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THE HIDDEN COST OF BANANAS: PESTICIDE EFFECTS ON NEWBORNS' HEALTH

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Title: The hidden cost of bananas: pesticide effects on newborns' health

Abstract: We study the effects of aerial fumigation of banana plantations on newborns' birth weight during the period 2015-2017 in Ecuador. We use mothers' addresses and information on the perimeter of the plantations to create an individual measure of newborns' exposure to pesticides. We use this measure to implement three independent identification strategies to address the endogeneity of exposure to aerial fumigations. First, we consider a difference-in-differences strategy that exploits seasonal variations in the use of pesticides across provinces. Second, we estimate a difference-in-differences model that considers geographical variations in the use of pesticides across comparable crops. Third, and finally, we estimate a maternal fixed effects model to examine the effect of pesticides on siblings who had a different residence during gestation and who were exposed to different levels of fumigations. Our first empirical model shows that newborns exposed to pesticides, when their first gestational trimester coincides with the periods of intensive fumigations of the plantations, have a birth weight reduction of between 38 and 89 grams. Moreover, exposure to pesticides increases the likelihood of low birth weight and low Apgar score at the first minute by around 0.35 and 0.33, respectively. The second model finds that newborns exposed to fumigated banana plantations have a birth weight deficit of between 29 and 76 grams, when compared to those exposed to other fumigated crops. Finally, the maternal fixed effect model shows that girl newborns exposed to pesticides have a birth weight deficit of 346 grams when compared to non-exposed siblings.

JEL Codes: I15, I18, O12, O13, Q18, Q53

Keywords: Air pollution, pesticides, aerial fumigation, newborns' birth weight

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1. Introduction

The increasing demand for agricultural products, combined with land restrictions and changing weather conditions, has impelled farmers across the world to adopt extensive use of agrochemicals to increase productivity and reduce crop loss (Cassou, 2018). This use of chemicals has severe negative effects on populations living close to the farms or working on them. It is estimated that pesticides cause 200,000 acute poisoning deaths each year, most of these in developing countries, and have catastrophic impacts on health in communities living near agricultural land (Svensson et al., 2013; UNHR, 2017). In recent decades, national governments and international institutions have adopted different initiatives to limit the use of pesticides and to protect their populations (UNEP, 2014; Watts, 2013; USEPA, 1996; CPR, 2015; Martinez-Alier et al., 2016). Yet, there are few studies of "large communities" that analyze the effects of pesticides on the population's health and that can serve to orient public policy. This paper fills this gap by examining the impact of aerial fumigation of the banana plantations in Ecuador.

There is a growing body of literature addressing the consequences of air pollution on children's health. The economic research has shown that birth weight, gestational length, and in utero survival are all affected by industrial activity (Hansman et al., 2019), environmental regulations (Greenstone and Hanna, 2014; Tanaka, 2015), major forest fires (Frankenberg, McKee and Thomas, 2012; Tan-Soo and Pattanayak, 2019), agricultural fires (Rangel and Vogl, 2019) and indoor pollution (Hanna, Duflo and Greenstone, 2016; Barron and Torero, 2017). Several papers have also raised an alert about the persistent effects of air pollution on physical development and cognitive ability (Currie et al., 2014; Rosalies-Rueda and Triyana, 2018; Molina, 2020).[1] In spite of this, there are few studies analyzing the effects of the intensive use of pesticides in agriculture (some exceptions are Bustos et al., 2016; Camacho and Mejia, 2017; Larsen et al., 2017; Dias et al., 2019; Maertens, 2019). Farms around the world use pesticides to fight against fungus, pests and crop disease, but in order to regulate these activities it is important to understand the causal effect of exposure to pesticides on health outcomes for workers and the neighboring population.

Ecuador provides an excellent case to analyze the effects of pesticide use in agriculture. Ecuador is the fifth largest producer and the largest exporter of bananas in the world. In the last few decades, national producers have dedicated significant effort to increasing their efficiency and have incorporated the use of agrochemicals on a massive scale at different stages of the production process (Maldonado and Martínez, 2007; Harari, 2009; FAO, 2016). In the early 1970s, banana producers started to use aerial fumigations to treat the disease known as *Sigatoka Negra*, the main fungal disease affecting banana fruit plants. Despite the effectiveness of fumigations in stopping the spread of this fungus, there are important concerns about its environmental and health implications (Naranjo, 2017; Defensoría del Pueblo, 2019). Children

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[1] More generally, the research shows how health at birth can affect health status in adulthood (Barker, 1995) and socio-economic outcomes such as school attainment, high school graduation or earnings during adulthood (Black et al., 2007; Currie and Vogl, 2013; Bharadwaj et al., 2013; Almond and Currie, 2011; Almond et al., 2005).

and adult populations who live, attend school or work near banana fields are exposed to high levels of pesticides and this makes them vulnerable to different types of diseases. Public interest in this problem has prompted the regulation of aerial fumigations.[2] Specifically, in 2012, a new law was passed that sets a protective distance between fumigated areas and neighboring households. Despite this, the lack of enforcement capacity of the responsible authorities and the defiant climate conditions might reduce the effectiveness of this measure (UNHR, 2017).

The objective of this study is to examine the effects of pesticide fumigation of banana plantations on newborns' health. Analyzing the causal effects of agricultural pesticides on nearby residents' health entails two important difficulties. First, households' addresses are usually not available for confidentiality reasons and, as a result, location is usually approximated using the centroid of the reported neighborhood or municipality (Bustos et al., 2016; Camacho and Mejia, 2017; Dias et al., 2019; Maertens, 2019; Rangel and Vogl, 2019). Moreover, the lack of precise information on the perimeter of the plantations generates inaccuracies on exposure measurement. Second, there is the concern that households living close to the plantations might have different characteristics than those living at a distance from them, and for this reason it is difficult to disentangle the causal impact of pesticides from unobservable factors that affect newborns' health (Chay and Greenstone, 2003; Greenstone and Hanna, 2014; Cesur, Tekin and Ulker, 2017; Rangel and Vogl, 2019). Our paper overcomes these problems with the creation of an exposure variable that is based on the geolocation of the mothers during pregnancy and on the perimeter of the fumigated plantation. For each mother, we compute 25–meter-radius buffers from their residential address up to 2.5 kilometers, which compute the number of fumigated square meters of banana plantations. We use this information to construct an exposure measure that weights the resulting 100 buffers using a decaying kernel function.[3] This approach offers a precise measurement of in-utero exposure to fumigated plantations that allows us to estimate the effects of pesticides on birth outcomes (weight at birth, Apgar score at first minute, and gestational length).

We use our exposure measure to implement three different empirical designs to analyze the causal effects of pesticides on newborns' health. First, we exploit the seasonal changes in the intensity of fumigations across provinces. Banana plantations are fumigated over the whole year, but fumigations are more intense during the rainy season, which is when the *Sigatoka Negra* fungus propagates more easily. We use seasonal fumigation patterns across provinces to estimate a difference-in-differences (DID) model that compares the difference between newborns living in exposed areas in intense and non-intense fumigations seasons, relative to the difference between newborns living in not exposed areas in the same two seasons. Second, we estimate a DID model that compares the difference between newborns exposed and not exposed to fumigated banana plantations, relative to the difference between newborns exposed

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[2] See for example the following media reports and interviews: (1) https://www.americaeconomia.com/negocios-industrias/defensoria-de-ecuador-advierte-riesgo-de-quimicos-en-bananeras; (2) https://www.planv.com.ec/investigacion/investigacion/vivir-y-morir-del-banano

[3] The effects of pesticides (and of other types of air pollution) vanishes importantly for distances longer than 100-250 meters (Currie et al., 2009; Currie et al., 2015; Deziel et al., 2017; Dereumeaux et al. 2020; and Gibbs et al. 2017). We calculate the buffers for a distance of up to 2.5 kilometers from the mothers' residences to be able to perform several robustness checks.

and not exposed to any other crops. This analysis is based on the fact that other crops (rice, cocoa and corn) produced in Ecuador are fumigated much less intensively than banana plantations and on the assumption that in each municipality the population living close to banana plantations and living close to the other crops are not statistically different. Third, and finally, we use a sub-sample of mothers that had more than one child during the period we study to estimate a model with maternal fixed effects. During this period, a relevant percentage of mothers moved to a different address, which allows us to analyze the difference in birth weight between siblings exposed and not exposed to pesticides during gestation.

