)	(7.459)
Niño-Q1	0.004	0.002	0.012	-4.597
	(0.007)	(0.005)	(0.051)	(9.274)
Niña-Q3	0.003	0.003	0.014	10.898
	(0.007)	(0.004)	(0.051)	(8.416)
Niña-Q2	0.000	-0.001	0.002	-10.686
	(0.008)	(0.006)	(0.060)	(9.286)
Niña-Q1	-0.009	-0.011	0.094	8.040
	(0.009)	(0.008)	(0.072)	(13.297)
ws_ave-Q3	-0.046	0.000	0.409	-11.770
	(0.042)	(0.020)	(0.322)	(34.705)
ws_ave-Q2	-0.028	0.005	0.204	-37.445
	(0.046)	(0.029)	(0.338)	(88.949)
ws_ave-Q1	-0.061	0.006	0.458	-90.533
	(0.047)	(0.046)	(0.360)	(80.426)
wd_rose_Cat3-Q3	0.004	-0.020	0.044	17.173
	(0.036)	(0.029)	(0.284)	(50.170)
wd_rose_Cat4-Q3	-0.036	0.014	0.331	23.530
	(0.041)	(0.020)	(0.322)	(34.725)
wd_rose_Cat5-Q3	-0.039	0.003	0.382	27.916
	(0.041)	(0.021)	(0.321)	(35.730)
wd_rose_Cat6-Q3	-0.042	-0.001	0.390	43.269
	(0.043)	(0.026)	(0.341)	(44.856)
wd_rose_Cat3-Q2	-0.035	0.001	0.283	-7.503
	(0.055)	(0.029)	(0.390)	(96.731)
wd_rose_Cat4-Q2	-0.029	0.010	0.211	-14.646
	(0.059)	(0.026)	(0.421)	(95.165)
wd_rose_Cat5-Q2	-0.036	0.013	0.266	-12.909
	(0.062)	(0.028)	(0.440)	(96.336)
wd_rose_Cat6-Q2	-0.039	0.009	0.321	-16.121
	(0.064)	(0.033)	(0.455)	(95.670)
wd_rose_Cat3-Q1	-0.076	-0.020	0.582	-67.897
	(0.047)	(0.048)	(0.391)	(88.900)
wd_rose_Cat4-Q1	-0.070	0.026	0.558	-66.923
	(0.049)	(0.042)	(0.404)	(82.829)
wd_rose_Cat5-Q1	-0.070	0.031	0.566	-78.409
	(0.052)	(0.046)	(0.421)	(86.025)
wd_rose_Cat6-Q1	-0.076	0.037	0.617	-68.770
	(0.053)	(0.047)	(0.430)	(86.696)
N	11027	11027	11027	11027
R2a_RF	0.37	0.31	0.35	0.34

* p<0.05> , ** p<0.01, *** p<0.001

Note: The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. Each regression of the health outcomes has three equations in the first stage, one for each quarter of gestation. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay). The interaction of the wind direction rose with wind speed not shown to save space.

Table 15: REDUCED FORM: IV ON HEALTH PM_{10} $PM_{2.5}$ (average)

	PM10 (average)				PM2.5 (average)			
	Premature	Low Weight	Weeks Gest.	Birth Weight	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niño-Q3	0.004	0.007	-0.028	-25.230***	0.016	-0.024*	-0.129	-10.128
	(0.006)	(0.005)	(0.046)	(7.726)	(0.020)	(0.013)	(0.153)	(17.885)
Niño-Q2	0.005	-0.001	-0.038	2.211	0.046***	0.001	-0.291***	-21.603
	(0.006)	(0.004)	(0.044)	(7.459)	(0.014)	(0.010)	(0.103)	(17.364)
Niño-Q1	0.004	0.002	0.012	-4.597	0.012	0.015	-0.049	-28.714
	(0.007)	(0.005)	(0.051)	(9.274)	(0.015)	(0.012)	(0.115)	(18.102)
Niña-Q3	0.003	0.003	0.014	10.898	-0.026	-0.015	0.283	25.935
	(0.007)	(0.004)	(0.051)	(8.416)	(0.028)	(0.019)	(0.220)	(30.873)
Niña-Q2	0.000	-0.001	0.002	-10.686	0.039	0.005	-0.274	-40.906
	(0.008)	(0.006)	(0.060)	(9.286)	(0.032)	(0.017)	(0.237)	(26.000)
Niña-Q1	-0.009	-0.011	0.094	8.040	0.003	-0.009	0.082	-3.457
	(0.009)	(0.008)	(0.072)	(13.297)	(0.022)	(0.019)	(0.186)	(32.556)
ws_ave-Q3	-0.046	0.000	0.409	-11.770	-0.056	0.350	0.249	92.891
	(0.042)	(0.020)	(0.322)	(34.705)	(0.488)	(0.451)	(3.353)	(576.529)
ws_ave-Q2	-0.028	0.005	0.204	-37.445	-0.779*	-0.567	5.993*	1306.477**
	(0.046)	(0.029)	(0.338)	(88.949)	(0.469)	(0.353)	(3.264)	(552.255)
ws_ave-Q1	-0.061	0.006	0.458	-90.533	-0.244	-0.137	1.331	-771.656
	(0.047)	(0.046)	(0.360)	(80.426)	(0.325)	(0.638)	(2.247)	(564.553)
wd_rose_Cat3-Q3	0.004	-0.020	0.044	17.173	0.009	0.460	-0.206	69.150
	(0.036)	(0.029)	(0.284)	(50.170)	(0.572)	(0.543)	(3.929)	(693.632)
wd_rose_Cat4-Q3	-0.036	0.014	0.331	23.530	-0.098	0.521	0.461	10.843
	(0.041)	(0.020)	(0.322)	(34.725)	(0.584)	(0.538)	(4.005)	(672.912)
wd_rose_Cat5-Q3	-0.039	0.003	0.382	27.916	-0.089	0.502	0.416	28.201
	(0.041)	(0.021)	(0.321)	(35.730)	(0.586)	(0.531)	(4.026)	(678.438)
wd_rose_Cat6-Q3	-0.042	-0.001	0.390	43.269	-0.075	0.537	0.316	-15.186
	(0.043)	(0.026)	(0.341)	(44.856)	(0.589)	(0.532)	(4.045)	(683.301)
wd_rose_Cat3-Q2	-0.035	0.001	0.283	-7.503	-0.872	-0.630	6.769*	1471.141**
	(0.055)	(0.029)	(0.390)	(96.731)	(0.554)	(0.393)	(3.866)	(633.713)
wd_rose_Cat4-Q2	-0.029	0.010	0.211	-14.646	-0.903*	-0.580	6.975*	1471.396**
	(0.059)	(0.026)	(0.421)	(95.165)	(0.543)	(0.393)	(3.806)	(644.099)
wd_rose_Cat5-Q2	-0.036	0.013	0.266	-12.909	-0.978*	-0.601	7.430*	1533.656**
	(0.062)	(0.028)	(0.440)	(96.336)	(0.542)	(0.396)	(3.798)	(650.463)
wd_rose_Cat6-Q2	-0.039	0.009	0.321	-16.121	-0.979*	-0.603	7.477*	1527.237**
	(0.064)	(0.033)	(0.455)	(95.670)	(0.549)	(0.391)	(3.860)	(645.125)
wd_rose_Cat3-Q1	-0.076	-0.020	0.582	-67.897	-0.326	-0.173	1.762	-880.841
	(0.047)	(0.048)	(0.391)	(88.900)	(0.397)	(0.767)	(2.721)	(701.816)
wd_rose_Cat4-Q1	-0.070	0.026	0.558	-66.923	-0.359	-0.140	2.044	-781.602
	(0.049)	(0.042)	(0.404)	(82.829)	(0.429)	(0.786)	(2.945)	(695.192)
wd_rose_Cat5-Q1	-0.070	0.031	0.566	-78.409	-0.403	-0.173	2.401	-759.094
	(0.052)	(0.046)	(0.421)	(86.025)	(0.443)	(0.788)	(3.042)	(705.716)
wd_rose_Cat6-Q1	-0.076	0.037	0.617	-68.770	-0.399	-0.166	2.435	-741.730
	(0.053)	(0.047)	(0.430)	(86.696)	(0.451)	(0.794)	(3.096)	(712.152)
N	11027	11027	11027	11027	4413	4413	4413	4413
R2a_RF	0.37	0.31	0.35	0.34	0.36	0.32	0.35	0.36

* p<0.05> , ** p<0.01, *** p<0.001

Note: the estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. Each regression of the health outcomes has three equations in the first stage, one for each quarter of gestation. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay). The interaction of the wind direction rose with wind speed not shown to save space.

Table 16: REDUCED FORM: IV ON HEALTH $CO\text{-}NO_X$ (peak afternoon)

	CO (peak afternoon)				NOX (peak afternoon)			
	Premature (1)	Low Weight (2)	Weeks Gest. (3)	Birth Weight (4)	Premature (5)	Low Weight (6)	Weeks Gest. (7)	Birth Weight (8)
Niño-Q3	-0.000	0.001	0.012	-14.769*	0.002	0.005	-0.027	-24.453***
	(0.008)	(0.006)	(0.058)	(8.687)	(0.007)	(0.005)	(0.051)	(8.910)
Niño-Q2	0.002	0.001	-0.008	-2.292	0.002	-0.004	-0.006	9.777
	(0.010)	(0.006)	(0.074)	(10.511)	(0.007)	(0.005)	(0.055)	(9.009)
Niño-Q1	-0.001	0.003	0.048	-3.242	0.006	0.012**	-0.002	-9.449
	(0.008)	(0.006)	(0.057)	(10.691)	(0.007)	(0.006)	(0.055)	(9.992)
Niña-Q3	0.002	-0.001	0.031	15.286	-0.002	0.000	0.067	24.126**
	(0.008)	(0.005)	(0.061)	(11.193)	(0.008)	(0.005)	(0.064)	(10.141)
Niña-Q2	-0.005	-0.006	0.053	-2.561	-0.000	-0.003	-0.001	-9.733
	(0.007)	(0.005)	(0.057)	(9.631)	(0.008)	(0.005)	(0.065)	(9.772)
Niña-Q1	-0.013	-0.013	0.133*	13.798	-0.012	-0.014	0.125*	13.809
	(0.010)	(0.008)	(0.080)	(13.769)	(0.009)	(0.010)	(0.073)	(15.121)
ws_peaka-Q3	0.003	-0.031	0.069	88.708	-0.040	-0.004	0.338*	-0.102
	(0.076)	(0.043)	(0.547)	(100.629)	(0.026)	(0.017)	(0.194)	(30.092)
ws_peaka-Q2	-0.007	0.006	0.013	-68.466	-0.009	-0.002	0.063	-34.533
	(0.042)	(0.035)	(0.335)	(96.029)	(0.030)	(0.024)	(0.212)	(66.402)
ws_peaka-Q1	-0.051	-0.007	0.398	-113.239*	-0.013	0.028	0.091	-82.804
	(0.041)	(0.039)	(0.326)	(68.392)	(0.030)	(0.027)	(0.242)	(60.878)
wd_rose_Cat3-Q3	0.033	-0.050	-0.151	148.113	-0.001	-0.018	0.051	25.528
	(0.085)	(0.056)	(0.622)	(137.056)	(0.030)	(0.027)	(0.216)	(51.164)
wd_rose_Cat4-Q3	0.007	-0.015	0.079	159.136	-0.025	0.015	0.207	19.261
	(0.081)	(0.046)	(0.592)	(121.855)	(0.037)	(0.018)	(0.269)	(37.467)
wd_rose_Cat5-Q3	0.014	-0.020	0.072	154.441	-0.032	0.009	0.282	17.363
	(0.080)	(0.047)	(0.597)	(122.599)	(0.037)	(0.021)	(0.270)	(39.956)
wd_rose_Cat6-Q3	0.004	-0.021	0.103	165.091	-0.040	-0.005	0.341	44.138
	(0.084)	(0.049)	(0.626)	(125.806)	(0.040)	(0.026)	(0.291)	(51.269)
wd_rose_Cat3-Q2	-0.036	0.013	0.239	-46.815	-0.008	0.001	0.144	-24.645
	(0.062)	(0.047)	(0.476)	(125.521)	(0.046)	(0.028)	(0.313)	(88.320)
wd_rose_Cat4-Q2	-0.024	0.015	0.139	-46.427	-0.004	0.004	0.037	-34.288
	(0.065)	(0.047)	(0.503)	(125.748)	(0.049)	(0.026)	(0.337)	(83.038)
wd_rose_Cat5-Q2	-0.021	0.025	0.107	-50.914	-0.007	0.009	0.082	-34.892
	(0.068)	(0.048)	(0.519)	(127.515)	(0.052)	(0.027)	(0.358)	(84.557)
wd_rose_Cat6-Q2	-0.025	0.016	0.170	-36.637	-0.012	-0.003	0.168	-39.904
	(0.071)	(0.052)	(0.534)	(126.148)	(0.057)	(0.034)	(0.392)	(86.578)
wd_rose_Cat3-Q1	-0.082*	-0.032	0.632	-122.398	-0.038	0.002	0.273	-73.553
	(0.047)	(0.045)	(0.388)	(93.935)	(0.042)	(0.043)	(0.348)	(84.268)
wd_rose_Cat4-Q1	-0.066	0.017	0.524	-134.205*	-0.033	0.051	0.250	-66.464
	(0.046)	(0.040)	(0.381)	(77.633)	(0.044)	(0.039)	(0.359)	(84.516)
wd_rose_Cat5-Q1	-0.066	0.016	0.556	-138.405*	-0.020	0.060	0.168	-84.966
	(0.048)	(0.042)	(0.391)	(81.505)	(0.047)	(0.044)	(0.376)	(88.103)
wd_rose_Cat6-Q1	-0.073	0.017	0.618	-119.186	-0.026	0.062	0.245	-66.360
	(0.048)	(0.044)	(0.396)	(82.078)	(0.049)	(0.046)	(0.389)	(88.851)
N	9833	9833	9833	9833	7683	7683	7683	7683
R2a_RF	0.37	0.30	0.35	0.34	0.38	0.33	0.36	0.37

* p<0.05> , ** p<0.01, *** p<0.001

Note: the estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay). The interaction of the wind direction rose with wind speed not shown to save space.