Our study draws on a public data set obtained from the National Register of Live Births (*Registro estadístico de nacidos vivos*) for the period 2015-2017, which contains information for nearly 270 thousand newborns and from which we obtained the mothers' residence addresses during pregnancy. Almost 51 thousand of these mothers resided within 2.5 kilometers of the banana plantations, which is the distance we use to construct the exposure buffers. This data set includes information on several observable characteristics of children and mothers. We complement this data set with information on Ecuador's banana plantations from the 2013 agricultural census and the 2014 register of aerial fumigations. The former contains information on the perimeter of each plantation and the use of aerial or manual fumigations, and the latter contains geocoded data on the application of pesticides (i.e., quantity, toxicity, date of application). We combine the information on the mothers' locations, the perimeters of the plantations and the use of pesticides to compute the measure of exposure for each newborn.

The results of our analysis confirm the hypothesis that pesticides have a relevant impact on newborns' birth weight. Most of the effect of pesticides occurs within the first 100-150 meters around the plantation and that this impact quickly vanishes at further distances. We use this finding to create the treatment and control populations that are used in the causal analysis. The DID model design that analyzes variation in pesticides' intensity shows that pesticides have a relevant impact on newborns health when the first and the second trimesters of gestation coincides with the season of intense fumigations. Newborns exposed to intense fumigations during this gestational period have an average birth weight that is between 38 and 89 grams lower than those not exposed. This effect is larger for the female newborns and for those born to low-educated mothers. These results should be considered as a lower bound for the effect of pesticides, since all newborns that are located close to a plantation can be affected by fumigations. Our second model compares the mothers' exposure to banana plantations with an analogous exposure to other crop plantations (rice, corn, cocoa). In this case, we obtain that being exposed to banana plantations reduces birth weight by approximately 29 to 76 grams. Finally, the third identification strategy uses maternal fixed effects to compare siblings exposed and non-exposed to pesticides. Here, we find that newborn girls, exposed to pesticides in utero, have an average birth weight 250 to 346 grams lower than that of non-exposed siblings.

The estimated average effect that we obtain for the exposure to pesticides in Ecuador is greater than the 30 grams found by Bozzoli and Quintana-Domeque (2014) for the effects of the collapse of the economy in Argentina in 2000-05, and also greater than the 23 grams found by Rangel and Vogl (2019) for the effect of sugar cane harvesting in Brazil. However, it is close to the 200-grams effect found for mothers that smoke (Kramer, 1987; Lindbohm et al., 2002) and to the 30-200 grams found in recent medical and environmental studies on the use of pesticides in agriculture (Rauch et al. 2012; Gemmil et al., 2013; Tago et al., 2014; Larsen et al., 2017; and Mostafalou and Abdollahi, 2017).

Our research contributes to the literature analyzing external factors that affect fetal health during gestation.[4] Previous works have shown that economic shocks during gestation affect fetal health, especially in the third trimester of pregnancy. This effect has been identified for the Dutch famine (Stein and Lumey, 2000), the food stamp program in the United States (Almond, Hoynes and Schanzenbach, 2011) and the economic crisis in Argentina in the period 2000-2005 (Bozzoli and Quintana-Domeque, 2014). Other papers have shown evidence that maternal stress due to exposure to different types of violence affects birth weight, especially when it occurs in the first trimester of pregnancy (Camacho, 2008; Torche, 2011; Foureaux, Koppensteiner and Manacorda, 2016; Currie et al., 2020). Additional research has documented that fetal health can be negatively affected by in utero exposure to temperature level variations (Andalón et al., 2014; Rocha and Soares, 2015; Deschênes et al., 2016;), rainfall shocks (Pereda et al., 2014; Rabassa et al., 2014) and natural disasters (Simeonova, 2011; Currie and Rosin-Slater, 2013).

Our paper is more closely aligned to the body of evidence documenting the effects of air pollution on newborns health outcomes (Currie, Neidell and Schmieder, 2009; Chen, Ebenstein, Greenstone and Li, 2013), children (Hyland and Laribi, 2017; Ding and Bao, 2014) and adults (Lai, 2017).[5] Among these, we contribute to the literature studying the effects of pollution from agricultural activities on fetal and child health (Hyland and Laribi, 2017; Lai, 2017). The literature has used different approaches to identify the causal effect of pollution on the population's health. Rangel and Vogl (2019) estimate the effect of smoke from agricultural fires in Brazil on health at birth. Exploiting daily changes in the location of fires and wind direction for identification, they find that late-stage pregnancy exposure to smoke from upwind fires decreases birth weight by 23 grams, gestational length, and in utero survival. Dias et al. (2019) examine the impact of glyphosate use in soybean-producing areas of Brazil on birth outcomes in the surrounding populations. They find that locations receiving water from areas that expanded the use of glyphosate in the 2000s experienced significant deterioration in infant mortality and in the frequency of low birth weights. Maertens (2019) estimates the health impact of a pesticide called atrazine, using as instrument the expansion in corn production driven by

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[4] "External factors" such as environmental and meteorological conditions are not controlled by pregnant women and can affect fetal health. Mothers' respiratory ingestion of particles can penetrate the placental barrier, through the blood system, and reach the fetus. "Internal factors" are related to a mother's genetics, health, nutrition, behavior and living conditions.

[5] Laboratory and case-control medical research studies have shown the biological mechanisms that intervene in in utero exposure to pesticides. They show the relevance for health outcomes at birth of exposure to pesticides in the last trimester of pregnancy (Laborde et al., 2015). Some case-control studies have shown that the number of pesticides in cord blood is inversely related to birth weight (Wang et al., 2012; Wickerham et al., 2012; Konishi et al., 2009; Vizcaino et al., 2014). Laboratory studies also point out the negative health implications of fumigation compounds, which can cause skin and brain diseases, fetal malformation and several more diseases in children and adult individuals (Byrns and Fuller, 2011; Bain, 2010; Bradman et al., 2003; EJF, 2003; WHO, 2005; OPS/OMS, 2007; Ling et al., 2018).

enactment of the Renewable Fuel Standard (RFS) in 2005 in the US. His strategy relies on the plausibly exogenous geographic variation in potential for corn expansion after the introduction of the RFS and on the seasonal variation in corn pesticide applications during the year. Results show that the persistent demand shock that followed the introduction of the RFS increased the risks of abdominal wall defects, fetuses being small for gestational age, and perinatal death.

This research is also related to the medical studies that have used geographical buffers to examine the effects of pesticides on health at birth. These studies defines pesticide exposure by summing the pesticides applied in the area close to the mother's residence during pregnancy, although they do not usually have precise information about the perimeter of the plantations and for this reason they use relatively large buffers. Gemmil et al. (2013) analyze whether residential proximity to methyl bromide applications is associated with fetal growth and gestational length in a cohort of pregnant women living in an agricultural community in the Salinas Valley (California, USA) in the period 1999-2000. Their findings suggest that an increase in methyl bromide use in the second trimester of gestation was associated with decreases in birth weight of 113 grams, birth length and head circumference, for residents close to the pollution source. Larsen et al. (2017) examine the use of pesticides in the agricultural land of San Joaquin Valley (California, USA) for the period 1997-2011. They find that agricultural pesticide exposure increases adverse birth outcomes, but only among the population exposed to very high quantities of pesticides. They find a statistically significant decrease in birth weight of about 13-30 grams following cumulative pesticide exposure and pesticide exposure in the first trimester for individuals in the high exposure group.

The rest of the paper is organized as follows. Section 2 describes the banana plantations in Ecuador, the use of pesticides and their potential health impact. Section 3 describes the data and the merging strategy. Section 4 describes the empirical strategies. Section 5 presents the results. Finally, Section 6 concludes and discusses public policy implications.

2. Background

2.1 Banana plantations in Ecuador

Banana production is one of the main economic activities in Ecuador. In 2016, banana plantations covered more than 186,000 Has. and produced more than 6.5 million tons of bananas, which represents 6% of the world's total production. Banana exportation accounts for 2% of total Ecuadorian GDP and represents approximately 35% of the agricultural sector's share of GDP (MCE, 2017). The banana plantations are mostly concentrated in the coastal region of the country, which has adequate weather conditions and soil nutrients for raising this crop. Most of the country's population is concentrated in this region.

The strategic relevance of this crop has led the government to control its production. In 2010, the government banned the expansion of banana plantations across the whole country, regardless of their size, structure and variety of fruit.[6] This was justified by the large number of plantations (registered and unregistered) with very low productivity rates. Moreover, in 2012, the Ministry of Agriculture created the Banana Unit (*Unibanano*), which acts as a registry for plantations, regulates their activities and promotes their efficiency. *Unibanano* assists producers in the exportation of their fruit and the acquisition of inputs, guarantees a minimum reserve price according to the quality of the fruit, and promotes the establishment of specific labor regulations for the sector. Because of these interventions, the price received by banana producers has been very stable in the period we consider (Figure 1A in Appendix A).

2.2 Plantations and aerial fumigation

The phenological stages of banana plantations are seeding, growth, blossoming and harvesting. After the seedtime, farms control the development of banana trees and apply pesticides to preserve the health of the plantations and quality of the bananas. Later, during the blossoming and harvest, they apply agrochemicals to maintain the fertility of the soil and preserve the young seedlings, but fumigations are less intense. Pesticides are applied manually with pumps or from airplanes, which are frequently contracted by several farmers collectively.[7] Aerial fumigations were first adopted in the early 1970s to treat a fungal disease known as *Sigatoka Negra* (*Mycosphaerella Fijiensis*). This fungus generates a leaf-spot disease that causes progressive destruction of the foliage and the photosynthetic process. The infected plant reaches the flowering stage with a reduced number of leaves, accelerating the maturation process and causing the fruits to shrink or die. The main factors contributing to the spread of *Sigatoka Negra* fungus are high temperature, high rainfall and light. In the coastal region of Ecuador there are small variations in temperature and luminosity from one season to the rest, but precipitations are concentrated in the winter period (usually from January to May). The rain and humidity of the winter season favor the spread of *Sigatoka Negra* across the banana trees (Jesus Júnior et al., 2008; Khan et al., 2015) and for this reason producers intensify fumigations in this period.[8] Figure 1 shows aerial fumigations in the provinces where most of the banana plantations in the country are concentrated. These results reveal that the use of pesticides is more intense during the rainy season in Los Rios and Guayas, whereas in the case of El Oro the opposite pattern prevails, although fumigations are more regular.

The Ecuadorian government has introduced several measures that stipulate a minimum distance from *aerial fumigation* sites to households and public spaces. In October 2012, a law established a protection distance of 200 meters from households, schools, health centers and highways and a requirement to construct natural barriers to protect public spaces. *Manual fumigations* were banned within 50 meters of these areas. In February 2015, a new regulation

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[6] Although there are several types of bananas, all of them receive the same fumigation treatment. The most common variety, representing more than 90% of the production and exportation is called Cavendish.

[7] The use of pesticides is one of the main economic costs for producers. Around 60% of their annual budget is spent on plantations maintenance, control of pests and fungus diseases (MAGAP, 2013).

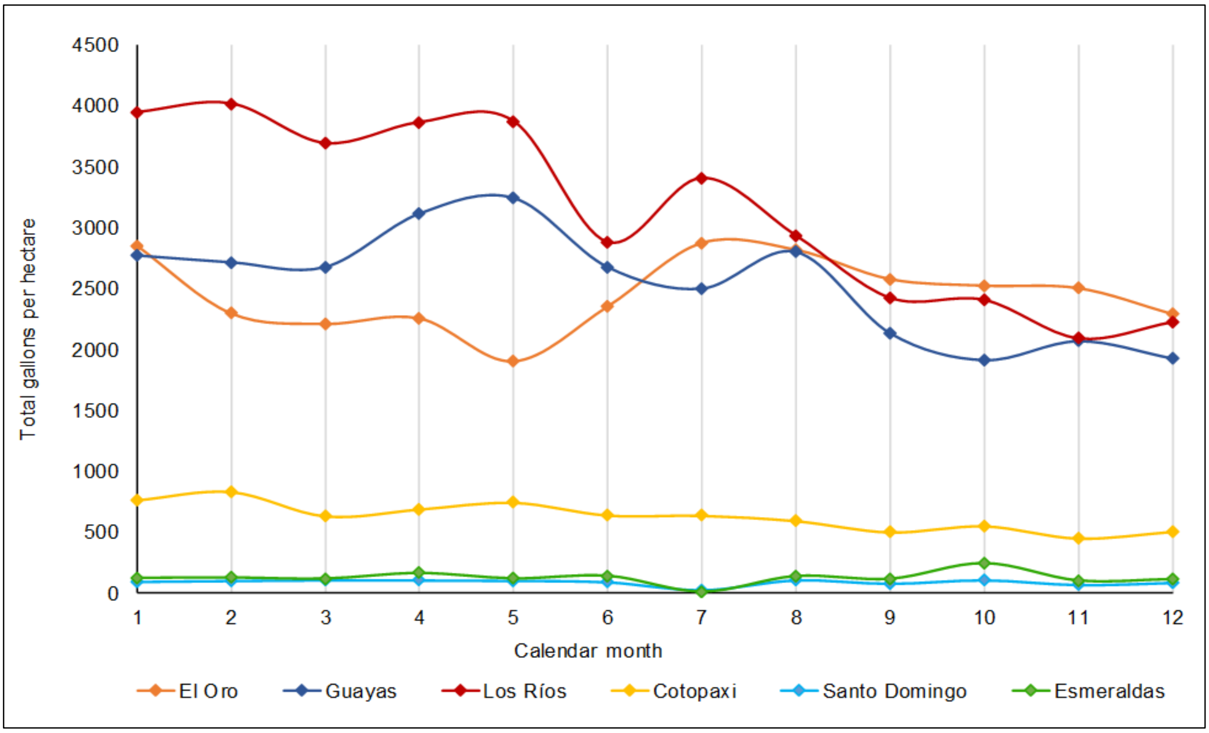
[8] Banana plantations could also pollute water sources, as recently evidenced by Soares et al. (2019). In Ecuador, there are specific regulations of water system in plantations to avoid water draining and pollution.

established a security distance of 60 meters where there were no living tree barriers, and 30 meters with living tree barriers, from riversides and water infrastructure not dedicated to human consumption. These distance regulations have relevant consequences for banana producers who must apply pesticides in the plantations close to households manually, which is more expensive. The Ministry of Agriculture has also promoted the use of greener actions and alternative practices to increase the productivity of plantations and reduce the use of pesticides, such as the introduction of other crops like soy and maize to complement traditional ones such as banana, cocoa and palm oil.