2F IV 2 STAGE: moving average 7 days-maximum

Table 17: IV SECOND STAGE: SO_2 (Ave. MA7) ON HEALTH

	SO2 (Ave. MA7)			
	Birth Weight (1)	Premature (2)	Low Weight (3)	Weeks Gest. (4)
Niño-Q3	0.011*	0.014***	-0.086*	-30.442***
	(0.006)	(0.005)	(0.048)	(8.691)
Niño-Q2	-0.006	-0.011**	0.041	12.065
	(0.007)	(0.005)	(0.056)	(9.186)
Niño-Q1	0.008	0.012**	-0.031	-16.271**
	(0.006)	(0.005)	(0.044)	(7.989)
Niña-Q3	0.002	0.006	0.008	3.104
	(0.006)	(0.004)	(0.047)	(7.836)
Niña-Q2	-0.001	0.014***	-0.004	-21.704***
	(0.006)	(0.004)	(0.042)	(7.378)
Niña-Q1	-0.014*	-0.005	0.119**	10.388
	(0.008)	(0.006)	(0.060)	(10.102)
so2_avma7-Q3	0.000	-0.001	-0.004	-2.025
	(0.001)	(0.001)	(0.011)	(2.282)
so2_avma7-Q2	-0.003**	0.001	0.023*	-0.819
	(0.002)	(0.002)	(0.012)	(2.910)
so2_avma7-Q1	0.006***	0.004**	-0.040**	-6.757**
	(0.002)	(0.002)	(0.016)	(2.710)
Observations	11003	11003	11003	11003
NINO	0.01	0.01	-0.08	-34.65
P_NINO	0.05	0.01	0.12	0.00
NINA	-0.01	0.02	0.12	-8.21
P_NINA	0.25	0.07	0.12	0.52
POL	0.00	0.00	-0.02	-9.60
P_POL	0.24	0.04	0.25	0.00
r2_a	0.36	0.30	0.35	0.34

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. For pollutants: Ave. MA7 is the moving average of the last 7 days calculated per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 18: IV SECOND STAGE: PM_{10}-$PM_{2.5}$ (Ave. MA7) ON HEALTH

	PM10 (Ave. MA7)				PM2.5 (Ave. MA7)			
	Premature	Low Weight	Weeks Gest.	Birth Weight	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niño-Q3	0.007	0.005	-0.054	-21.377***	-0.004	-0.004	0.032	-10.242
	(0.006)	(0.005)	(0.042)	(7.990)	(0.011)	(0.007)	(0.087)	(12.922)
Niño-Q2	0.003	-0.003	-0.016	0.231	0.011	0.004	-0.065	-8.057
	(0.006)	(0.005)	(0.047)	(7.567)	(0.009)	(0.007)	(0.068)	(9.587)
Niño-Q1	0.008	0.010*	-0.020	-12.233	0.012	0.018***	-0.062	-22.852**
	(0.006)	(0.006)	(0.046)	(9.464)	(0.010)	(0.007)	(0.072)	(11.450)
Niña-Q3	0.000	0.001	0.021	6.481	-0.037**	-0.015	0.305**	18.927
	(0.006)	(0.005)	(0.041)	(8.634)	(0.017)	(0.010)	(0.130)	(17.134)
Niña-Q2	0.002	0.009	-0.015	-21.097**	0.036***	0.033***	-0.236**	-44.788***
	(0.006)	(0.006)	(0.045)	(10.631)	(0.012)	(0.008)	(0.093)	(10.371)
Niña-Q1	-0.002	0.000	0.037	-5.058	0.004	0.001	0.006	0.710
	(0.007)	(0.006)	(0.057)	(10.350)	(0.012)	(0.010)	(0.092)	(13.547)
pm10_avma7-Q3	0.001	-0.001**	-0.004	0.503				
	(0.001)	(0.001)	(0.005)	(0.772)				
pm10_avma7-Q2	0.000	0.001	-0.002	-1.448				
	(0.001)	(0.001)	(0.005)	(0.909)				
pm10_avma7-Q1	0.001	0.001	-0.003	-0.956				
	(0.001)	(0.001)	(0.006)	(1.256)				
pm25_avma7-Q3					0.005***	0.002	-0.037***	-2.315
					(0.002)	(0.001)	(0.014)	(1.846)
pm25_avma7-Q2					-0.004**	0.001	0.021	-1.838
					(0.002)	(0.001)	(0.014)	(2.151)
pm25_avma7-Q1					0.000	-0.000	-0.001	0.137
					(0.001)	(0.001)	(0.009)	(1.319)
Observations	11023	11023	11023	11023	4405	4405	4405	4405
NINO	0.02	0.01	-0.09	-33.38	0.02	0.02	-0.09	-41.15
P_NINO	0.02	0.06	0.09	0.01	0.24	0.05	0.43	0.01
NINA	-0.00	0.01	0.04	-19.67	0.00	0.02	0.08	-25.15
P_NINA	0.99	0.20	0.57	0.12	0.85	0.17	0.62	0.23
POL	0.00	0.00	-0.01	-1.90	0.00	0.00	-0.02	-4.02
P_POL	0.12	0.54	0.23	0.18	0.59	0.36	0.51	0.26
r2_a	0.36	0.30	0.35	0.34	0.35	0.32	0.35	0.36

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. For pollutants: Ave. MA7 is the moving average of the last 7 days calculated per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 19: IV SECOND STAGE: CO-NO_X (Max.) ON HEALTH

	CO (Max.)				NOX (Max.)			
	Premature	Low Weight	Weeks Gest.	Birth Weight	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niño-Q3	0.001	0.012**	-0.011	-24.583***	0.002	0.009	-0.029	-20.476**
	(0.006)	(0.006)	(0.045)	(8.708)	(0.007)	(0.007)	(0.052)	(10.216)
Niño-Q2	-0.009	0.002	0.055	5.812	-0.005	-0.004	0.042	7.595
	(0.009)	(0.006)	(0.069)	(9.745)	(0.007)	(0.006)	(0.049)	(10.584)
Niño-Q1	0.004	0.008	0.002	-11.676	0.010	0.021***	-0.044	-21.020**
	(0.007)	(0.006)	(0.053)	(8.797)	(0.007)	(0.007)	(0.056)	(9.097)
Niña-Q3	-0.003	0.003	0.051	2.673	-0.003	-0.003	0.051	12.851
	(0.007)	(0.005)	(0.055)	(9.642)	(0.007)	(0.005)	(0.049)	(9.099)
Niña-Q2	-0.003	0.013***	0.017	-19.976**	-0.008	0.015***	0.042	-19.955**
	(0.006)	(0.004)	(0.043)	(8.549)	(0.006)	(0.005)	(0.044)	(8.870)
Niña-Q1	-0.005	0.003	0.045	-0.254	-0.005	-0.004	0.061	4.233
	(0.008)	(0.005)	(0.058)	(9.065)	(0.008)	(0.006)	(0.063)	(9.740)
co_max-Q3	0.003	0.008	-0.035	-4.968				
	(0.006)	(0.005)	(0.048)	(9.068)				
co_max-Q2	-0.008*	0.009**	0.048	-3.976				
	(0.005)	(0.004)	(0.037)	(6.459)				
co_max-Q1	0.001	0.003	-0.016	1.636				
	(0.004)	(0.004)	(0.035)	(8.263)				
nox_max-Q3					-0.000	-0.000	0.000	0.313
					(0.000)	(0.000)	(0.002)	(0.248)
nox_max-Q2					0.000	0.000	-0.001	-0.338
					(0.000)	(0.000)	(0.001)	(0.256)
nox_max-Q1					-0.000**	-0.000	0.002**	0.243
					(0.000)	(0.000)	(0.001)	(0.205)
Observations	9963	9963	9963	9963	7705	7705	7705	7705
NINO	-0.00	0.02	0.05	-30.45	0.01	0.03	-0.03	-33.90
P_NINO	0.69	0.00	0.53	0.00	0.40	0.00	0.62	0.01
NINA	-0.01	0.02	0.11	-17.56	-0.02	0.01	0.15	-2.87
P_NINA	0.30	0.01	0.15	0.12	0.21	0.36	0.08	0.82
POL	-0.00	0.02	-0.00	-7.31	-0.00	-0.00	0.00	0.22
P_POL	0.76	0.02	0.97	0.66	0.32	0.92	0.41	0.60
r2_a	0.37	0.29	0.35	0.34	0.38	0.33	0.36	0.36

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. For pollutants: Max. is the maximum per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

2G Variation in the spatial correlation over time and residential sorting

Table 20: Moran Index for main pollutants and weather variables (Yearly)

	PM10	Pval	PM25	Pval	O3	Pval	SO2	Pval	CO	Pval	NO	Pval
1998	0.68	0.00	-0.05	2.00	0.07	0.00	0.88	0.00	0.90	0.00	0.73	0.00
1999	0.86	0.00	-0.02	1.94	0.47	0.00	0.74	0.00	0.51	0.00	0.62	0.00
2000	0.67	0.00			0.13	0.00	0.87	0.00	0.54	0.00	0.75	0.00
2001	0.73	0.00			0.17	0.00	0.50	0.00	0.31	0.00	0.55	0.00
2002	0.71	0.00			0.24	0.00	0.68	0.00	0.63	0.00	0.63	0.00
2003	0.71	0.00			-0.00	1.15	0.71	0.00	0.10	0.00	0.01	0.21
2004	0.59	0.00			0.36	0.00	0.47	0.00	0.60	0.00	0.06	0.00
2005	0.80	0.00	-0.38	2.00	0.49	0.00	0.85	0.00	0.09	0.00		
2006	0.86	0.00	-0.18	2.00	0.36	0.00	0.49	0.00			0.14	0.00
2007	0.70	0.00	-0.00	0.98	-0.01	1.87	0.38	0.00	0.79	0.00	0.55	0.00
2008	0.51	0.00	0.44	0.00	0.00	0.62	0.51	0.00	0.46	0.00	0.35	0.00
2009	0.53	0.00	0.53	0.00	0.34	0.00	0.32	0.00	0.43	0.00	0.74	0.00
2010	0.76	0.00	0.27	0.00	0.39	0.00	0.59	0.00	0.63	0.00	0.83	0.00
2011	0.63	0.00	-0.05	2.00	0.48	0.00	0.89	0.00	0.43	0.00	0.35	0.00
2012	0.46	0.00	0.25	0.00	0.51	0.00	0.79	0.00	0.47	0.00	0.54	0.00
2013	0.55	0.00	0.38	0.00	0.54	0.00	0.79	0.00	0.27	0.00	0.70	0.00
2014	0.69	0.00	0.41	0.00	0.56	0.00	0.45	0.00	0.43	0.00	0.27	0.00
2015	0.57	0.00	0.48	0.00	0.63	0.00	0.72	0.00	0.58	0.00	0.63	0.00

	NO2	Pval	NOX	Pval	RAIN	Pval	TMP	Pval	WS	Pval
1998	0.51	0.00	0.74	0.00	0.25	0.00	0.50	0.00	0.74	0.00
1999	0.72	0.00	0.70	0.00	0.09	0.00	0.68	0.00	0.76	0.00
2000	0.49	0.00	0.82	0.00	0.22	0.00	0.53	0.00	0.83	0.00
2001	0.54	0.00	0.57	0.00	0.19	0.00	0.76	0.00	0.87	0.00
2002	0.51	0.00	0.64	0.00	0.04	0.00	0.70	0.00	0.80	0.00
2003	0.03	0.01	0.02	0.04	0.14	0.00	0.38	0.00	0.78	0.00
2004	0.09	0.00	0.15	0.00	0.12	0.00	0.49	0.00	0.68	0.00
2005					0.42	0.00	0.64	0.00	0.55	0.00
2006	0.19	0.00	0.27	0.00	0.12	0.00	0.76	0.00	0.61	0.00
2007	0.46	0.00	0.56	0.00	0.04	0.00	0.65	0.00	0.69	0.00
2008	0.07	0.00	0.31	0.00	0.17	0.00	0.29	0.00	0.80	0.00
2009	0.59	0.00	0.75	0.00	0.13	0.00	0.62	0.00	0.81	0.00
2010	0.69	0.00	0.90	0.00	0.08	0.00	0.16	0.00	0.90	0.00
2011	0.06	0.00			0.14	0.00	0.58	0.00	0.78	0.00
2012	0.28	0.00			0.05	0.00	0.78	0.00	0.79	0.00
2013	0.66	0.00			0.04	0.00	0.73	0.00	0.75	0.00
2014	0.41	0.00	0.27	0.00	0.00	0.48	0.77	0.00	0.70	0.00
2015	0.33	0.00	0.51	0.00	0.06	0.00	0.76	0.00	0.87	0.00

Note: Moran's I Statistic of spatial correlation per variable and per year, calculated for a spatial distance of 2km. It also has the respective p-value. All variables used are yearly average. The table shows how the spatial variation varies year by year for the main pollutants and the weather factors. We observe different spatial correlation, with some years with higher correlation than others for PM_{10}, and others like O_3 have higher variation, even towards negative values. Similar spatial correlation patterns are observed for weather variables too.

Table 21: OLS Estimations of NIÑO-NIÑA and Instrumental Variables (Wind direction and Wind Speed) on socioeconomic characteristics