2.3 Pesticides and health

Several medical and environmental studies have shown negative health effects for households close to agricultural land treated with pesticides. According to the World Health Organization (WHO), absorption of pesticides occurs by inhalation, accidental ingestion and by penetration through the skin. Pesticides are absorbed more quickly if the formulation is liquid, oily or if the skin is hot or bears injuries. The type of exposure that presents most risk for human health is the inhalation of dust, airborne droplets, vapors or gas, where smaller particles reach the alveoli and some can enter the bloodstream directly.

Figure 1. Seasonal application of pesticides in 2014 (gallons per hectare)



Source: Dirección General de Aviación Civil, GDAC.

The literature has found higher pesticide concentrations in blood and urine tests, and in both outdoor and indoor surface deposition of chlorpyrifos, in residences located within 60 meters, 100 meters and up to 250 meters of agricultural fields (Coronado et al., 2011; van Wendel de Joode et al., 2012; Deziel et al., 2017; Gibbs et al., 2017; Dereumeaux et al., 2020). Benner et al. (2014) examine glyphosate aerial drift distances and find the presence of high concentrations of glyphosate in areas located within the first 226 meters from the pollution source[9]. Whyatt et al. (2004) and Rauh et al. (2006) have shown a direct correlation between chlorpyrifos exposure and higher risk of intrauterine growth restriction, low birth weight and small cranial circumference at birth, when exposure happens at short distances from the plantations. More recently, Friedman et al. (2020) found that children in households located within 100 meters of floricultural lands in an Ecuadorian municipality have lower average neurobehavioral performance than those living in locations further away.

Other papers have exploited seasonal variation in the application of pesticides by comparing seasonally exposed and non-exposed households, finding that seasonally exposed households have higher concentrations of pesticide metabolites in urine samples and a decrease in nervous system functioning (Bradman et al., 2011; Cecchi et al., 2012; Galea et al., 2015; Quintana et al., 2017).[10]

The medical literature has also shown that exposure to pesticides during gestation can cause intrauterine growth restriction, weight problems and birth defects. At the embryonic stage, pesticides are especially damaging, as this is a critical period for prenatal development and birth weight. Later, during the fetal stage, the environment provided by the mother affects the baby's size and health, rather than the formation of organs and limbs (Bernstein and Nash, 2008). During the second and third trimester of gestation, growth is important for these structures and organs, and the fetus begins to gain weight steadily. In this period, harmful exposure to pesticides can lead to functional defects like learning problems (Bleyl, 2010; Carlson, 2008; Cochard, 2012; Moore, 2013).

3. Data and merging strategy

The paper combines different administrative data sets: the Ecuadorian register of newborns for the period 2015-17; the 2013 census of banana plantations; the 2016 satellite map of rice, cocoa and corn, and the 2014 register of aerial fumigations.

Newborns register

The national register of live births from the National Institute for Statistics and Census (INEC) is a data set containing information for all newborns in Ecuador. We use the information from

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[9] The authors also find pesticide particles at beyond 2.5 kilometers. The drift distance mainly depends on meteorological factors, droplet size and the pressurized airflow from the nozzles. For common cases, in which the droplet size is 150 um (dense substance), pesticides will drift less than 226 meters.

[10] Some case studies have found high levels of dermatological, lung, and functional system incidences on the population living near banana plantations during the winter season (Laborde et al., 2015; Harari, 2009).

the years 2015 to 2017, which is the period for which the mother's address during pregnancy is available. The data includes information for more than 300 thousand newborns per year across the whole country, although our analysis focuses on the provinces with banana plantations.

The data set includes the birth weight measured in grams, the gestation length in weeks and the Apgar score at the first minute, which are the outcome variables used in the paper. In addition, it contains information about birth conditions (number of prenatal controls, type of delivery, number of previous births, multiple births), newborn characteristics (sex, birth order) and mother characteristics (education level, ethnicity, marital status, C-section) that according to the economic literature are relevant factors for newborn health outcomes (Bharadwaj, Loken and Neilson, 2013; Almond and Currie, 2011; Almond, Chay and Lee, 2005). Following Bozzoli and Quintana-Domeque (2014), we focus on mothers aged 15 to 49 and we exclude newborns whose weight was either under 500 grams or above 9,000 grams. Following Larsen et al. (2017), we also exclude very premature births with gestation of less than 26 weeks and those births at later than 50 weeks. [11]

Banana plantations census

Information about the banana plantations comes from the 2013 *Catastro Bananero,* from the *Ministerio de Agricultura, Ganadería Acuacultura y Pesca* (MAGAP). Banana plantations are present in around 140 municipalities that belong to 5 Ecuadorian provinces. Our analysis focuses on the coastal region of Ecuador, where most banana plantations are located.

This census contains the information on the plantations' locations and perimeters that we use to construct our exposure variable. It also contains other relevant information about the plantations, such as the fumigation method (aerial or manual fumigation) and the surface. In our analysis, we assume that the plantations' perimeter has remained stable since 2013, which is when the government restricted the amount of land that can be dedicated to banana plantations.[12]

Approximately 85% of the total plantations in our study employ aerial fumigation, which is more relevant for large plantations. Indeed, while only 31% of the small plantations (less than 5 hectares) use aerial fumigation, the percentage rises to 97% for large plantations (more than 30 hectares). Note that large plantations usually surround smaller ones, and that in many cases aerial fumigation is contracted collectively.