	Father's age	Mother's age	Marital Status	Female's birth	Father's education			Mother's education			Type Social Security			
					Primary	Secondary	Tertiary	Primary	Secondary	Tertiary	Contributed	Subsidized	Others	Uninsured
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
nino	-0.009	0.001	0.001	0.000	-0.006	0.014	-0.012	0.005	-0.009	0.004	0.001	0.009*	-0.003	-0.013
	(0.0967)	(0.0583)	(0.00449)	(0.00393)	(0.00435)	(0.00790)	(0.00951)	(0.00430)	(0.00450)	(0.00230)	(0.00430)	(0.00406)	(0.00525)	(0.00461)
nina	-0.001	-0.006	-0.014*	-0.007	-0.003	0.010	-0.013	-0.001	0.008	-0.008	-0.000	0.017***	0.000	-0.033**
	(0.0992)	(0.0623)	(0.00472)	(0.00380)	(0.00366)	(0.00523)	(0.00564)	(0.00381)	(0.00393)	(0.00272)	(0.00437)	(0.00470)	(0.00407)	(0.00523)
ws_ave	-0.041	-0.142*	-0.062	0.111	0.240*	0.086	-0.206	0.221	-0.010	-0.155	-0.038	-0.018	0.161***	-0.121
	(0.380)	(0.499)	(0.0413)	(0.0324)	(0.0317)	(0.0579)	(0.0726)	(0.0370)	(0.0682)	(0.0909)	(0.0355)	(0.0648)	(0.0252)	(0.0260)
3.wd_rose	-0.035**	-0.013	-0.023	0.018	0.054	0.009	-0.034	0.032	0.005	-0.031	-0.004	-0.007	0.025	-0.017
	(0.543)	(0.642)	(0.0643)	(0.0362)	(0.0436)	(0.0646)	(0.0725)	(0.0375)	(0.0770)	(0.0956)	(0.0580)	(0.0939)	(0.0451)	(0.0287)
4.wd_rose	-0.025	-0.004	-0.027	0.061	0.098	0.116	-0.136	0.065	0.040	-0.101	-0.006	-0.089	0.100**	0.023
	(0.357)	(0.487)	(0.0573)	(0.0293)	(0.0334)	(0.0627)	(0.0740)	(0.0344)	(0.0737)	(0.0945)	(0.0451)	(0.0833)	(0.0315)	(0.0282)
5.wd_rose	-0.020	-0.022	-0.025	0.050	0.123	0.090	-0.122	0.088	0.044	-0.121	-0.048	-0.048	0.115**	0.036
	(0.334)	(0.495)	(0.0563)	(0.0299)	(0.0330)	(0.0630)	(0.0751)	(0.0347)	(0.0739)	(0.0947)	(0.0457)	(0.0834)	(0.0310)	(0.0291)
6.wd_rose	0.015	-0.013	-0.035	0.094	0.112	0.057	-0.101	0.013	0.079	-0.107	-0.021	-0.023	0.032	0.047
	(0.400)	(0.538)	(0.0582)	(0.0327)	(0.0352)	(0.0645)	(0.0758)	(0.0361)	(0.0748)	(0.0949)	(0.0480)	(0.0844)	(0.0345)	(0.0308)
3.wd_rose X ws_ave	0.020	0.030	0.026	-0.047	-0.084**	-0.008	0.051	-0.073*	0.006	0.047	0.005	-0.005	-0.038*	0.058***
	(0.532)	(0.600)	(0.0464)	(0.0366)	(0.0384)	(0.0605)	(0.0724)	(0.0398)	(0.0703)	(0.0923)	(0.0442)	(0.0712)	(0.0367)	(0.0256)
4.wd_rose X ws_ave	0.028	0.150	0.073	-0.177	-0.273*	-0.126	0.248	-0.219	-0.008	0.181	0.031	0.005	-0.167**	0.174*
	(0.403)	(0.496)	(0.0429)	(0.0321)	(0.0331)	(0.0578)	(0.0728)	(0.0369)	(0.0688)	(0.0918)	(0.0347)	(0.0653)	(0.0273)	(0.0255)
5.wd_rose X ws_ave	0.042	0.239*	0.095	-0.222	-0.382*	-0.147	0.318	-0.339	0.018	0.245	0.087	-0.038	-0.242***	0.226
	(0.394)	(0.492)	(0.0418)	(0.0324)	(0.0324)	(0.0575)	(0.0731)	(0.0373)	(0.0687)	(0.0918)	(0.0349)	(0.0653)	(0.0268)	(0.0262)
6.wd_rose X ws_ave	-0.010	0.154*	0.083	-0.207*	-0.281*	-0.093	0.225	-0.177	-0.039	0.188	0.047	-0.037	-0.117*	0.130
	(0.410)	(0.491)	(0.0426)	(0.0332)	(0.0333)	(0.0580)	(0.0734)	(0.0380)	(0.0690)	(0.0916)	(0.0356)	(0.0658)	(0.0271)	(0.0270)
FE YEAR-LOCALITY	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE MONTH	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE IPS HEALTH CENTER	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standardized beta coefficients; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the table shows the coefficient estimates of wind direction, wind speed (the instrumental variables for pollution) and NIÑO-NIÑA on some key socioeconomic characteristics of the running-quarter analysis. All variables are averaged at health center or IPS. Column 1 and 2 have the average of the father and mother's age, column 3 is the percentage of mothers with a couple (Marital Status), column 4 is the percentage of female born in the IPS, columns 5-7 have the percentage of fathers with primary, secondary and tertiary education in each IPS, columns 8-10 have the percentage of mothers with primary, secondary and tertiary education in each IPS, columns 11-14 have the percentage of mothers with different types of social security in each IPS. Wind Direction Rose: 1 "WD: N 337.5-22.5" 2 "WD: NE 22.5-67.5" 3 "WD: E 67.5-112.5" 4 "WD: SE 112.5-157.5" 5 "WD: S 157.5-202.5" 6 "WD: SW 202.5-247.5" 7 "WD: W 247.5-292.5" 8 "WD: NW 292.5-337.5". The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 22: Socioeconomic characteristics from the EMB - Migration

a) Migration from locality

Locality of origin	2011		2014		Total			
	Obs.	Per.	Obs.	Per.	Obs.	Per.	Diff	se
USAQUEN	88899	7.0	90019	7.5	178919	7.2	0.003	(0.008)
CHAPINERO	36981	2.9	35667	3.0	72648	2.9	-0.002	(0.004)
SANTA FE	9920	0.8	8679	0.7	18600	0.8	0.002	(0.002)
SAN CRISTOBAL	70101	5.5	59047	4.9	129148	5.2	-0.004	(0.06)
USME	58024	4.5	57710	4.8	115734	4.7	0.002	(0.007)
TUNJUELITO	34867	2.7	24317	2.0	59184	2.4	-0.007	(0.004)
BOSA	117635	9.2	116513	9.7	234148	9.5	0.010	(0.020)
KENNEDY	159858	12.5	163085	13.6	322943	13.1	0.023	(0.030)
FONTIBON	51227	4.0	53906	4.5	105133	4.3	0.002	(0.006)
ENGATIVA	142864	11.2	117431	9.8	260295	10.5	-0.016	(0.006)**
SUBA	182169	14.3	189672	15.9	371841	15.0	-0.003	(0.007)
BARRIOS UNIDOS	23068	1.8	25638	2.1	48706	2.0	0.001	(0.006)
TEUSAQUILLO	20320	1.6	17904	1.5	38225	1.5	-0.002	(0.004)
LOS MARTIRES	14036	1.1	11044	0.9	25080	1.0	-0.001	(0.003)
ANTONIO NARINO	27111	2.1	17128	1.4	44239	1.8	-0.005	(0.004)
PUENTE ARANDA	34202	2.7	36659	3.1	70861	2.9	0.004	(0.005)
LA CANDELARIA	7884	0.6	7698	0.6	15581	0.6	0.000	(0.002)
RAFAEL URIBE URIBE	69241	5.4	50029	4.2	119270	4.8	-0.005	(0.006)
CIUDAD BOLIVAR	105299	8.3	90132	7.5	195430	7.9	-0.005	(0.007)
No Info	21813	1.7	23957	2.0	45770	1.9	0.004	(0.007)
Total	1275519	100.0	1196234	100.0	2471753	100.0		

b) Reasons to migrate

Reason to Migrate	2011	2014	2017	Total
	Per.	Per.	Per.	Per.
Economic	42.5	46.0	54.8	47.4
Family	28.2	28.4	20.9	26.0
Education	17.0	14.6	13.6	15.2
Risk for life security	9.3	7.5	4.1	7.1
Better dwelling	0.0	0.0	4.3	1.3
Health	2.2	1.9	1.2	1.8
Others	0.8	1.6	1.1	1.1
Total	100.0	100.0	100.0	100.0

	2011	2014	2017
Z-value	92.994	86.001	84.546
Economic vs Health (p-val)	1	1	1

Source: calculated using the Multipurpose Survey for Bogotá (EMB) for 2011, 2014 and 2017. Part a) uses the declared locality of origin for individuals moving inside the city, for whom the movement took place three years ago or less. Part b) shows the percentage of each declared reasons for migrating per year for the city. While part a) compares migration between localities, part b) analyses migration towards the city. Statistics are calculated using individual' weights provided by the EMB. In part b), migration is defined as migrating to the city five years ago or less; this definition allowed to homogenize the variables for the different waves. The original categories were: 1) For work or business, 2) Education opportunity, 3) Health motives, 4) Marriage or making family, 5) Risk-natural disaster, 6) Threat for life-risk, 7) Buying dwelling, 8) Better dwelling or location, 9) Problem or partner's problems, 10) Economic reason, 11) joint family member, 12) Others.

Part a) shows not large changes in the percentage of migration per each locality along the years we have in the EMB survey. Part b) shows that individuals migrate mainly for economic reasons and family reasons and once that problem is solved, they think on moving for other reasons such as health. The results again do not show large changes along the years. Individuals moving to avoid air pollution hence is less a concern in our results and migration between localities has been stable in the years we have information (no residential sorting in this sense). The column Diff of part a) does not correspond exactly to the difference between the columns of the percentages 2014 and 2011, as the test includes controls for stratus and locality fixed effects; the standard error in the tests are clustered at the locality level.

Table 23: Socioeconomic characteristics from the EMB

a) Descriptive Statistics

Locality	2011				2014				2017			
	Fem.	Age	Edu-year	Mig.	Fem.	Age	Edu-year	Mig.	Fem.	Age	Edu-year	Mig.
ANTONIO NARINO	0.52	32.9	10.8	0.08	0.51	33.9	10.4	0.04	0.50	35.9	11.8	0.04
BARRIOS UNIDOS	0.52	36.8	12.1	0.07	0.52	37.9	12.2	0.07	0.50	38.8	13.3	0.08
BOSA	0.51	28.4	8.6	0.09	0.51	29.5	8.7	0.09	0.50	31.1	9.6	0.08
CHAPINERO	0.54	36.8	14.6	0.19	0.53	37.9	14.6	0.18	0.51	37.1	14.9	0.13
CIUDAD BOLIVAR	0.51	27.7	8.4	0.07	0.51	28.6	8.6	0.04	0.50	30.5	9.0	0.08
ENGATIVA	0.52	33.2	11.2	0.08	0.52	34.3	11.2	0.06	0.50	35.7	11.9	0.06
FONTIBON	0.53	32.1	11.9	0.11	0.53	33.0	11.7	0.07	0.51	35.1	12.4	0.08
KENNEDY	0.51	30.8	9.9	0.09	0.51	31.7	10.2	0.07	0.51	33.2	10.9	0.08
LA CANDELARIA	0.47	35.4	11.2	0.12	0.47	36.2	11.0	0.09	0.50	38.5	12.2	0.09
LOS MARTIRES	0.50	34.1	10.6	0.09	0.50	35.2	10.2	0.07	0.50	37.2	11.6	0.09
PUENTE ARANDA	0.51	34.2	11.3	0.07	0.51	35.5	11.1	0.04	0.50	36.8	11.6	0.06
RAFAEL URIBE U	0.51	30.8	9.1	0.05	0.51	31.8	9.2	0.04	0.50	33.5	9.9	0.06
SAN CRISTOBAL	0.51	30.2	8.7	0.04	0.51	30.9	8.8	0.05	0.50	32.8	9.5	0.06
SANTA FE	0.50	32.2	10.3	0.10	0.50	33.5	9.2	0.05	0.50	35.8	10.5	0.06
SUBA	0.53	31.7	11.6	0.09	0.53	32.8	11.5	0.09	0.50	34.1	12.2	0.07
TEUSAQUILLO	0.54	38.0	14.4	0.13	0.53	39.1	14.7	0.09	0.50	38.8	15.3	0.11
TUNJUELITO	0.51	31.4	9.7	0.06	0.50	32.5	9.6	0.06	0.50	34.1	10.4	0.11
USAQUEN	0.54	34.5	13.3	0.08	0.54	36.3	13.0	0.06	0.50	36.7	13.9	0.13
USME	0.51	27.4	8.2	0.08	0.51	28.3	8.4	0.04	0.50	30.7	8.7	0.05
Total	0.52	31.5	10.5	0.08	0.52	32.5	10.5	0.07	0.50	34.0	11.2	0.08

b) T-test of difference between years

2014 vs 2011				2017 vs 2014				2017 vs 2014-2011			
Variable	Mean 2011	Mean 2014	Diff	Variable	Mean 2014	Mean 2017	Diff	Variable	Mean 2011-2014	Mean 2017	Diff
Fem.	0.518	0.517	-0.028	Fem.	0.517	0.505	-0.032	Fem.	0.517	0.505	-0.033
	(0.500)	(0.500)	(0.000)		(0.500)	(0.500)	(0.000)		(0.500)	(0.500)	(0.000)
Age	31.500	32.549	-5.846	Age	32.549	33.955	-5.760	Age	32.036	33.955	-3.969
	(20.243)	(20.622)	(0.000)		(20.622)	(20.079)	(0.000)		(20.444)	(20.079)	(0.000)
Edu-year	10.531	10.547	-4.718	Edu-year	10.547	11.243	-3.922	Edu-year	10.539	11.243	-4.251
	(4.681)	(4.665)	(0.000)		(4.665)	(4.596)	(0.000)		(4.673)	(4.596)	(0.000)
Mig.	0.084	0.067	-0.048	Mig.	0.067	0.076	0.015	Mig.	0.075	0.076	-0.006
	(0.277)	(0.250)	(0.000)		(0.250)	(0.264)	(0.000)		(0.264)	(0.264)	(0.000)

The standard error in parenthesis.
$p < 0.1$ *, $p < 0.05$ **, $p < 0.01$ ***
Source: calculated using the Multipurpose Survey for Bogotá (EMB) for 2011, 2014 and 2017. Part a) shows statistics for percentage of female (fem), average age, years of education and percentage of migrants in the locality are calculated using individual' weights. Migration is defined as migrating to the city five years ago or less (see previous part b) for reasons to migrate); this definition allowed to homogenize the variables for the different waves.
We do not see large changes in the socioeconomic variables between the different years. Migration is very low by locality and the percentage of women by locality does not change. Although there is an increasing trend in the years of education and age, this is a general aspect similar along all localities. By including yearxlocality fixed effects in our estimations, we expect that the general trend is controlled for already. In general, we do not observe drastic changes in these variables by locality that can be interpreted as evidence of a residential sorting problem. In addition, part b) of the table compares the difference in mean for the different years. The column Diff does not correspond exactly to the difference between the columns of the percentages of the years compared, as the test includes controls for stratus, yearxlocality fixed effects; the standard error in the tests are clustered at the locality level. The results of part b) show that there are no statistically significant differences in the average of the socioeconomic characteristics along the years. We do not have evidence to assert the presence of a residential sorting problem in terms of these variables, as they do not change drastically during the years of the sample.

2H Restricting sample to South-West[22] of the city.