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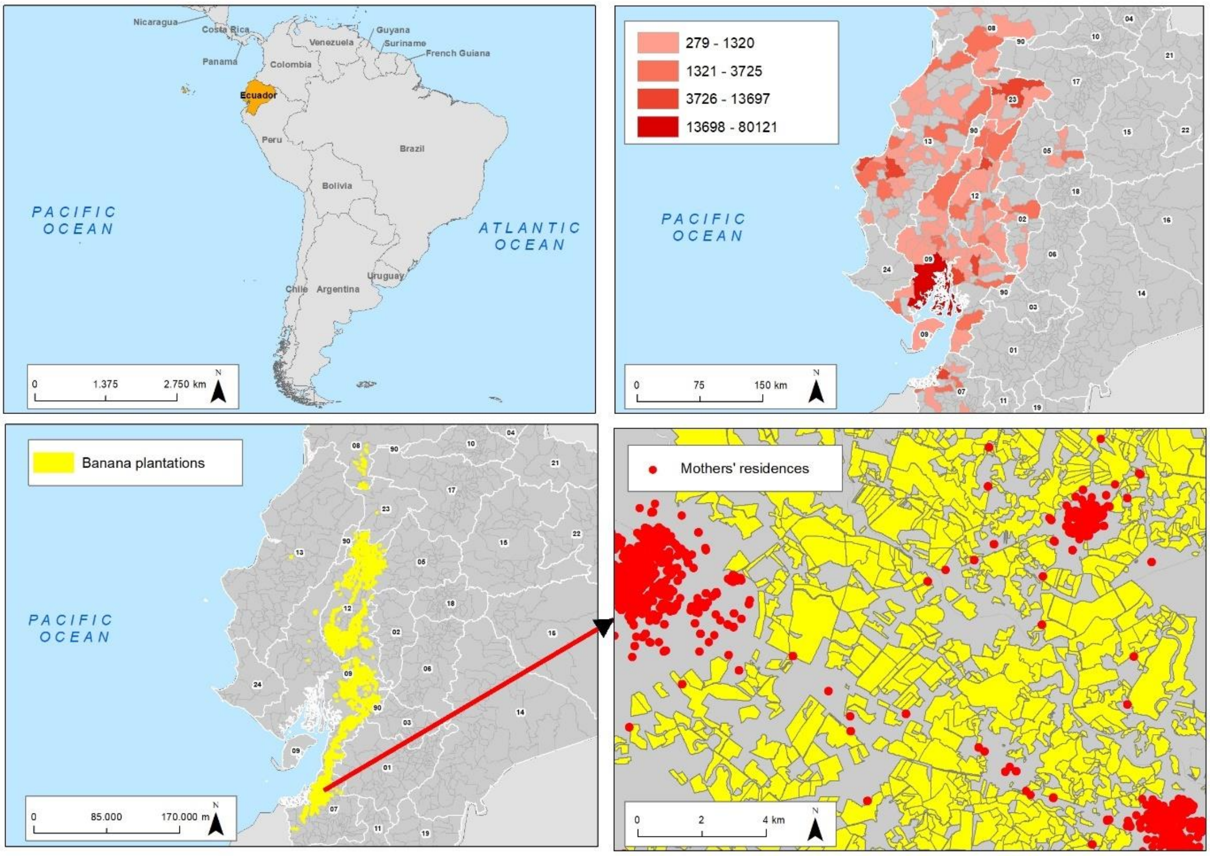
[11] We excluded 4,500 observations of births from mothers aged under 15 and over 49 years old, respectively. No observations are excluded from the birth weight criteria. 613 observations are excluded from gestation week criteria. Our results are robust when including these observations in the analysis.

[12] According to the Ministry of Agriculture, the extension of banana plantations has not undergone relevant changes since 2013. In 2004, the government forbid the use of more land to grow bananas (*Ley para Estimular y Controlar la Producción y Comercialización del Banano, Plátano (Barraganete) y otras musáceas afines destinadas a la exportación*, coded in the *Registro Oficial -S315 del 16 de Abril del 2004*). In 2010, new banana farms were allowed, subject to the authorization of the Ministry of Agriculture (*Suplemento - Registro Oficial N° 351 - 29 de Diciembre del 2010*). In addition to these regulations, between 2012 and 2013, the Ministry of Agriculture created the census of plantations to control production.

Figure 2 presents the geographic distribution of the banana plantations in Ecuador and shows how mothers' residences are usually surrounded by several plantations at different distances. In the lower right image, the yellow areas are the banana plantations that apply aerial fumigation, and the red dots are the mothers' residences during pregnancy.

Figure 2. Mother's locations and banana plantations in Ecuador (2015-2017)



Note: The upper left image shows the location of Ecuador in South America. The upper right image presents the geographic distribution of newborns across provinces with banana plantations. The lower left image shows the location of banana plantations in Ecuador in yellow colour. The lower right imagine is an example to illustrate that mothers' residences (red dots) are usually surrounded by several plantations (yellow areas) at different distances.
Source: INEC – MAGAP

Aerial fumigation register

Information on the type and quantity of pesticides applied in banana plantations comes from the 2014 register of aerial fumigation activity, gathered by the *Dirección General de Aviación Civil (GDAC)*, the institution responsible for controlling air activity in Ecuador. The register was created by the Project for Environmental Reparation of the Environment Ministry in 2014 and has not been updated since. It contains information about the dates and coordinates of aerial fumigations, the chemical compounds, toxicity degrees and quantities in gallons of agrochemicals.

This register indicates that nearly 3.5 million gallons of agrochemicals was aerially sprayed in banana plantations in 2014, of which 90% are classified as having moderate to high toxicity.[13] Pesticides are classified from 1 to 5, according to toxicity. The most frequently used pesticides are chlorpyrifos, dithiocarbamate and triazole, which are described as "less harmful" or "low toxicity". For their application, toxic pesticides are mixed with petroleum-based horticultural oil. Following Larsen et al. (2017), in our analysis we aggregate pesticides with high and low toxicity, due to the large variety of chemicals applied in banana plantations.

Pesticides are applied throughout the year, but more intensively during the winter because the high humidity rates and frequent rainfall favor the spread of *Sigatoka Negra* (Figure 1). Fumigations must follow strict regulations set by law.[14] Specifically, they cannot be applied under high temperatures, humid conditions, or when wind speed is high. In our study, we assume that fumigations are not applied in strong winds, which implies that the effect of fumigations does not depend on wind direction (Appendix B presents an analysis confirming that aerial fumigations of banana plantations are negatively related to wind intensity). Note also that our exposure variable considers the area of the plantations surrounding the mother's residence. As a result, winds can have different effects on mothers, depending on the position of the surrounding plantations.

The aerial fumigations register has at least three relevant limitations. First, the information refers to 2014, that is, one year before our information on health outcomes starts. Second, although we have the coordinates of each fumigation application, we are unable to determine if pesticides are applied to one particular plantation or to a group of plantations with the same or different owners. Indeed, fumigations are expensive and farmers of small and medium plantations can jointly contract this service to reduce costs. To address this problem, we use the information in the register to compute the gallons of pesticides sprayed in each municipality in each month (a similar approach is adopted in Gimmil et al., 2013, and Larsen et al., 2017). We then assign these gallons to the plantations of each municipality according to their area in square meters (See Appendix C for more details). As a result, we can construct two exposure variables, one that only accounts for the square meters of aerially fumigated plantations (based on the MAGAP banana register) and another that considers the monthly application of pesticides in the municipality (according to the 2014 GDAC register). Finally, another limitation of the fumigation register is that it does not contain information on other crops. In light of this, we do not use this register in our second identification strategy, when we compare the health effects of banana plantations and of other crops.

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[13] If we include the petroleum-based horticultural oil and water used to mix the agrochemicals, the quantity applied in 2014 escalates to 13 million gallons. Notwithstanding, according to the register, the most harmful pesticides containing dithiocarbamate are sprayed mostly without water dilution.

[14] According to the Registro Oficial No. 431 (February 4th, 2015), aerial fumigations cannot be applied when: a) the temperature inside the plantations exceeds 30ºC; b) the relative humidity is greater than or equal to 70%; c) the wind speed exceeds 8 km/h; d) there is a sheet of water on the leaves; e) there are drops of water covering 60% or more of the leaf surface; f) there was rainfall within one hour before the application and, g) there is an inversion phenomenon (fog) limiting visibility during flights.

4. Empirical strategy

The aim of our paper is to analyze the causal effect of pesticides used in banana plantations on birth outcomes. One difficulty of this analysis is that unobserved socio-economic characteristics of the families might affect both the location of their residence and newborns' health outcomes. This will lead to biased estimates of the effect of pesticides. We adopt different strategies to overcome the identification challenges posed by economic correlates. First, we construct a measure of exposure to pesticides that reflects the density of aerially fumigated plantations in the surroundings of the mother's residence. We use this measure to classify newborns as exposed and not exposed to pesticides. Second, we use the previous classification of newborns to implement three estimation designs to identify the causal effects of pesticides. We exploit seasonal variations in the fumigation of banana plantations and differences in the use of fumigations across crops. Moreover, following Currie et al. (2020), we adopt a maternal fixed effects approach to account for time-invariant differences across mothers who had more than one child in the period 2015-2017 and that had different residences during each pregnancy, i.e., we examine siblings that had different levels of exposition to pesticides during pregnancy.