Table 24: IV SECOND STAGE: SO_2 (average) ON HEALTH

	SO2 (average)			
	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)
Niño-Q3	0.012	0.014**	-0.076	-34.387***
	(0.010)	(0.006)	(0.067)	(12.820)
Niño-Q2	0.004	0.002	-0.036	4.252
	(0.012)	(0.007)	(0.081)	(12.864)
Niño-Q1	0.012	-0.004	-0.054	-8.761
	(0.012)	(0.006)	(0.086)	(12.750)
Niña-Q3	0.019*	0.011**	-0.126*	3.572
	(0.010)	(0.005)	(0.066)	(11.265)
Niña-Q2	0.003	0.009	-0.037	-18.734
	(0.009)	(0.006)	(0.063)	(12.498)
Niña-Q1	0.001	0.002	0.018	-11.534
	(0.009)	(0.007)	(0.059)	(13.168)
so2_ave-Q3	-0.001	-0.000	0.007	-0.993
	(0.001)	(0.001)	(0.010)	(2.079)
so2_ave-Q2	-0.003**	-0.001	0.020**	0.386
	(0.001)	(0.001)	(0.009)	(2.276)
so2_ave-Q1	0.000	-0.000	-0.004	-1.648
	(0.002)	(0.001)	(0.011)	(2.877)
Observations	3368	3368	3368	3368
NINO	0.03	0.01	-0.17	-38.90
P_NINO	0.02	0.07	0.04	0.01
NINA	0.02	0.02	-0.15	-26.70
P_NINA	0.09	0.03	0.13	0.19
POL	-0.00	-0.00	0.02	-2.26
P_POL	0.11	0.51	0.19	0.55
r2_a	0.40	0.30	0.40	0.35

* $p<0.05>$, ** $p<0.01$, *** $p<0.001$

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

[22] Localities: Bosa, Ciudad Bolivar, Engativa, Fontibon, Kennedy, Puente Aranda and Tunjuelito

Table 25: IV SECOND STAGE: PM_{10}-$PM_{2.5}$ (average) ON HEALTH

	PM10 (average)				PM2.5 (average)			
	Premature	Low Weight	Weeks Gest.	Birth Weight	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niño-Q3	0.011	0.016***	-0.074	-36.608***	0.019	0.043**	-0.147	-41.666
	(0.010)	(0.006)	(0.066)	(13.205)	(0.023)	(0.017)	(0.164)	(27.096)
Niño-Q2	0.008	0.004	-0.065	-9.663	-0.010	0.027**	0.034	-41.416*
	(0.011)	(0.006)	(0.074)	(13.041)	(0.018)	(0.012)	(0.127)	(24.499)
Niño-Q1	0.019	-0.000	-0.102	-13.863	0.023	-0.002	-0.094	10.340
	(0.013)	(0.006)	(0.087)	(14.661)	(0.015)	(0.011)	(0.101)	(19.806)
Niña-Q3	0.014	0.011**	-0.101	-2.360	-0.032	-0.019	0.220	21.633
	(0.010)	(0.005)	(0.062)	(10.073)	(0.021)	(0.018)	(0.147)	(25.696)
Niña-Q2	0.003	0.010	-0.039	-21.517	0.052***	0.041***	-0.327**	-52.093*
	(0.010)	(0.007)	(0.065)	(14.001)	(0.019)	(0.016)	(0.140)	(26.752)
Niña-Q1	0.008	0.005	-0.036	-28.926**	-0.002	-0.007	0.044	-14.910
	(0.010)	(0.007)	(0.063)	(12.875)	(0.015)	(0.013)	(0.102)	(21.058)
pm10_ave-Q3	0.000	0.000	-0.004	0.075				
	(0.001)	(0.001)	(0.007)	(1.172)				
pm10_ave-Q2	0.001*	0.001	-0.010**	-2.339**				
	(0.001)	(0.001)	(0.005)	(1.075)				
pm10_ave-Q1	0.001	0.001	-0.005	-0.917				
	(0.001)	(0.001)	(0.007)	(1.325)				
pm25_ave-Q3					0.007**	0.004*	-0.046**	-6.202
					(0.003)	(0.002)	(0.018)	(3.830)
pm25_ave-Q2					-0.004	0.006***	0.024	-6.507
					(0.003)	(0.002)	(0.023)	(4.218)
pm25_ave-Q1					-0.000	0.003*	0.002	-4.657
					(0.002)	(0.002)	(0.016)	(3.193)
Observations	3368	3368	3368	3368	1456	1456	1456	1456
NINO	0.04	0.02	-0.24	-60.13	0.03	0.07	-0.21	-72.74
P_NINO	0.01	0.04	0.01	0.00	0.23	0.00	0.27	0.07
NINA	0.03	0.03	-0.18	-52.80	0.02	0.01	-0.06	-45.37
P_NINA	0.10	0.01	0.10	0.01	0.47	0.62	0.69	0.28
POL	0.00	0.00	-0.02	-3.18	0.00	0.01	-0.02	-17.37
P_POL	0.03	0.12	0.03	0.09	0.75	0.01	0.69	0.06
r2_a	0.39	0.29	0.39	0.34	0.41	0.29	0.42	0.32

* $p<0.05>$, ** $p<0.01$, *** $p<0.001$

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 26: IV SECOND STAGE: CO-NO_X (peak afternoon) ON HEALTH

	CO (peak afternoon)				NOX (peak afternoon)			
	Premature	Low Weight	Weeks Gest.	Birth Weight	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niño-Q3	0.003	0.015**	-0.012	-39.050***	-0.015*	0.011	0.113*	-23.697
	(0.010)	(0.007)	(0.071)	(12.020)	(0.009)	(0.008)	(0.062)	(16.098)
Niño-Q2	-0.010	0.006	0.061	9.144	-0.004	0.002	0.011	6.606
	(0.013)	(0.008)	(0.090)	(14.269)	(0.011)	(0.007)	(0.081)	(16.152)
Niño-Q1	0.016	0.002	-0.082	-31.199**	0.005	0.006	-0.013	-18.386
	(0.015)	(0.007)	(0.101)	(14.373)	(0.015)	(0.007)	(0.105)	(11.934)
Niña-Q3	0.011	0.009	-0.071	-3.618	0.009	0.005	-0.057	12.656
	(0.009)	(0.006)	(0.062)	(10.441)	(0.010)	(0.006)	(0.072)	(11.782)
Niña-Q2	-0.006	0.005	0.030	-12.314	-0.019*	-0.007	0.099	-17.138
	(0.009)	(0.006)	(0.057)	(10.747)	(0.010)	(0.006)	(0.070)	(11.983)
Niña-Q1	-0.001	0.002	0.030	-9.442	0.002	-0.006	0.008	-11.240
	(0.011)	(0.007)	(0.072)	(11.633)	(0.010)	(0.010)	(0.068)	(16.982)
co_peaka-Q3	0.010	0.004	-0.063	6.755				
	(0.010)	(0.008)	(0.067)	(14.682)				
co_peaka-Q2	-0.011	0.005	0.070	2.176				
	(0.009)	(0.007)	(0.063)	(12.795)				
co_peaka-Q1	-0.001	0.008	0.011	9.519				
	(0.006)	(0.005)	(0.042)	(8.947)				
nox_peaka-Q3					0.000	0.001	0.000	0.826
					(0.001)	(0.000)	(0.004)	(0.796)
nox_peaka-Q2					-0.001**	-0.000	0.005**	0.158
					(0.000)	(0.000)	(0.003)	(0.384)
nox_peaka-Q1					-0.001*	0.001*	0.004*	-0.307
					(0.000)	(0.000)	(0.003)	(0.517)
Observations	3056	3056	3056	3056	2256	2256	2256	2256
NINO	0.01	0.02	-0.03	-61.11	-0.01	0.02	0.11	-35.48
P_NINO	0.58	0.02	0.75	0.00	0.35	0.08	0.28	0.05
NINA	0.00	0.02	-0.01	-25.37	-0.01	-0.01	0.05	-15.72
P_NINA	0.81	0.14	0.92	0.16	0.65	0.49	0.68	0.52
POL	-0.00	0.02	0.02	18.45	-0.00	0.00	0.01	0.68
P_POL	0.92	0.32	0.90	0.54	0.13	0.16	0.11	0.61
r2_a	0.40	0.28	0.40	0.34	0.39	0.29	0.39	0.35

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Peak afternoon is the average pollution during the peak in the afternoon per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 27: IV FIRST STAGE: IV ON SO_2 PM_{10} $PM_{2.5}$ (average)

	SO2 (average)			PM10 (average)			PM2.5 (average)		
	Q3-gest.	Q2-gest.	Q1-gest.	Q3-gest.	Q2-gest.	Q1-gest.	Q3-gest.	Q2-gest.	Q1-gest.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Niño-Q3	1.152**	1.527**	-0.224	-3.337	0.319	-0.701	-1.074	-3.362***	-0.779
	(0.566)	(0.675)	(0.574)	(2.405)	(1.632)	(1.709)	(1.373)	(0.951)	(1.387)
Niño-Q2	-1.132**	1.564**	2.315***	-0.830	-4.744**	-0.493	2.606	-5.512***	1.094
	(0.563)	(0.718)	(0.594)	(1.974)	(2.098)	(1.284)	(1.616)	(1.211)	(1.220)
Niño-Q1	0.339	-1.688**	-0.495	-1.333	0.599	-4.485	-0.079	0.095	-0.382
	(0.685)	(0.731)	(0.567)	(1.735)	(2.428)	(3.339)	(1.209)	(1.180)	(1.091)
Niña-Q3	1.051*	0.103	0.754	-1.337	-2.473	-0.089	1.309	-3.595**	7.505***
	(0.591)	(0.626)	(0.575)	(2.012)	(1.870)	(2.234)	(1.579)	(1.599)	(1.632)
Niña-Q2	0.251	1.234*	0.105	-4.576**	1.247	-3.051	-3.987**	-1.412	-5.766***
	(0.645)	(0.683)	(0.813)	(2.231)	(2.767)	(2.688)	(1.760)	(1.623)	(2.094)
Niña-Q1	0.630	0.131	4.398***	-0.048	-5.659***	-0.498	0.500	-5.618***	4.543**
	(0.651)	(0.695)	(1.268)	(2.007)	(1.793)	(2.204)	(1.606)	(1.183)	(1.933)
ws_ave-Q3	0.511	-1.411***	-0.807*	-2.352	1.163	0.818	0.297	-1.351*	0.488
	(0.409)	(0.460)	(0.414)	(1.818)	(1.506)	(1.127)	(0.830)	(0.789)	(0.771)
ws_ave-Q2	0.500	1.246**	-0.854	0.959	-4.328**	-0.177	-1.389**	0.793	0.225
	(0.396)	(0.524)	(0.537)	(1.392)	(1.842)	(1.164)	(0.664)	(0.760)	(0.714)
ws_ave-Q1	-0.732*	0.094	1.447**	3.576***	0.223	-4.690***	1.035	-2.787***	-0.592
	(0.383)	(0.445)	(0.566)	(0.932)	(1.215)	(1.495)	(0.808)	(0.920)	(0.785)
wd_rose_Cat3-Q3	1.861	0.870	4.264**	13.963**	1.989	-16.041*			
	(3.530)	(2.460)	(2.103)	(6.668)	(6.594)	(8.914)			
wd_rose_Cat4-Q3	0.708	-1.737	1.146	-2.816	-5.763**	-4.918	-2.293*	-1.933**	0.941
	(0.954)	(1.078)	(0.968)	(2.565)	(2.798)	(3.083)	(1.197)	(0.801)	(1.211)
wd_rose_Cat6-Q3	-3.605***	-1.372	-0.783	4.982**	5.725**	4.259	-0.684	2.784***	-1.301
	(0.773)	(0.945)	(1.140)	(1.987)	(2.474)	(2.929)	(0.814)	(0.874)	(0.952)
wd_rose_Cat3-Q2	-13.164***	3.825	9.859***	0.222	9.831*	-12.063			
	(2.908)	(3.539)	(2.349)	(5.041)	(5.815)	(7.524)			
wd_rose_Cat4-Q2	-1.362	0.382	-1.072	-2.218	-1.854	-7.067***	-1.337	-2.450***	-0.649
	(1.023)	(1.018)	(1.108)	(2.656)	(2.279)	(2.671)	(1.400)	(0.893)	(0.924)
wd_rose_Cat6-Q2	1.670**	-4.577***	-2.298**	-2.790	3.583	5.547**	-2.971***	-4.263***	2.354**
	(0.743)	(0.883)	(1.142)	(2.808)	(2.642)	(2.164)	(0.847)	(1.197)	(1.078)
wd_rose_Cat3-Q1	-12.722***	-9.459***	2.362	0.048	-0.353	7.526			
	(3.234)	(3.569)	(2.370)	(5.643)	(5.058)	(6.748)			
wd_rose_Cat4-Q1	0.677	-1.485*	-1.695	-1.137	-2.599	-8.590***	-0.695	0.112	-3.139***
	(0.903)	(0.776)	(1.305)	(2.774)	(2.144)	(2.547)	(1.156)	(1.211)	(0.843)
wd_rose_Cat6-Q1	1.780**	0.334	-4.520***	2.284	-3.471	-0.447	2.513**	-3.683***	-2.208**
	(0.726)	(0.866)	(1.334)	(2.364)	(2.874)	(2.497)	(1.046)	(1.086)	(0.876)
N	3368	3368	3368	3368	3368	3368	1456	1456	1456
R2_first_a	0.32	0.28	0.18	0.09	0.11	0.09	0.30	0.27	0.34
F_first_a	19.20	20.10	13.66	30.24	18.07	7.23	15.21	12.79	23.96

* p<0.05> , ** p<0.01, *** p<0.001

Note: Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. Each regression of the health outcomes has three equations in the first stage, one for each quarter of gestation. In this case, the three equations are the same for each set of four health outcomes presented in the second stage, for instance, the first four columns of Table 6 (for SO_2) share the same equations in the first stage, so we will only present once the results. The same holds for the other pollutants. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay). The interaction of the wind direction rose with wind speed not shown to save space. Wind direction baseline is category 5 here.

Table 28: IV FIRST STAGE: IV ON CO NO_X (peak afternoon)

	CO (peak afternoon)			NOX (peak afternoon)		
	Q3-gest. (1)	Q2-gest. (2)	Q1-gest. (3)	Q3-gest. (4)	Q2-gest. (5)	Q1-gest. (6)
Niño-Q3	0.053	-0.323**	0.264*	-4.972	-12.717***	-9.535***
	(0.149)	(0.156)	(0.151)	(3.577)	(2.713)	(2.379)
Niño-Q2	-0.174	0.031	-0.349*	3.227	-6.667***	-8.162***
	(0.167)	(0.134)	(0.209)	(3.572)	(2.513)	(2.263)
Niño-Q1	0.075	-0.338	0.417**	0.711	-1.785	-4.362
	(0.115)	(0.225)	(0.164)	(3.991)	(4.402)	(3.013)
Niña-Q3	-0.246*	-0.189*	0.546***	0.845	-8.608***	9.646***
	(0.133)	(0.111)	(0.160)	(2.937)	(2.954)	(3.006)
Niña-Q2	-0.014	-0.335*	-0.024	5.463	1.025	-6.912**
	(0.110)	(0.173)	(0.123)	(3.902)	(3.192)	(3.271)
Niña-Q1	-0.481***	-0.178*	-0.317**	-5.343	8.855	8.349***
	(0.151)	(0.098)	(0.152)	(4.046)	(5.674)	(3.165)
ws_peaka-Q3	0.009	0.098*	0.003	0.014	0.515	-1.739
	(0.062)	(0.054)	(0.063)	(1.517)	(1.796)	(1.444)
ws_peaka-Q2	0.119*	-0.164***	0.016	-1.415	-0.022	3.194*
	(0.061)	(0.063)	(0.087)	(2.019)	(1.790)	(1.703)
ws_peaka-Q1	-0.148***	0.281***	0.088	-4.878***	-1.882	-2.616
	(0.052)	(0.076)	(0.078)	(1.813)	(2.124)	(1.743)
wd_rose_Cat3-Q3	-1.827***	-2.487***	4.243***	62.925***	56.386**	-21.126*
	(0.564)	(0.660)	(1.153)	(22.513)	(22.235)	(12.096)
wd_rose_Cat4-Q3	-0.137	0.224**	0.086	-4.008	-5.142	-1.568
	(0.109)	(0.113)	(0.124)	(4.093)	(4.172)	(3.036)
wd_rose_Cat6-Q3	0.034	0.104	0.448***	-0.840	1.768	5.318
	(0.108)	(0.122)	(0.124)	(4.512)	(3.904)	(3.688)
wd_rose_Cat3-Q2	-1.864***	-2.097***	1.019**	13.993	23.826	-3.511
	(0.384)	(0.591)	(0.517)	(14.104)	(19.294)	(13.161)
wd_rose_Cat4-Q2	-0.186	-0.147	0.237**	0.450	-7.309	-5.381
	(0.141)	(0.145)	(0.112)	(3.821)	(4.645)	(3.812)
wd_rose_Cat6-Q2	0.298***	0.059	0.244**	-1.096	-1.042	3.463
	(0.081)	(0.087)	(0.112)	(4.889)	(4.567)	(3.477)
wd_rose_Cat3-Q1	-0.881**	-0.555	-1.764**	-32.026**	-10.675	3.447
	(0.360)	(0.410)	(0.706)	(15.346)	(19.127)	(11.540)
wd_rose_Cat4-Q1	-0.572***	0.124	0.127	-1.342	-1.608	-6.704**
	(0.135)	(0.120)	(0.146)	(5.039)	(2.920)	(3.209)
wd_rose_Cat6-Q1	0.205**	0.148	-0.046	8.183*	2.743	-8.318**
	(0.089)	(0.091)	(0.107)	(4.486)	(3.422)	(3.783)
N	3056	3056	3056	2256	2256	2256
R2_first_a	0.40	0.40	0.41	0.14	0.22	0.29
F_first_a	44.77	35.21	35.20	8.24	11.25	26.27

* p<0.05> , ** p<0.01, *** p<0.001

Note: Peak afternoon is the average pollution during the peak in the afternoon per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. Each regression of the health outcomes has three equations in the first stage, one for each quarter of gestation. In this case, the three equations are the same for each set of four health outcomes presented in the second stage, for instance, the first four columns of Table 6 (for SO_2) share the same equations in the first stage, so we will only present once the results. The same holds for the other pollutants. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay). The interaction of the wind direction rose with wind speed not shown to save space. Wind direction baseline is category 5 here.

2I Aggregating the sample by localities of the city

Table 29: IV SECOND STAGE: SO_2 (average) ON HEALTH

	SO2 (average)			
	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)
Niño-Q3	-0.003	0.001	0.020	-6.316
	(0.006)	(0.004)	(0.046)	(7.837)
Niño-Q2	0.009	0.001	-0.065	-3.987
	(0.007)	(0.004)	(0.049)	(8.292)
Niño-Q1	-0.010	-0.001	0.072*	-5.379
	(0.006)	(0.003)	(0.043)	(7.103)
Niña-Q3	-0.000	0.005	-0.000	-3.780
	(0.006)	(0.004)	(0.040)	(8.006)
Niña-Q2	0.005	0.009**	-0.036	-7.791
	(0.006)	(0.004)	(0.038)	(7.553)
Niña-Q1	-0.013*	0.003	0.091*	-8.023
	(0.008)	(0.004)	(0.054)	(8.867)
so2_ave-Q3	-0.000	-0.002**	-0.001	3.328*
	(0.001)	(0.001)	(0.009)	(1.851)
so2_ave-Q2	-0.005***	-0.001	0.035***	-1.440
	(0.001)	(0.001)	(0.009)	(1.756)
so2_ave-Q1	0.003	0.002*	-0.018	0.721
	(0.002)	(0.001)	(0.013)	(2.073)
Observations	3347	3347	3347	3347
NINO	-0.00	0.00	0.03	-15.68
P_NINO	0.55	0.75	0.55	0.03
NINA	-0.01	0.02	0.06	-19.59
P_NINA	0.41	0.00	0.43	0.10
POL	-0.00	-0.00	0.02	2.61
P_POL	0.28	0.37	0.30	0.32
r2_a	0.52	0.44	0.53	0.51

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the locality, Weeks gest. is the average of weeks of gestation for all the children born in that locality and Birth Weight is the average weight for all the children born in that locality. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 30: IV SECOND STAGE: PM_{10}-$PM_{2.5}$ (average) ON HEALTH

	PM10 (average)				PM2.5 (average)			
	Premature	Low Weight	Weeks Gest.	Birth Weight	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niño-Q3	-0.006	-0.003	0.037	-8.357	-0.001	-0.004	0.002	6.652
	(0.005)	(0.004)	(0.037)	(7.733)	(0.012)	(0.008)	(0.084)	(10.717)
Niño-Q2	0.012*	0.007*	-0.083*	-15.269*	0.023**	0.018***	-0.169**	-20.524**
	(0.007)	(0.004)	(0.048)	(8.318)	(0.010)	(0.007)	(0.067)	(8.837)
Niño-Q1	-0.007	-0.000	0.049	-5.244	-0.007	-0.006	0.042	5.572
	(0.006)	(0.004)	(0.043)	(8.674)	(0.009)	(0.005)	(0.065)	(8.361)
Niña-Q3	-0.002	0.001	0.008	2.291	-0.001	-0.002	0.004	-0.888
	(0.004)	(0.003)	(0.031)	(6.683)	(0.011)	(0.008)	(0.077)	(12.536)
Niña-Q2	0.003	0.008**	-0.023	-16.482**	0.007	0.017***	-0.045	-14.870
	(0.005)	(0.004)	(0.035)	(7.636)	(0.008)	(0.007)	(0.055)	(9.480)
Niña-Q1	-0.007	0.006	0.053	-15.768	0.011	0.008	-0.096	-14.155
	(0.008)	(0.005)	(0.054)	(11.224)	(0.009)	(0.006)	(0.066)	(11.886)
pm10_ave-Q3	0.001	0.000	-0.005	-1.043*				
	(0.001)	(0.000)	(0.004)	(0.604)				
pm10_ave-Q2	0.000	0.000	-0.000	-1.131				
	(0.001)	(0.000)	(0.004)	(0.834)				
pm10_ave-Q1	-0.000	0.001	0.001	-1.318				
	(0.001)	(0.001)	(0.005)	(1.105)				
pm25_ave-Q3					0.002	0.001	-0.015	-2.516
					(0.001)	(0.001)	(0.010)	(2.116)
pm25_ave-Q2					0.000	0.001	-0.007	1.517
					(0.002)	(0.001)	(0.013)	(1.841)
pm25_ave-Q1					0.001	0.001	-0.009	0.121
					(0.001)	(0.001)	(0.008)	(1.093)
Observations	3347	3347	3347	3347	1471	1471	1471	1471
NINO	-0.00	0.00	0.00	-28.87	0.01	0.01	-0.12	-8.30
P_NINO	0.98	0.44	0.93	0.01	0.27	0.53	0.20	0.61
NINA	-0.01	0.01	0.04	-29.96	0.02	0.02	-0.14	-29.91
P_NINA	0.59	0.02	0.60	0.03	0.31	0.03	0.24	0.11
POL	0.00	0.00	-0.00	-3.49	0.00	0.00	-0.03	-0.88
P_POL	0.39	0.41	0.45	0.02	0.33	0.25	0.21	0.85
r2_a	0.53	0.45	0.54	0.50	0.59	0.44	0.59	0.54

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the locality, Weeks gest. is the average of weeks of gestation for all the children born in that locality and Birth Weight is the average weight for all the children born in that locality. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 31: IV SECOND STAGE: CO-NO_X (peak afternoon) ON HEALTH

	CO (peak afternoon)				NOX (peak afternoon)			
	Premature	Low Weight	Weeks Gest.	Birth Weight	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niño-Q3	-0.010**	-0.003	0.069**	-7.410	-0.009	0.001	0.064	-14.411*
	(0.005)	(0.004)	(0.032)	(8.554)	(0.006)	(0.003)	(0.041)	(8.644)
Niño-Q2	0.016**	0.011**	-0.115**	-6.657	0.005	0.003	-0.036	-0.817
	(0.007)	(0.004)	(0.047)	(9.572)	(0.007)	(0.004)	(0.047)	(8.665)
Niño-Q1	-0.003	-0.002	0.027	-8.812	-0.014**	-0.004	0.107**	-5.646
	(0.008)	(0.005)	(0.055)	(7.905)	(0.007)	(0.004)	(0.050)	(9.697)
Niña-Q3	0.000	0.005	-0.008	-7.411	0.000	-0.002	-0.013	7.873
	(0.005)	(0.004)	(0.033)	(6.602)	(0.005)	(0.003)	(0.038)	(9.777)
Niña-Q2	-0.002	0.004	0.015	-3.472	-0.011*	-0.005*	0.074*	13.714*
	(0.005)	(0.003)	(0.034)	(6.033)	(0.006)	(0.003)	(0.039)	(8.279)
Niña-Q1	0.004	0.013***	-0.023	-14.359*	-0.008	0.004	0.058	-4.987
	(0.007)	(0.004)	(0.051)	(7.336)	(0.007)	(0.003)	(0.051)	(8.166)
co_peaka-Q3	0.025***	0.010*	-0.173***	-7.119				
	(0.009)	(0.005)	(0.062)	(9.476)				
co_peaka-Q2	0.005	0.009**	-0.029	2.362				
	(0.007)	(0.004)	(0.049)	(8.368)				
co_peaka-Q1	-0.003	0.002	0.016	8.260				
	(0.005)	(0.003)	(0.034)	(5.964)				
nox_peaka-Q3					-0.000	0.000**	0.003	-1.622***
					(0.000)	(0.000)	(0.002)	(0.601)
nox_peaka-Q2					0.000	0.000	0.000	-0.156
					(0.000)	(0.000)	(0.002)	(0.377)
nox_peaka-Q1					-0.001**	0.000	0.006**	-0.727*
					(0.000)	(0.000)	(0.002)	(0.428)
Observations	3027	3027	3027	3027	2348	2348	2348	2348
NINO	0.00	0.01	-0.02	-22.88	-0.02	0.00	0.13	-20.87
P_NINO	0.77	0.28	0.75	0.02	0.08	0.92	0.06	0.13
NINA	0.00	0.02	-0.02	-25.24	-0.02	-0.00	0.12	16.60
P_NINA	0.87	0.00	0.82	0.01	0.09	0.61	0.11	0.21
POL	0.03	0.02	-0.19	3.50	-0.00	0.00	0.01	-2.50
P_POL	0.08	0.05	0.09	0.87	0.08	0.14	0.06	0.02
r2_a	0.57	0.46	0.58	0.51	0.55	0.45	0.56	0.53

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the locality, Weeks gest. is the average of weeks of gestation for all the children born in that locality and Birth Weight is the average weight for all the children born in that locality. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 32: IV FIRST STAGE: IV ON SO_2 PM_{10} $PM_{2.5}$ (average)

	SO2 (average)			PM10 (average)			PM2.5 (average)		
	Q3-gest.	Q2-gest.	Q1-gest.	Q3-gest.	Q2-gest.	Q1-gest.	Q3-gest.	Q2-gest.	Q1-gest.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Niño-Q3	0.288	1.351**	0.038	-3.562	0.302	1.075	0.966	-3.415***	-1.173
	(0.404)	(0.591)	(0.389)	(2.225)	(1.553)	(1.653)	(1.985)	(1.050)	(1.774)
Niño-Q2	-1.392***	0.442	1.731***	-2.424	-5.013***	-1.132	2.159	-4.175***	2.438*
	(0.445)	(0.599)	(0.481)	(1.872)	(1.588)	(1.008)	(1.599)	(1.097)	(1.336)
Niño-Q1	0.280	-1.345**	-0.694	1.735	0.255	-3.838	-0.992	-0.046	1.242
	(0.497)	(0.578)	(0.512)	(1.669)	(2.088)	(2.610)	(1.343)	(1.250)	(1.343)
Niña-Q3	0.511	-0.164	0.461	-1.506	-0.418	-0.797	0.699	-2.433	9.620***
	(0.437)	(0.556)	(0.404)	(2.207)	(1.869)	(2.062)	(1.730)	(2.100)	(1.864)
Niña-Q2	0.109	0.583	-0.119	-4.290**	-0.978	-1.375	-2.110	-0.984	-5.136**
	(0.575)	(0.583)	(0.618)	(2.020)	(3.204)	(2.115)	(2.251)	(1.781)	(2.433)
Niña-Q1	1.023**	0.037	1.996***	-1.431	-5.474***	-2.430	1.158	-6.039***	4.966**
	(0.435)	(0.632)	(0.677)	(2.051)	(1.849)	(1.923)	(2.000)	(1.468)	(2.384)
ws_ave-Q3	0.687	0.756	-3.212***	-4.047	-4.473**	3.330	3.249	1.177	-9.189
	(1.232)	(0.857)	(0.717)	(2.567)	(2.264)	(2.700)	(6.230)	(6.004)	(6.744)
ws_ave-Q2	-0.249	-0.601	-0.952	3.938**	0.706	1.091	-5.795	-5.449	26.457***
	(0.998)	(1.043)	(0.855)	(1.983)	(2.494)	(1.963)	(5.498)	(4.853)	(9.796)
ws_ave-Q1	-0.329	-0.738	-1.852*	5.723***	3.424	0.597	-3.142	-7.698	-2.071
	(0.650)	(0.810)	(0.982)	(1.850)	(2.110)	(2.479)	(6.112)	(6.842)	(4.933)
wd_rose_Cat4-Q3	-2.019	0.949	-4.254***	-4.906	-6.207	3.923	2.585	1.090	-10.106
	(1.554)	(1.238)	(1.273)	(3.447)	(3.815)	(5.531)	(10.366)	(10.179)	(11.332)
wd_rose_Cat5-Q3	-2.092	1.446	-4.426***	-0.472	-5.701	4.104	3.953	1.622	-12.171
	(1.504)	(1.098)	(1.318)	(3.446)	(3.573)	(5.223)	(10.567)	(10.051)	(11.042)
wd_rose_Cat6-Q3	-3.399*	1.906	-3.572**	3.784	-0.034	9.796*	3.040	2.438	-11.790
	(1.778)	(1.472)	(1.797)	(3.871)	(4.278)	(5.656)	(10.454)	(9.927)	(11.350)
wd_rose_Cat4-Q2	-2.442**	-3.318***	0.469	6.928**	5.310**	-1.306	-5.234	-12.173	44.698***
	(1.144)	(0.783)	(0.934)	(2.791)	(2.200)	(2.878)	(8.329)	(8.508)	(16.414)
wd_rose_Cat5-Q2	-1.609	-2.964***	0.496	9.474***	8.507***	-2.280	-7.420	-10.462	44.219***
	(1.210)	(0.824)	(1.017)	(2.878)	(2.529)	(3.054)	(8.559)	(8.221)	(16.504)
wd_rose_Cat6-Q2	-0.848	-4.141***	0.514	3.649	12.407***	4.708	-10.033	-12.175	46.316***
	(1.500)	(1.304)	(1.468)	(3.903)	(3.252)	(4.076)	(8.703)	(8.309)	(17.131)
wd_rose_Cat4-Q1	0.267	-2.760***	-5.008***	4.639*	3.139	3.524*	-5.987	-7.323	-4.045
	(0.809)	(0.902)	(1.138)	(2.458)	(1.994)	(1.965)	(10.243)	(12.063)	(7.746)
wd_rose_Cat5-Q1	0.032	-1.129	-4.853***	5.821**	2.859	4.660**	-5.345	-9.254	-1.591
	(1.015)	(0.919)	(0.994)	(2.633)	(2.132)	(2.131)	(10.081)	(11.956)	(7.543)
wd_rose_Cat6-Q1	0.264	-0.133	-6.136***	6.964**	-1.475	8.300**	-2.887	-12.637	-1.567
	(1.290)	(1.303)	(1.273)	(3.000)	(2.778)	(3.230)	(9.925)	(11.629)	(7.541)
N	3347	3347	3347	3347	3347	3347	1471	1471	1471
R2_first_a	0.17	0.18	0.10	0.15	0.13	0.08	0.22	0.24	0.38
F_first_a	29.00	15.88	14.09	17.10	10.39	7.82	6.67	20.44	33.22

* p<0.05> , ** p<0.01, *** p<0.001

Note: Pollution is averaged per day, then averaged by month and by quarter of gestation for each locality. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. Each regression of the health outcomes has three equations in the first stage, one for each quarter of gestation. In this case, the three equations are the same for each set of four health outcomes presented in the second stage, for instance, the first four columns of Table 6 (for SO_2) share the same equations in the first stage, so we will only present once the results. The same holds for the other pollutants. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay). The interaction of the wind direction rose with wind speed not shown to save space.