Exposure analysis

We define exposure to pesticides as residence in an area with a high presence of fumigated plantations. To measure exposure, we use geographical buffers that compute the square meters of plantations surrounding each mother's residence. Using the precise address of the mother during pregnancy, and the perimeter of the aerially fumigated plantation, we compute for each mother 25-meter-radius buffers from their position up to 2.5 kilometers. In each buffer, we compute the square meters of banana plantations, which may be fumigated manually or with an aircraft. Appendix C presents a detailed explanation of how we compute the buffers. We then weight and aggregate the resulting 100 buffers for each mother to construct our exposure variable. The following kernel function represents the weights given to the buffers,

$$Weight = \frac{1}{1+\left(\frac{a}{c}\right)^{b}}, \qquad (1)$$

where a is the buffer's radius, b is the steepness and c is the cut-off value at which the decaying function starts to decrease more rapidly. The steepness parameter b determines how quickly the effects of pesticides decay as we move away from the perimeter of the plantation, and the cut-off parameter c reflects the distance at which there is an inflexion in the decaying function. If fumigations are administered in the absence of wind and at a low height over the banana trees, the pesticides will not spread far from the perimeter of the plantation and exposure should quickly decay. Otherwise, pesticides can spread across larger distances. We compute for each mother 100 buffers of 25 meters assuming that exposure completely vanishes beyond 2.5 kilometers. Moreover, we follow the literature on air pollution (Currie et al., 2009; Currie et al., 2015; Gemmil et al., 2013; Larsen et al. 2017; Gibbs et al., 2017; Dereumeaux et al., 2020) and consider that most of the effect of pesticides is concentrated in the area close to the plantations and that the effects quickly decay with the distance. Figure C6 in Appendix C illustrates different combinations of the parameters b and c for the weighing function in (1) that we consider in our analysis. These weights imply that most of the effect of pesticides is concentrated in the 50, 100 or 250 meters from the perimeter of the plantations. Our exposure analysis of section 5.2 will help us to determine the values of parameters b and c that are better adjusted to our case. More specifically, we use the following model to examine the distance at which pesticides affect birth outcomes:

$$Y_{ijmy} = \theta ExposureBuffers_i + \beta X_i + \mu_j + \psi_m + \phi_y + \varepsilon_{ijmy} \qquad (2)$$

where Y_{ijmy} shows the birth outcomes (i.e., birth weight, low birth weight, gestation weeks, Apgar score) of newborn $i,$ in municipality $j,$ in month $m,$ and year y. $ExposureBuffers_i$ is the continuous variable capturing the sum of the 100 weighted buffers reflecting the square meters of fumigated plantations close to the mothers' residences. X_i is a group of children and mother control variables. The model also includes municipality fixed effects, μ_j, and month and year (cohort) fixed effects, ψ_m and ϕ_y, respectively. Finally, we assume the error term ε_{ijmy} to be iid and normally distributed. The coefficient θ shows an estimate of the effect of exposure to pesticides on birth outcomes. Our analysis will identify the values of the decaying function in (1) that better adjusts to this equation.

Other studies have used analysis tools of geographic information systems (GIS) to sum the pesticides applied within different radial distances between agricultural lands and households (Cockburn et al., 2011; Gemmill et al., 2013; Li et al., 2005; Reynolds et al., 2004; Rull et al., 2009). In Gemmil et al. (2013), the exposure to pesticides (methyl bromide) is computed by summing the kilograms of pesticides applied in all 1.6 km^2 Public Land Survey System (PLSS) sections that fell within 5 km of the maternal residence. The authors sum these totals over each day of a trimester interval, yielding an estimate of the total amount of methyl bromide (kilograms) applied within 5 km of the maternal residence during each trimester of pregnancy. In Larsen et al. (2017), exposure is measured as kilograms of active ingredients applied in the 2.6 km^2 PLSS section encompassing the mother's address. One advantage of our analysis over these studies is that we can use the exact perimeter of the aerially fumigated banana plantation and for this reason we have accurate measures of the number of square meters fumigated close to the mothers' residences. Despite this, we do not have detailed information on the kilograms of pesticides applied to each plantation in the period 2015-17.

Seasonality analysis

Banana plantations are fumigated throughout the year to maintain the continuous production. However, fumigations are more intense during the rainy season when humidity conditions favor the propagation of *Sigatoka Negra*. The intensification of fumigations varies across provinces (Figure 1). In Los Rios, fumigations are more important between January and July, in Guayas, between March and June, and in El Oro, between July and September. In other provinces such as Cotopaxi and Manabí, fumigations are much less frequent and there is little variation in their intensity. We use these seasonal patterns to estimate a DID model comparing the difference between newborns living in exposed areas in intense and non-intense fumigations seasons during gestation, relative to the difference between newborns living in not exposed areas in the same two seasons. We estimate the following model:

$$Y_{ijpmy} = \beta_0 + \beta_1 Banana\ Exposure_i + \sum_{z=1}^{3} \beta_z\, Z^{th}\ Intense\ Fumigations_i$$
$$+ \sum_{z=1}^{3} \theta_z\, Banana\ Exposure_i * Z^{th}\ Intense\ Fumigations_i + \delta X_i + \mu_j + \psi_m + \phi_y + \varepsilon_{ijpmy} \tag{3}$$

where Y_{ijmy} shows the birth outcomes of newborn i, in municipality j, month m, and year y. $Banana\ Exposure_i$ is a dummy variable that takes the value 1 for newborn mothers highly exposed to pesticides, where high exposition is determined according to the results of the previous section. In particular, we will consider mothers exposed to banana plantations to be those with a weighted buffer above the average level at 100 meters distance, and that are located within 100 meters of the closest plantation.[15] The variable $Z^{th}\ Intense\ Fumigations_i$ is a dummy variable that takes the value 1 for newborns that were affected by high-intensity fumigations in their province during their Z^{th} gestation trimester. We construct this variable taking into account the fumigation patterns observed in each province and the newborns' respective gestation stages (see figure 1).

Our parameter of interest is θ_z (the DID parameter), which captures the change in the birth outcome generated by an increase in the intensity of fumigations when the exposed newborn was in the Z^{th} gestation trimester. This identification strategy exploits the time variations of fumigations across provinces and the differing seasonal prenatal exposure to pesticides. This approach has been used in other papers to examine the effect of fertilizers on water sources (Brainerd and Menon, 2014) and in the medical literature to analyze the effects of pesticides (Bradman et al., 2003, 2011; Cecchi et al., 2012; Laborde, 2015). One general finding is that

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[15] The use of a binary measure of exposure is justified because the functional form of the relationship between pesticide exposure and birth outcomes is not well understood and could be nonlinear (Larsen et al., 2017).

children exposed to higher concentrations of agrichemicals during the first gestation trimester experience worse health outcomes across a variety of measures.

Comparison with other crops

Our second research design considers a DID model that compares the difference between mothers exposed to the fumigations of banana plantations and those not exposed, relative to the difference between mothers exposed and not exposed to any other crops. To do so, we estimate the following model:

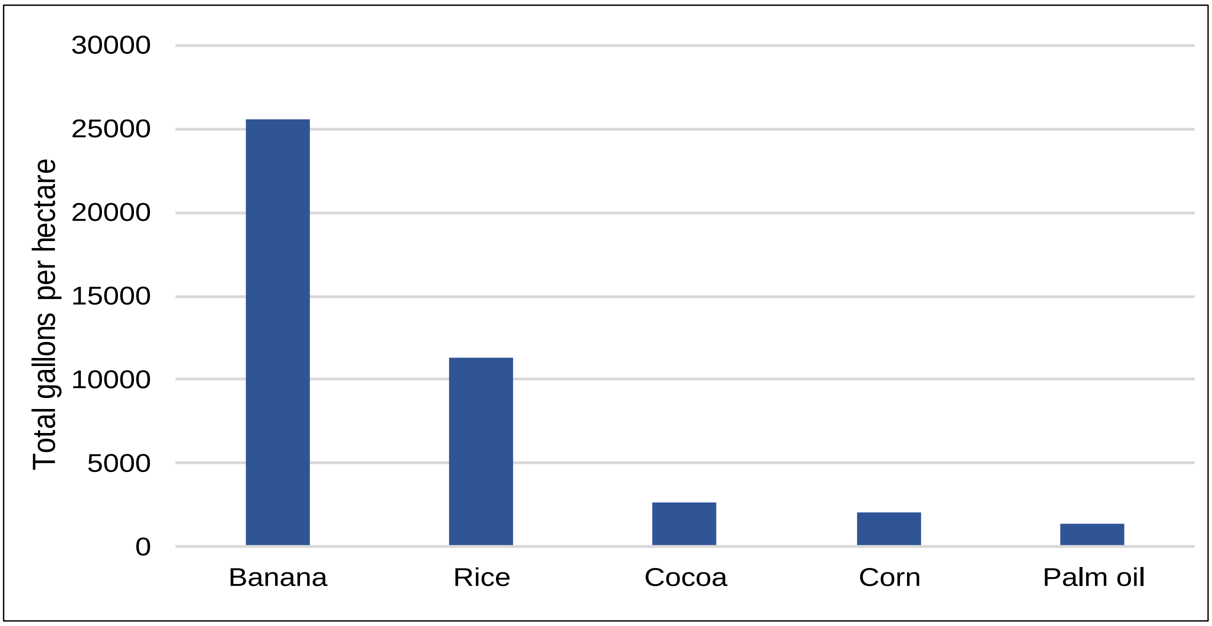
$$Y_{ijmy} = \beta\ Crops\ Exposure_i +\ \theta\ Crops\ Exposure_i * Banana\ Exposure_i$$
$$+ \delta X_i + \mu_j + \psi_m + \phi_y + \varepsilon_{ijmy} \tag{4}$$

where $Crops\ Exposure\ _i$ is a dummy variable that takes the value 1 for mothers exposed to any crop (banana, rice, corn and cocoa), where exposure is constructed as in the previous section. Exposed mothers are those whose weighted buffer is above the average level at 100 meters distance, and that are located within 100 meters of the closest plantation. The variable $Banana\ Exposure_i$ is the same than in the previous section. The model also consider several newborn and mother control variables, as well as municipality and birth cohort fixed effects.

The coefficient of interest in this model is θ, which shows differences in birth outcomes between newborns exposed to banana plantations and newborns exposed to any other crop, due to the effect of fumigations. Note that an essential assumption of this analysis is that there are no relevant differences between mothers living close to banana plantations and those living close to other crops. Table 1 presents mean maternal and newborn characteristics for newborns exposed to banana plantations and for those exposed to rice, corn and cocoa. We find statistically significant differences for some crops and for some relevant characteristics such as mother's age, prenatal control sessions, education or social status. However, most of these differences disappear when we repeat the analysis at the province level (see Tables D.1 to D.3 in Appendix D) or at the municipality level (not reported, for simplicity).

Another important assumption for the identification is that fumigations are much less important for the other crops than for banana plantations. Figure 3 supports this assumption by comparing gallons applied per hectare for the crops considered in our analysis.

Figure 3. Gallons of pesticides per hectare for crops in coastal provinces (2015-2017)



Source: Encuesta de Superficie y Producción Agropecuaria Continua (INEC).

Maternal Fixed Effects

Our third empirical strategy uses mothers' identifiers in our birth records data to link siblings born to the same mother and estimates a maternal fixed effects model. Following a similar approach by Currie et al. (2020), we analyze the effects of pesticides focusing on those mothers who had two or more children in the period examined, and we exploit the fact that a portion of these mothers report different residences for each of the pregnancies. We consider the following model:

$$Y_{ijmyk} = \theta \; Banana\ Exposure_i + \beta X_{ik} + \delta_k + \mu_j + \psi_m + \phi_y + \varepsilon_{ijmy}, \tag{5}$$

Where k is the mother's indicator. As in the first identification strategy, the variable $Banana\ Exposure_i$ is a dummy variable that takes the value 1 for newborns highly exposed to pesticides during the gestation period. The vector of control variables X_{ik} includes birth order and birth interval dummies: first birth, less than 12 months from previous birth, 12-24 months from previous birth, and 24-36 months from previous birth. On the other hand, δ_k is the maternal fixed effect that accounts for newborns that have the same mother. The key coefficient of interest in equation (5) is θ, which we identify using 852 newborns from 422 mothers who had at least one pregnancy in a residence highly exposed to aerial fumigations, and one pregnancy in a residence not exposed to pesticides.[16] Finally, note that in this model we cluster standard errors at the mother level.

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[16] Out of approximately 51 thousand newborns researched, some 6% are from a mother with at least two pregnancies and 3% (1,351) from a mother with at least two pregnancies who resided at a different address for each pregnancy.

5. Results

5.1 Exposure to pesticides

This sub-section estimates the model in equation (2) to analyze the relationship between newborns' birth weight and the exposure measure $Exposure\ Buffer_i$. We will then use the results from these estimates to construct the dummy variable $Banana\ Exposure_i$ that we employ in our causality analysis to identify the newborns exposed and not exposed to pesticides. Table 2 reports the results of our estimations, applying different values of b and c to construct the variable $Exposure\ Buffer$. In particular, we consider that b can take the value of 4, 6, 10 or 15, where a low value implies that pesticides spread over a wider area after their application, and a high value means that pesticide droplets fall almost vertically over the banana trees. Moreover, we consider that c can take the value of 50, 100 or 250 meters, where larger values mean that pesticides fall further away from the perimeters of the plantations. In panel A in the table, the exposure variable considers the square meters of fumigated plantations and in panel B the exposure is the log of the gallons of pesticides applied in each square meter of the plantations. All regressions include newborn and mother controls, as well as municipality and birth cohort fixed effects. Moreover, the regressions include all mothers located at a distance of up to 2.5 kilometers from the plantations.

The results reveal that the mother's exposure to pesticides, measured with the weighted buffers, is negatively associated with newborns birth weight. Interestingly, high values of b and low values of c derive higher coefficients. Specifically, we find that the effects of pesticides are mostly concentrated at approximately 100 meters from the plantation perimeters and those effects decrease rapidly with distance. These results suggest that pesticides generate an average birth weight reduction of 12 grams and 15 grams, at a distance of 100 meters and 50 meters, respectively, from the plantation perimeter. Notice that our findings do not mean that fumigation firms do not respect the protection distance imposed by the law, as it could be that the regulated distance is not enough to protect the neighboring population.