Table 33: IV FIRST STAGE: IV ON CO NO_X (peak afternoon)

	CO (peak afternoon)			NOX (peak afternoon)		
	Q3-gest.	Q2-gest.	Q1-gest.	Q3-gest.	Q2-gest.	Q1-gest.
	(1)	(2)	(3)	(4)	(5)	(6)
Niño-Q3	0.087	-0.405***	0.163	-3.699	-5.968***	-3.560*
	(0.089)	(0.114)	(0.110)	(3.191)	(2.301)	(2.129)
Niño-Q2	-0.134	0.052	-0.413***	1.669	-4.340*	-5.311***
	(0.131)	(0.116)	(0.154)	(3.503)	(2.279)	(1.888)
Niño-Q1	0.004	-0.301	0.323**	0.153	-1.405	-5.738**
	(0.089)	(0.249)	(0.135)	(3.752)	(3.678)	(2.775)
Niña-Q3	-0.135	-0.250**	0.399***	0.810	-6.107***	8.619***
	(0.096)	(0.100)	(0.126)	(2.337)	(2.265)	(2.802)
Niña-Q2	-0.080	-0.245*	-0.054	4.515	-0.399	-2.656
	(0.080)	(0.143)	(0.114)	(3.092)	(2.303)	(3.233)
Niña-Q1	-0.490***	-0.190*	-0.175*	-5.516*	6.474	4.889*
	(0.123)	(0.102)	(0.106)	(2.989)	(3.980)	(2.635)
ws_peaka-Q3	-0.645***	0.790***	0.181*	-2.729	-3.711	9.794***
	(0.115)	(0.177)	(0.105)	(2.677)	(3.874)	(2.822)
ws_peaka-Q2	-0.232	-0.765***	0.406***	-1.195	0.195	-1.981
	(0.158)	(0.161)	(0.099)	(1.918)	(1.891)	(1.766)
ws_peaka-Q1	0.052	-0.234	-0.068	-5.959***	-2.640	-3.232*
	(0.145)	(0.156)	(0.150)	(2.096)	(1.872)	(1.779)
wd_rose_Cat4-Q3	-1.136***	0.436	0.401	15.043**	-0.208	11.170**
	(0.371)	(0.483)	(0.273)	(5.894)	(7.328)	(5.555)
wd_rose_Cat5-Q3	-1.237***	0.438	0.265	20.918***	-2.573	8.832
	(0.370)	(0.485)	(0.289)	(5.790)	(7.736)	(5.918)
wd_rose_Cat6-Q3	-1.230***	0.361	0.346	23.612***	1.219	11.775
	(0.400)	(0.477)	(0.335)	(6.758)	(9.083)	(7.350)
wd_rose_Cat4-Q2	-0.860***	-1.398***	0.824***	-2.353	9.139**	-6.713***
	(0.317)	(0.303)	(0.127)	(2.998)	(3.640)	(2.468)
wd_rose_Cat5-Q2	-0.946***	-1.731***	0.937***	6.092*	14.131***	-10.310***
	(0.342)	(0.325)	(0.155)	(3.507)	(4.270)	(3.247)
wd_rose_Cat6-Q2	-0.898***	-1.648***	1.068***	6.014	12.196**	-12.500***
	(0.343)	(0.357)	(0.180)	(4.559)	(5.494)	(4.590)
wd_rose_Cat4-Q1	0.083	-1.011***	-0.488***	-4.704*	-2.061	2.158
	(0.303)	(0.320)	(0.165)	(2.818)	(2.705)	(1.704)
wd_rose_Cat5-Q1	0.261	-1.139***	-0.739***	-2.110	0.658	3.196
	(0.296)	(0.347)	(0.190)	(2.752)	(2.617)	(2.335)
wd_rose_Cat6-Q1	0.186	-1.081***	-0.957***	-1.401	3.223	-1.309
	(0.297)	(0.382)	(0.231)	(4.278)	(4.218)	(3.874)
N	3027	3027	3027	2348	2348	2348
R2_first_a	0.30	0.35	0.39	0.19	0.24	0.29
F_first_a	28.30	31.67	28.29	9.45	15.95	35.87

* p<0.05> , ** p<0.01, *** p<0.001

Note: Peak afternoon is the average pollution during the peak in the afternoon per day, then averaged by month and by quarter of gestation for each locality. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. Each regression of the health outcomes has three equations in the first stage, one for each quarter of gestation. In this case, the three equations are the same for each set of four health outcomes presented in the second stage, for instance, the first four columns of Table 6 (for SO_2) share the same equations in the first stage, so we will only present once the results. The same holds for the other pollutants. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay). The interaction of the wind direction rose with wind speed not shown to save space.

2J Changing buffer to 4km

Table 34: IV SECOND STAGE: SO_2 (average) ON HEALTH

	SO2 (average)			
	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)
Niño-Q3	0.010	0.013***	-0.075	-29.372***
	(0.006)	(0.005)	(0.050)	(8.261)
Niño-Q2	-0.007	-0.012**	0.048	14.154*
	(0.007)	(0.005)	(0.055)	(8.412)
Niño-Q1	0.007	0.011**	-0.019	-13.822
	(0.006)	(0.005)	(0.046)	(8.715)
Niña-Q3	0.001	0.005	0.014	4.327
	(0.006)	(0.004)	(0.046)	(7.439)
Niña-Q2	-0.003	0.011***	0.014	-17.118**
	(0.006)	(0.004)	(0.045)	(7.359)
Niña-Q1	-0.014*	-0.007	0.120**	10.680
	(0.008)	(0.006)	(0.060)	(10.454)
so2_ave-Q3	0.000	-0.001	-0.002	-1.038
	(0.001)	(0.001)	(0.012)	(2.378)
so2_ave-Q2	-0.003	0.001	0.020	-1.639
	(0.002)	(0.002)	(0.014)	(3.190)
so2_ave-Q1	0.005**	0.004**	-0.038**	-5.472*
	(0.002)	(0.002)	(0.018)	(3.209)
Observations	11112	11112	11112	11112
NINO	0.01	0.01	-0.05	-29.04
P_NINO	0.09	0.02	0.34	0.00
NINA	-0.02	0.01	0.15	-2.11
P_NINA	0.14	0.21	0.05	0.86
POL	0.00	0.00	-0.02	-8.15
P_POL	0.25	0.02	0.26	0.01
r2_a	0.36	0.30	0.35	0.34

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 35: IV SECOND STAGE: PM_{10}-$PM_{2.5}$ (average) ON HEALTH

	PM10 (average)				PM2.5 (average)			
	Premature	Low Weight	Weeks Gest.	Birth Weight	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niño-Q3	0.004	0.004	-0.036	-21.491***	0.011	0.003	-0.067	-12.562
	(0.006)	(0.005)	(0.042)	(7.954)	(0.010)	(0.006)	(0.081)	(12.824)
Niño-Q2	0.001	-0.004	-0.007	2.137	-0.000	-0.001	0.001	-4.805
	(0.006)	(0.005)	(0.045)	(7.711)	(0.009)	(0.006)	(0.072)	(10.498)
Niño-Q1	0.007	0.011*	-0.018	-11.534	0.020**	0.010	-0.113	-13.682
	(0.006)	(0.006)	(0.048)	(9.358)	(0.010)	(0.007)	(0.072)	(11.527)
Niña-Q3	0.000	0.000	0.022	6.378	-0.030**	-0.021**	0.246**	21.186
	(0.006)	(0.005)	(0.043)	(8.592)	(0.015)	(0.009)	(0.118)	(18.497)
Niña-Q2	-0.003	0.007	0.018	-17.617*	0.035***	0.035***	-0.227**	-42.680***
	(0.007)	(0.006)	(0.047)	(10.329)	(0.011)	(0.007)	(0.089)	(11.722)
Niña-Q1	-0.005	-0.002	0.058	0.081	-0.004	-0.005	0.037	5.190
	(0.007)	(0.006)	(0.057)	(10.518)	(0.012)	(0.007)	(0.091)	(11.693)
pm10_ave-Q3	-0.000	-0.001***	0.000	0.826				
	(0.001)	(0.000)	(0.005)	(0.792)				
pm10_ave-Q2	0.001	0.001	-0.004	-1.459				
	(0.001)	(0.001)	(0.005)	(0.965)				
pm10_ave-Q1	-0.000	0.001	0.001	-0.496				
	(0.001)	(0.001)	(0.006)	(1.181)				
pm25_ave-Q3					0.005***	0.001	-0.040***	-2.491
					(0.002)	(0.001)	(0.014)	(1.976)
pm25_ave-Q2					-0.002	0.002*	0.010	-3.018
					(0.002)	(0.001)	(0.014)	(2.541)
pm25_ave-Q1					0.001	0.001	-0.003	-0.529
					(0.001)	(0.001)	(0.008)	(1.378)
Observations	11112	11112	11112	11112	4658	4658	4658	4658
NINO	0.01	0.01	-0.06	-30.89	0.03	0.01	-0.18	-31.05
P_NINO	0.06	0.10	0.22	0.01	0.06	0.21	0.16	0.08
NINA	-0.01	0.01	0.10	-11.16	0.00	0.01	0.06	-16.30
P_NINA	0.41	0.52	0.20	0.39	0.99	0.44	0.70	0.38
POL	0.00	0.00	-0.00	-1.13	0.00	0.00	-0.03	-6.04
P_POL	0.63	0.73	0.74	0.44	0.31	0.07	0.27	0.18
r2_a	0.37	0.30	0.35	0.34	0.35	0.30	0.34	0.33

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 36: IV SECOND STAGE: CO-NO_X (peak afternoon) ON HEALTH

	CO (peak afternoon)				NOX (peak afternoon)			
	Premature (1)	Low Weight (2)	Weeks Gest. (3)	Birth Weight (4)	Premature (5)	Low Weight (6)	Weeks Gest. (7)	Birth Weight (8)
Niño-Q3	0.002	0.012**	-0.019	-24.052***	0.000	0.007	-0.014	-24.999***
	(0.006)	(0.005)	(0.043)	(7.971)	(0.006)	(0.006)	(0.047)	(9.080)
Niño-Q2	-0.005	-0.003	0.030	10.653	-0.002	-0.009*	0.023	10.103
	(0.008)	(0.005)	(0.064)	(8.895)	(0.007)	(0.005)	(0.051)	(8.986)
Niño-Q1	0.006	0.013**	-0.015	-15.238*	0.007	0.015***	-0.011	-19.045**
	(0.007)	(0.005)	(0.050)	(9.216)	(0.006)	(0.005)	(0.048)	(8.565)
Niña-Q3	0.001	0.007*	0.019	0.496	-0.004	0.001	0.060	12.673
	(0.006)	(0.004)	(0.042)	(8.046)	(0.007)	(0.005)	(0.048)	(9.276)
Niña-Q2	-0.003	0.012***	0.017	-18.348**	-0.008	0.010**	0.045	-16.426*
	(0.005)	(0.004)	(0.038)	(7.876)	(0.007)	(0.005)	(0.054)	(9.393)
Niña-Q1	-0.004	0.000	0.046	6.581	-0.009	-0.008	0.088	10.784
	(0.007)	(0.005)	(0.056)	(9.692)	(0.007)	(0.007)	(0.055)	(9.760)
co_peaka-Q3	0.010	0.010	-0.074	3.570				
	(0.007)	(0.006)	(0.054)	(12.833)				
co_peaka-Q2	-0.007	0.005	0.044	12.911				
	(0.006)	(0.005)	(0.044)	(10.361)				
co_peaka-Q1	-0.003	0.001	0.013	9.787				
	(0.005)	(0.004)	(0.037)	(8.309)				
nox_peaka-Q3					0.000	0.000	0.000	-0.432
					(0.000)	(0.000)	(0.003)	(0.506)
nox_peaka-Q2					0.000	-0.000	-0.000	-0.239
					(0.000)	(0.000)	(0.002)	(0.472)
nox_peaka-Q1					-0.000	0.000	0.003	-0.504
					(0.000)	(0.000)	(0.002)	(0.421)
Observations	9965	9965	9965	9965	7879	7879	7879	7879
NINO	0.00	0.02	-0.00	-28.64	0.00	0.01	-0.00	-33.94
P_NINO	0.69	0.00	0.95	0.01	0.54	0.08	0.98	0.01
NINA	-0.01	0.02	0.08	-11.27	-0.02	0.00	0.19	7.03
P_NINA	0.49	0.00	0.25	0.36	0.06	0.80	0.02	0.61
POL	-0.00	0.02	-0.02	26.27	-0.00	0.00	0.00	-1.18
P_POL	0.98	0.15	0.87	0.26	0.72	0.69	0.69	0.33
r2_a	0.37	0.30	0.35	0.34	0.37	0.32	0.36	0.37

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Peak afternoon is the average pollution during the peak in the afternoon per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

2K OLS estimations of pollution on Health - NO instruments

Table 37: OLS: SO_2-PM_{10} (average) CO-NOX (peak afternoon) ON HEALTH

	SO2 (average)				PM10 (average)				CO (peak afternoon)				NOX (peak afternoon)			
	Premature (1)	Low Weight (2)	Weeks Gest. (3)	Birth Weight (4)	Premature (5)	Low Weight (6)	Weeks Gest. (7)	Birth Weight (8)	Premature (9)	Low Weight (10)	Weeks Gest. (11)	Birth Weight (12)	Premature (13)	Low Weight (14)	Weeks Gest. (15)	Birth Weight (16)
Niño-Q3	0.005	0.010**	-0.045	-26.713***	0.005	0.009*	-0.037	-24.881***	0.003	0.009	-0.025	-22.953***	0.002	0.008	-0.029	-23.299**
	(0.005)	(0.005)	(0.039)	(7.896)	(0.005)	(0.005)	(0.039)	(7.728)	(0.006)	(0.006)	(0.045)	(8.205)	(0.006)	(0.005)	(0.043)	(9.161)
Niño-Q2	-0.003	-0.007	0.023	10.869	-0.003	-0.007	0.026	9.259	-0.009	-0.003	0.063	9.312	-0.004	-0.009*	0.031	11.339
	(0.006)	(0.005)	(0.046)	(7.653)	(0.006)	(0.005)	(0.045)	(7.885)	(0.008)	(0.005)	(0.064)	(8.989)	(0.007)	(0.005)	(0.050)	(9.130)
Niño-Q1	0.007	0.008	-0.017	-10.628	0.007	0.008	-0.014	-9.542	0.007	0.013***	-0.017	-15.221*	0.009	0.018***	-0.027	-19.452**
	(0.006)	(0.005)	(0.044)	(8.324)	(0.006)	(0.005)	(0.043)	(8.385)	(0.007)	(0.005)	(0.050)	(8.313)	(0.006)	(0.005)	(0.048)	(8.584)
Niña-Q3	0.002	0.005	0.005	2.086	0.002	0.003	0.012	3.484	0.004	0.005	0.001	-0.225	-0.004	0.000	0.061	12.916
	(0.006)	(0.004)	(0.042)	(7.868)	(0.006)	(0.004)	(0.042)	(8.107)	(0.006)	(0.004)	(0.043)	(8.531)	(0.007)	(0.005)	(0.050)	(9.774)
Niña-Q2	-0.003	0.013***	0.012	-20.921**	-0.003	0.013***	0.018	-21.455**	-0.006	0.012***	0.032	-19.912**	-0.010	0.011**	0.057	-17.238*
	(0.006)	(0.004)	(0.043)	(8.412)	(0.006)	(0.005)	(0.039)	(8.462)	(0.005)	(0.004)	(0.038)	(8.251)	(0.006)	(0.005)	(0.046)	(9.866)
Niña-Q1	-0.007	-0.003	0.068	4.600	-0.009	-0.005	0.081	4.901	-0.006	-0.001	0.068	2.763	-0.009	-0.007	0.088	7.521
	(0.007)	(0.006)	(0.053)	(9.034)	(0.007)	(0.006)	(0.059)	(9.302)	(0.008)	(0.005)	(0.062)	(9.454)	(0.007)	(0.007)	(0.058)	(11.157)
so2_ave-Q3	-0.001	-0.001**	0.007	0.901												
	(0.001)	(0.000)	(0.004)	(0.737)												
so2_ave-Q2	-0.000	0.001	0.001	-0.692												
	(0.001)	(0.000)	(0.004)	(0.788)												
so2_ave-Q1	0.000	0.000	-0.005	-1.334												
	(0.001)	(0.000)	(0.004)	(0.925)												
pm10_ave-Q3					0.000	-0.000	0.000	-0.103								
					(0.000)	(0.000)	(0.001)	(0.274)								
pm10_ave-Q2					-0.000*	-0.000	0.003*	0.242								
					(0.000)	(0.000)	(0.001)	(0.238)								
pm10_ave-Q1					-0.000	-0.000	0.001	-0.169								
					(0.000)	(0.000)	(0.002)	(0.258)								
co_peaka-Q3									0.005	0.003	-0.022	-6.384				
									(0.004)	(0.003)	(0.033)	(5.016)				
co_peaka-Q2									-0.003	-0.003	0.020	8.671**				
									(0.003)	(0.002)	(0.020)	(4.345)				
co_peaka-Q1									-0.006*	-0.001	0.035	6.855				
									(0.004)	(0.002)	(0.027)	(4.222)				
nox_peaka-Q3													0.000	0.000	-0.001	-0.328
													(0.000)	(0.000)	(0.001)	(0.203)
nox_peaka-Q2													-0.000	-0.000	0.000	0.036
													(0.000)	(0.000)	(0.001)	(0.183)
nox_peaka-Q1													0.000	0.000	-0.001	-0.515***
													(0.000)	(0.000)	(0.001)	(0.200)
Observations	11027	11027	11027	11027	11027	11027	11027	11027	9833	9833	9833	9833	7683	7683	7683	7683
NINO	0.01	0.01	-0.04	-26.47	0.01	0.01	-0.03	-25.16	0.00	0.02	0.02	-28.86	0.01	0.02	-0.02	-31.41
P_NINO	0.14	0.03	0.41	0.00	0.21	0.05	0.59	0.01	0.95	0.00	0.77	0.01	0.36	0.00	0.65	0.00
NINA	-0.01	0.01	0.09	-14.24	-0.01	0.01	0.11	-13.07	-0.01	0.02	0.10	-17.37	-0.02	0.00	0.21	3.20
P_NINA	0.44	0.06	0.23	0.15	0.33	0.17	0.17	0.26	0.43	0.02	0.23	0.10	0.04	0.75	0.01	0.81
POL	-0.00	-0.00	0.00	-1.13	-0.00	-0.00	0.00	-0.03	-0.00	-0.00	0.03	9.14	0.00	0.00	-0.00	-0.81
P_POL	0.49	0.95	0.66	0.45	0.26	0.36	0.18	0.94	0.57	0.81	0.55	0.34	0.33	0.13	0.16	0.03
r2_a	0.37	0.31	0.35	0.34	0.37	0.31	0.35	0.34	0.37	0.30	0.35	0.34	0.38	0.33	0.36	0.37

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the locality, Weeks gest. is the average of weeks of gestation for all the children born in that locality and Birth Weight is the average weight for all the children born in that locality. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the three coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

2L Heterogeneity: mothers with tertiary education

Table 38: IV SECOND STAGE: SO_2 (average) ON HEALTH

	SO2 (average)			
	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)
Niño-Q3	0.008	0.015***	-0.057	-30.405***
	(0.007)	(0.004)	(0.051)	(8.749)
Niño-Q2	-0.004	-0.011**	0.043	22.256**
	(0.008)	(0.005)	(0.060)	(9.628)
Niño-Q1	0.004	0.008	-0.005	-11.267
	(0.006)	(0.005)	(0.050)	(9.598)
Niño-EDU-Q3	0.011	-0.007	-0.107	-0.840
	(0.024)	(0.019)	(0.184)	(33.094)
Niño-EDU-Q2	-0.012	-0.009	0.053	-8.107
	(0.026)	(0.020)	(0.188)	(36.652)
Niño-EDU-Q1	-0.021	-0.018	0.114	41.831
	(0.018)	(0.015)	(0.128)	(34.449)
Niña-Q3	0.003	0.009*	-0.018	-3.896
	(0.006)	(0.005)	(0.043)	(8.397)
Niña-Q2	0.005	0.013**	-0.043	-27.676***
	(0.007)	(0.005)	(0.051)	(8.027)
Niña-Q1	-0.016*	0.004	0.100	0.761
	(0.008)	(0.005)	(0.064)	(8.500)
Niña-EDU-Q3	-0.014	-0.014	0.045	-6.374
	(0.019)	(0.016)	(0.149)	(29.367)
Niña-EDU-Q2	0.009	-0.005	-0.072	41.345
	(0.022)	(0.016)	(0.165)	(29.095)
Niña-EDU-Q1	-0.045**	-0.044***	0.349**	71.075***
	(0.018)	(0.015)	(0.141)	(25.640)
so2_ave-Q3	-0.001	-0.001	0.002	0.322
	(0.001)	(0.001)	(0.009)	(1.608)
so2_ave-Q2	-0.003**	0.001	0.022**	-0.990
	(0.001)	(0.001)	(0.010)	(1.766)
so2_ave-Q1	0.006***	0.003**	-0.049***	-7.127***
	(0.002)	(0.001)	(0.015)	(2.147)
Observations	9537	9537	9537	9537
NINO	0.01	0.01	-0.02	-19.42
P_NINO	0.25	0.01	0.74	0.03
NINA	-0.01	0.03	0.04	-30.81
P_NINA	0.53	0.00	0.61	0.01
NINO_EDU	-0.02	-0.03	0.06	32.88
P_NINO_EDU	0.28	0.03	0.71	0.29
NINA_EDU	-0.05	-0.06	0.32	106.05
P_NINA_EDU	0.02	0.00	0.05	0.00
POL	0.00	0.00	-0.02	-7.80
P_POL	0.11	0.10	0.08	0.00
r2_a	0.45	0.43	0.44	0.44

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 39: IV SECOND STAGE: PM_{10} $PM_{2.5}$ (average) ON HEALTH

	PM10 (average)				PM2.5 (average)			
	Premature	Low Weight	Weeks Gest.	Birth Weight	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niño-Q3	0.000	0.010**	0.003	-20.201**	0.010	0.006	-0.053	-2.612
	(0.006)	(0.004)	(0.042)	(8.023)	(0.013)	(0.007)	(0.098)	(13.168)
Niño-Q2	0.008	-0.005	-0.045	6.093	0.019	0.008	-0.137	-6.554
	(0.007)	(0.005)	(0.048)	(8.778)	(0.013)	(0.007)	(0.095)	(9.735)
Niño-Q1	0.003	0.006	-0.002	-8.283	0.019*	0.019**	-0.130*	-22.687*
	(0.006)	(0.005)	(0.043)	(9.069)	(0.010)	(0.008)	(0.072)	(12.633)
Niño-EDU-Q3	0.016	-0.005	-0.142	2.829	0.014	-0.005	-0.128	-27.853
	(0.024)	(0.019)	(0.181)	(33.066)	(0.035)	(0.019)	(0.269)	(36.999)
Niño-EDU-Q2	-0.018	-0.015	0.100	9.009	-0.020	-0.014	0.114	20.988
	(0.025)	(0.021)	(0.184)	(36.884)	(0.037)	(0.023)	(0.271)	(38.460)
Niño-EDU-Q1	-0.018	-0.014	0.093	31.849	-0.020	-0.006	0.144	3.382
	(0.018)	(0.015)	(0.127)	(33.748)	(0.025)	(0.020)	(0.176)	(26.490)
Niña-Q3	0.004	0.007	-0.023	-0.364	0.006	-0.019*	-0.000	22.271
	(0.006)	(0.005)	(0.041)	(9.350)	(0.014)	(0.010)	(0.107)	(16.266)
Niña-Q2	0.004	0.011**	-0.028	-25.653***	0.028**	0.023***	-0.191*	-48.046***
	(0.007)	(0.005)	(0.049)	(8.615)	(0.014)	(0.009)	(0.102)	(12.434)
Niña-Q1	-0.006	0.006	0.027	-11.467	-0.001	-0.002	-0.011	11.382
	(0.006)	(0.005)	(0.049)	(8.490)	(0.016)	(0.009)	(0.123)	(11.984)
Niña-EDU-Q3	-0.024	-0.015	0.117	1.757	-0.041	-0.038	0.136	-9.336
	(0.019)	(0.017)	(0.148)	(29.574)	(0.042)	(0.042)	(0.326)	(67.038)
Niña-EDU-Q2	0.012	-0.002	-0.091	39.517	0.004	-0.020	-0.016	110.891***
	(0.023)	(0.016)	(0.175)	(29.819)	(0.043)	(0.025)	(0.307)	(29.780)
Niña-EDU-Q1	-0.044**	-0.043***	0.341**	73.908***	-0.012	-0.012	0.113	-4.377
	(0.019)	(0.015)	(0.145)	(26.394)	(0.030)	(0.021)	(0.243)	(34.296)
pm10_ave-Q3	0.000	-0.000	0.000	0.900				
	(0.001)	(0.000)	(0.004)	(0.551)				
pm10_ave-Q2	0.001*	0.000	-0.006	-1.369**				
	(0.001)	(0.000)	(0.004)	(0.681)				
pm10_ave-Q1	-0.000	-0.000	0.003	-0.470				
	(0.001)	(0.000)	(0.005)	(1.045)				
pm25_ave-Q3					0.004**	0.001	-0.026**	-0.746
					(0.001)	(0.001)	(0.011)	(1.104)
pm25_ave-Q2					0.000	0.002**	-0.007	-2.119
					(0.002)	(0.001)	(0.011)	(1.565)
pm25_ave-Q1					0.001	0.002***	-0.009	-1.822*
					(0.001)	(0.000)	(0.006)	(1.080)
Observations	9537	9537	9537	9537	3838	3838	3838	3838
NINO	0.01	0.01	-0.04	-22.39	0.05	0.03	-0.32	-31.85
P_NINO	0.10	0.04	0.44	0.04	0.01	0.00	0.01	0.08
NINA	0.00	0.02	-0.02	-37.48	0.03	0.00	-0.20	-14.39
P_NINA	0.85	0.00	0.72	0.00	0.12	0.94	0.18	0.47
NINO_EDU	-0.02	-0.03	0.05	43.69	-0.03	-0.03	0.13	-3.48
P_NINO_EDU	0.32	0.02	0.75	0.16	0.26	0.11	0.45	0.91
NINA_EDU	-0.06	-0.06	0.37	115.18	-0.05	-0.07	0.23	97.18
P_NINA_EDU	0.01	0.00	0.03	0.00	0.20	0.06	0.42	0.11
POL	0.00	-0.00	-0.00	-0.94	0.01	0.01	-0.04	-4.69
P_POL	0.54	0.62	0.58	0.42	0.05	0.00	0.03	0.11
r2_a	0.46	0.43	0.45	0.44	0.46	0.45	0.46	0.43

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 40: IV SECOND STAGE: CO NO_X (peak afternoon) ON HEALTH

	CO (peak afternoon)				NOX (peak afternoon)			
	Premature	Low Weight	Weeks Gest.	Birth Weight	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niño-Q3	-0.005	0.012**	0.027	-24.237**	0.001	0.014**	-0.013	-37.692***
	(0.006)	(0.005)	(0.045)	(9.493)	(0.007)	(0.005)	(0.051)	(11.636)
Niño-Q2	0.006	-0.001	-0.030	15.712	0.004	-0.005	-0.022	13.560
	(0.008)	(0.005)	(0.062)	(10.025)	(0.009)	(0.006)	(0.064)	(11.987)
Niño-Q1	0.005	0.012**	-0.026	-8.353	0.009	0.012**	-0.054	-17.472
	(0.007)	(0.006)	(0.049)	(8.505)	(0.007)	(0.005)	(0.050)	(10.870)
Niño-EDU-Q3	0.018	-0.009	-0.157	12.203	-0.034	-0.034	0.256	85.154*
	(0.025)	(0.017)	(0.192)	(30.938)	(0.037)	(0.025)	(0.264)	(48.574)
Niño-EDU-Q2	-0.022	-0.011	0.141	1.620	0.006	0.005	-0.066	-21.908
	(0.024)	(0.017)	(0.180)	(32.078)	(0.041)	(0.024)	(0.294)	(53.445)
Niño-EDU-Q1	-0.016	-0.020	0.090	19.597	-0.041	-0.024	0.301*	53.734
	(0.018)	(0.015)	(0.126)	(22.722)	(0.025)	(0.018)	(0.178)	(44.595)
Niña-Q3	0.006	0.011**	-0.028	-6.579	0.001	-0.001	-0.021	9.027
	(0.006)	(0.005)	(0.044)	(8.567)	(0.007)	(0.006)	(0.048)	(10.250)
Niña-Q2	0.001	0.012***	-0.013	-26.490***	-0.004	0.005	0.027	-21.978**
	(0.006)	(0.005)	(0.047)	(7.880)	(0.007)	(0.005)	(0.052)	(9.654)
Niña-Q1	-0.002	0.011**	0.002	-6.121	-0.014*	0.001	0.085	0.763
	(0.007)	(0.005)	(0.055)	(8.073)	(0.008)	(0.007)	(0.057)	(9.350)
Niña-EDU-Q3	-0.018	-0.011	0.065	-3.486	0.003	0.027	-0.033	-40.589
	(0.020)	(0.015)	(0.150)	(28.121)	(0.035)	(0.026)	(0.246)	(47.962)
Niña-EDU-Q2	0.013	-0.005	-0.089	34.279	0.031	0.013	-0.236	34.376
	(0.021)	(0.015)	(0.164)	(28.722)	(0.032)	(0.018)	(0.239)	(42.053)
Niña-EDU-Q1	-0.044**	-0.040***	0.348**	60.356**	-0.023	-0.019	0.162	51.348
	(0.018)	(0.014)	(0.144)	(26.576)	(0.029)	(0.020)	(0.210)	(35.499)
co_peaka-Q3	0.022***	0.012**	-0.140***	-8.605				
	(0.007)	(0.005)	(0.048)	(8.709)				
co_peaka-Q2	0.001	0.006	-0.014	3.426				
	(0.005)	(0.004)	(0.039)	(6.971)				
co_peaka-Q1	-0.002	-0.001	-0.005	4.781				
	(0.005)	(0.004)	(0.035)	(7.090)				
nox_peaka-Q3					-0.000	0.000	0.001	-0.136
					(0.000)	(0.000)	(0.002)	(0.338)
nox_peaka-Q2					-0.000	0.000	0.001	-0.353
					(0.000)	(0.000)	(0.002)	(0.309)
nox_peaka-Q1					-0.000	0.000	0.001	-0.554*
					(0.000)	(0.000)	(0.002)	(0.336)
Observations	8439	8439	8439	8439	6457	6457	6457	6457
NINO	0.01	0.02	-0.03	-16.88	0.01	0.02	-0.09	-41.60
P_NINO	0.48	0.00	0.68	0.14	0.08	0.00	0.10	0.00
NINA	0.01	0.03	-0.04	-39.19	-0.02	0.00	0.09	-12.19
P_NINA	0.59	0.00	0.60	0.00	0.12	0.67	0.25	0.39
NINO_EDU	-0.02	-0.04	0.07	33.42	-0.07	-0.05	0.49	116.98
P_NINO_EDU	0.28	0.01	0.62	0.25	0.12	0.02	0.11	0.03
NINA_EDU	-0.05	-0.06	0.32	91.15	0.01	0.02	-0.11	45.13
P_NINA_EDU	0.02	0.00	0.05	0.00	0.84	0.61	0.80	0.54
POL	0.02	0.02	-0.16	-0.40	-0.00	0.00	0.00	-1.04
P_POL	0.09	0.06	0.09	0.98	0.61	0.21	0.49	0.19
r2_a	0.47	0.42	0.46	0.43	0.47	0.45	0.48	0.48

* p<0.05> , ** p<0.01, *** p<0.001

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

2M Effects on additional outcomes

Table 41: IV SECOND STAGE: SO_2-PM_{10} (average) ON HEALTH

	SO2 (average)			PM10 (average)		
	Apgar1	Pre-Low Weight	Sex ratio	Apgar1	Pre-Low Weight	Sex ratio
	(1)	(2)	(3)	(4)	(5)	(6)
Niño-Q3	-0.018	0.013***	0.014	-0.006	0.005	0.028
	(0.014)	(0.004)	(0.026)	(0.015)	(0.004)	(0.024)
Niño-Q2	0.015	-0.010***	-0.048*	-0.009	-0.001	-0.072**
	(0.017)	(0.004)	(0.025)	(0.016)	(0.004)	(0.028)
Niño-Q1	0.012	0.007*	0.047*	0.005	0.007	0.042
	(0.015)	(0.004)	(0.026)	(0.017)	(0.005)	(0.027)
Niña-Q3	-0.006	0.004	0.025	0.007	-0.002	0.021
	(0.013)	(0.003)	(0.025)	(0.015)	(0.004)	(0.023)
Niña-Q2	0.017	0.004	-0.036	0.019	0.001	-0.041
	(0.014)	(0.003)	(0.024)	(0.017)	(0.004)	(0.025)
Niña-Q1	0.009	-0.006	0.013	-0.009	-0.001	-0.033
	(0.016)	(0.005)	(0.032)	(0.019)	(0.005)	(0.036)
so2_ave-Q3	0.005*	-0.002*	-0.009*			
	(0.003)	(0.001)	(0.005)			
so2_ave-Q2	0.006*	0.001	0.010*			
	(0.003)	(0.001)	(0.005)			
so2_ave-Q1	-0.005	0.003***	-0.017**			
	(0.004)	(0.001)	(0.008)			
pm10_ave-Q3				0.001	-0.001***	-0.001
				(0.001)	(0.000)	(0.002)
pm10_ave-Q2				-0.003	0.001**	-0.002
				(0.002)	(0.000)	(0.003)
pm10_ave-Q1				-0.001	0.001	-0.002
				(0.002)	(0.001)	(0.003)
Observations	11024	11027	10612	11024	11027	10612
NINO	0.01	0.01	0.01	-0.01	0.01	-0.00
P_NINO	0.57	0.01	0.66	0.59	0.05	0.94
NINA	0.02	0.00	0.00	0.02	-0.00	-0.05
P_NINA	0.30	0.82	0.96	0.44	0.74	0.23
POL	0.01	0.00	-0.02	-0.00	0.00	-0.01
P_POL	0.16	0.06	0.04	0.19	0.39	0.14
r2_a	0.98	0.35	0.08	0.98	0.35	0.09

* p<0.05> , ** p<0.01, *** p<0.001

Note: Apgar1 is the average of the APGAR score at 1 minute of birth (1-10) of the children born in the IPS, Pre-Low Weight is the percentage of premature and low birth weight children born in the IPS, and sex-ratio is the ratio of the percentage of boys over the percentage of girls for the children born in that IPS. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

Table 42: IV SECOND STAGE: CO-NO_X (peak afternoon) ON HEALTH

	CO (peak afternoon)			NOX (peak afternoon)		
	Apgar1	Pre-Low Weight	Sex ratio	Apgar1	Pre-Low Weight	Sex ratio
	(1)	(2)	(3)	(4)	(5)	(6)
Niño-Q3	-0.016	0.010**	0.026	0.005	0.008*	0.066**
	(0.015)	(0.004)	(0.026)	(0.015)	(0.005)	(0.027)
Niño-Q2	0.015	-0.002	-0.057*	0.010	-0.006	-0.051**
	(0.019)	(0.005)	(0.034)	(0.014)	(0.004)	(0.023)
Niño-Q1	0.022	0.008*	0.003	0.007	0.013***	0.057*
	(0.018)	(0.004)	(0.025)	(0.014)	(0.004)	(0.030)
Niña-Q3	-0.005	0.005	0.007	0.002	0.000	0.026
	(0.013)	(0.003)	(0.028)	(0.012)	(0.004)	(0.021)
Niña-Q2	0.016	0.004	-0.020	0.016	0.003	-0.021
	(0.015)	(0.003)	(0.024)	(0.013)	(0.004)	(0.024)
Niña-Q1	-0.002	-0.001	-0.027	0.004	-0.009	0.032
	(0.017)	(0.005)	(0.035)	(0.016)	(0.005)	(0.034)
co_peaka-Q3	-0.030	0.013***	-0.008			
	(0.020)	(0.005)	(0.046)			
co_peaka-Q2	-0.023	0.006	0.018			
	(0.016)	(0.004)	(0.031)			
co_peaka-Q1	-0.022**	0.004	0.025			
	(0.011)	(0.003)	(0.022)			
nox_peaka-Q3				0.001	0.000	-0.000
				(0.001)	(0.000)	(0.001)
nox_peaka-Q2				0.002**	0.000	-0.000
				(0.001)	(0.000)	(0.001)
nox_peaka-Q1				0.001	0.000	0.002
				(0.001)	(0.000)	(0.001)
Observations	9830	9833	9460	7680	7683	7408
NINO	0.02	0.02	-0.03	0.02	0.01	0.07
P_NINO	0.30	0.01	0.44	0.30	0.02	0.07
NINA	0.01	0.01	-0.04	0.02	-0.01	0.04
P_NINA	0.66	0.14	0.42	0.29	0.44	0.28
POL	-0.08	0.02	0.03	0.00	0.00	0.00
P_POL	0.05	0.01	0.63	0.04	0.30	0.73
r2_a	0.98	0.34	0.09	0.98	0.36	0.08

* p<0.05> , ** p<0.01, *** p<0.001

Note: Apgar1 is the average of the APGAR score at 1 minute of birth (1-10) of the children born in the IPS, Pre-Low Weight is the percentage of premature and low birth weight children born in the IPS, and sex-ratio is the ratio of the percentage of boys over the percentage of girls for the children born in that IPS. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay).

2N Index of pollution - Principal Component Analysis

Table 43: IV SECOND STAGE: PCA-A and PCA-B ON HEALTH

	PCA version A				PCA version B			
	Premature	Low Weight	Weeks Gest.	Birth Weight	Premature	Low Weight	Weeks Gest.	Birth Weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niño-Q3	-0.024	-0.009	0.133	2.073	-0.004	0.016**	0.007	-25.281**
	(0.025)	(0.012)	(0.188)	(17.419)	(0.007)	(0.007)	(0.051)	(10.529)
Niño-Q2	0.023	0.009	-0.117	-20.322	-0.004	-0.002	0.036	4.078
	(0.015)	(0.011)	(0.113)	(15.799)	(0.009)	(0.007)	(0.065)	(10.102)
Niño-Q1	0.004	0.013*	-0.008	-27.088*	0.005	0.018***	-0.004	-18.875**
	(0.009)	(0.008)	(0.071)	(14.144)	(0.006)	(0.006)	(0.049)	(9.125)
Niña-Q3	-0.009	-0.023**	0.106	-0.468	-0.008	-0.002	0.084*	10.247
	(0.015)	(0.011)	(0.123)	(14.985)	(0.006)	(0.005)	(0.044)	(8.930)
Niña-Q2	0.007	0.019*	-0.050	-22.326	-0.002	0.018***	-0.002	-24.796***
	(0.022)	(0.011)	(0.174)	(16.223)	(0.006)	(0.005)	(0.048)	(9.190)
Niña-Q1	0.026	-0.003	-0.122	-14.733	-0.005	-0.002	0.061	-2.782
	(0.019)	(0.016)	(0.154)	(19.764)	(0.008)	(0.007)	(0.065)	(10.575)
pcaA1-Q3	-0.014	0.030	0.162	263.387				
	(0.193)	(0.122)	(1.406)	(170.478)				
pcaA1-Q2	-0.253	0.166	1.695	-5.202				
	(0.163)	(0.142)	(1.137)	(174.836)				
pcaA1-Q1	-0.276**	0.019	1.991**	151.374				
	(0.127)	(0.095)	(0.962)	(132.264)				
pcaB1-Q3					0.115*	0.059	-0.902*	-128.453
					(0.062)	(0.059)	(0.479)	(94.796)
pcaB1-Q2					-0.056	0.078*	0.316	-41.247
					(0.038)	(0.043)	(0.304)	(58.204)
pcaB1-Q1					-0.021	0.050**	0.151	25.838
					(0.034)	(0.025)	(0.230)	(55.389)
Observations	2765	2765	2765	2765	6732	6732	6732	6732
NINO	0.00	0.01	0.01	-45.34	-0.00	0.03	0.04	-40.08
P_NINO	0.94	0.48	0.97	0.06	0.76	0.00	0.64	0.00
NINA	0.02	-0.01	-0.07	-37.53	-0.01	0.01	0.14	-17.33
P_NINA	0.59	0.82	0.85	0.28	0.20	0.13	0.11	0.21
POL	-0.54	0.22	3.85	409.56	0.04	0.19	-0.43	-143.86
P_POL	0.20	0.49	0.21	0.31	0.71	0.07	0.58	0.35
r2_a	0.36	0.30	0.34	0.39	0.37	0.31	0.35	0.36

* $p<0.05>$, ** $p<0.01$, *** $p<0.001$

Note: Premature is the percentage of premature births in the IPS, Low Birth is the percentage of low birth weight in the IPS, Weeks gest. is the average of weeks of gestation for all the children born in that IPS and Birth Weight is the average weight for all the children born in that IPS. Pollution is averaged per day, then averaged by month and by quarter of gestation for each IPS. The estimations include yearxlocality fixed effects, month fixed effects, health center fixed effects, controls for household characteristics and use the instruments mentioned in section 4.1.2. $NINO$, $NINA$ and POL correspond to the sum of the coefficients (the cumulative effect) of the variables for El Niño, for La Niña and for the pollutant, respectively, while P_NINO, P_NINA and P_POL are their respective p-values. The standard errors in parenthesis are robust to autocorrelated cross-panel disturbances (Driscoll-Kraay). The principal components (PCA) are constructed using the standardized version of the pollutants of the main specifications (SO_2, PM_{10}, $PM_{2.5}$ (average), CO, NO_X (peak afternoon)). The estimations use the first principal component, which has an eigenvalue larger than one. As $PM_{2.5}$ has many missing values, PCA-A version includes $PM_{2.5}$ (explained variation of 48.9%), while PCA-B does not include $PM_{2.5}$ (explained variation of 44.1%).