Tables D.4 and D.5 in Appendix D show the results of the baseline model in equation (2) when we use separate samples for girls and boys. The right-hand panel in each table shows the estimates when we restrict the sample to births with a normal delivery, as a C-section can modify the duration of the gestation period. We find that results are stronger and statistically significant when we restrict the sample to births with a normal delivery. On the other hand, Tables D.6 and D.7 repeat the analysis, considering mothers' education levels and shows that the negative effect of pesticides on birth weight is stronger for newborn girls whose mothers have only basic or no education. Pesticides negatively affect newborn boys, but the reduction in birth weight is not statistically significant.[17]

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[17] We have repeated this analysis calculating the variable $Exposure\ Buffer$ considering the volume of pesticides applied in gallons per hectare in each municipality in 2014, as in panel B of Table 2. The results obtained (not reported, for simplicity) are similar to those shown above. Likewise, we find that the effect of pesticides is more

Finally, we use the results from these analyses to construct the dummy variable $Banana\ Exposure_i$ that we consider in the causality analysis to group the newborns into exposed and not exposed to pesticides. Specifically, we consider that the variable $Banana\ Exposure_i$ takes the value 1 for mothers who reside within 100 meters of the plantation perimeter and with a weighted buffer above the average of the mothers living within this distance. We construct this variable using the values $b = 4$ and $c = 100$, so we assume that pesticides have a large effect on the population living within 100 meters of the plantation perimeter and that the effects quickly vanish with greater distance.

5.2 Effects of pesticides on health at birth

Seasonality analysis

Table 3 presents the estimates of the DID model in equation (3) that analyzes the effects of the seasonal intensification of fumigations on newborn health outcomes. Columns (1) and (4) show that, when the first gestation trimester occurs during the months of intensive fumigations, the birth weight of exposed newborns is reduced by 37.7 grams and the likelihood of low birth weight (LBW) increases by 0.35 (with an odds ratio of 1.41).[18] Moreover, column (9) shows that when the third gestation trimester occurs during the months of intensive fumigations, the likelihood of a low Apgar score at first minute increases by 0.33 (with an odds ratio of 1.39).[19] We do not find a significant impact of the interaction terms on the number of gestational weeks or on the preterm (premature birth) dummy variable.

Tables 4 to 6 present some further results for the birth weight outcome variable. Table 4 considers separately the effects of the seasonal intensification of fumigations in each gestation trimester. Column (1) is the baseline model and shows that exposure to pesticides reduces birth weight by 23.5 grams. Columns (2) to (4) present the results of the DID model for each gestation trimester. We find that birth weight is reduced by 37.3 grams when the first gestation trimester coincides with the months of intensive use of fumigations, but we do not find a statistically significant effect for the other two trimesters. Finally, column (5) reproduces column (1) in Table 3 and shows the effect of the seasonal intensification of fumigations at different trimesters of gestation. The results confirm that fumigations have the most impact when they occur during the first gestation trimester. At this point, it is important to clarify that these estimates reflect the effects of the seasonal increases of fumigations in the group of exposed newborns, so the overall impact of pesticides on birth weight can be higher.

Seasonal variation in the use of pesticides is more evident in the province of Los Rios, which experiences a substantial increase in fumigations during the rainy season and the months that follow (Figure 1). To further examine the seasonal effects of pesticides, Table 5 repeats the DID model in equation (3), focusing on this province. Results in column (2) confirm that

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concentrated within 100 meters of the plantations and that girls born to less educated mothers is the most affected group.

[18] We define low birth weight (LWB) as lower than 2,500 grams.

[19] We define low Apgar score at first minute as lower than or equal to 6, a normal score being 7 or above.

pesticides have a negative and significant effect on newborns that are more exposed to fumigations during the first trimester of gestation, and results in column (3) reveal that they also have an effect on those exposed in the second trimester. However, all newborns for whom the second trimester of gestation coincides with the rainy period have a higher birth weight, a factor that partly compensates for the effect of pesticides in the exposed group. Finally, column (5) shows that in Los Rios, newborns exposed to intensive fumigations in the first and second trimesters of gestation have an aggregated birth weight deficit of 89 grams compared to those newborns that are also exposed to fumigations but not in these trimesters of gestation.

Finally, Table 6 presents the heterogeneous results of seasonal fumigations considering the mother's education level and the sex of the newborn. Column (1) shows that newborns with less educated mothers that are exposed to intensive fumigations have a birth weight that is 44.4 grams lower than those not affected, but column (2) does not find a significant effect of seasonal intensification of fumigations on birth weight. On the other hand, while the estimates in column (3) do not find a significant effect of pesticides on newborns from more educated mothers, column (4) finds a birth weight effect of 50.2 grams for those exposed to intense fumigations in the first trimester of gestation. Regarding sex differences, column (5) shows that girls exposed to pesticides have a birth weight that is nearly 31.8 grams lower than those not exposed, and column (6) shows an effect of 50.3 grams on newborn girls exposed to intensive fumigations in the first gestational trimester. Finally, our estimates in columns (7) and (8) show no significant effect of exposure to fumigation on newborn boys.[20]

Comparison with other crops

Table 7 presents the main results of our second identification strategy, which compares the difference between infants born to mothers exposed to the banana plantation fumigations and those not exposed, relative to the difference between those born to mothers exposed and not exposed to any other crops (rice, corn and cocoa). The variables $Banana\ Exposure_i$ and $Crops\ Exposure_i$ are constructed as in the previous empirical design. Both dummy variables take the value 1 for mothers who reside within 100 meters of the perimeter of a plantation (banana or another crop) and with a weighted buffer above the average within that area. Column (1) considers the results for the whole sample and suggests that newborns exposed to fumigated banana plantations have a birth weight deficit of 29.3 grams compared to those exposed to other crops. Columns (2) and (3) consider separate samples for those born to less educated and more educated mothers, respectively. The estimates show that exposure to fumigations of banana plantations has a negative and significant effect of 76.9 grams on those born to less educated mothers and a positive but not significant effect on those born to more educated mothers. Table 8 presents separate regressions for newborn girls and boys. Columns (1) and (2) show negative and similar coefficients for the two groups, although they are not statistically significant. Columns (3) and (4) restrict the analysis to newborns with less educated

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[20] Our results are consistent with previous evidence that shows newborn females are more responsive than males to environmental shocks, due to a combination of biological and social factors (Ross and Desai, 2005; Maccini and Yang, 2009; Barron et al., 2017).

mothers and show that among this group, girls exposed to fumigated banana plantations have a birth weight deficit of 71.7 grams compared to girls highly exposed to other crops. We obtain a similar coefficient for boys, although it is not significant. To sum up, our results show that being close and highly exposed to aerially fumigated banana plantations during pregnancy entails an important detriment to health at birth, especially for newborn girls whose mothers have only basic or no education.

Maternal fixed effects

Tables 9 to 13 show the results from the maternal fixed effects model in expression (5). Specifically, we restrict the sample to those mothers giving birth to two or more children in the period 2015 to 2017, and we exploit the fact that a portion of these mothers had a different address when they registered each birth. Tables 9 and 10 show the results when we use the continuous variable $Exposure\ Buffer_i$, which captures the sum of the 100 weighted buffers considering the square meters of the plantation surrounding the mother's residence, as explained before. Table 9 considers different combinations of the parameters b and c to construct the exposure variable. Although all coefficients are negative, as expected, we do not find a statistically significant effect of pesticides on birth health. However, Table 10 analyzes girls and boys separately, showing that exposure to pesticides has a negative and significant effect for newborn girls. Considering the average value of the exposure variable, the calculated coefficient implies a birth weight deficit of between 70 and 200 grams, depending on the combination of parameters used to construct the buffer.

In Tables 11 and 12 we repeat the previous analysis, but now the variable $Exposure\ Buffer_i$ reflects the volume of pesticides (gallons per square meter) applied to the plantations of each municipality, according to the pattern offered by the 2014 fumigation register. This measure allows us to control for the different intensities of pesticide use across geographical areas. The results obtained are qualitatively similar to those of the previous tables, although the coefficients are not directly comparable.

Table 13 shows the results of the model in equation (5) when we use the dummy variable $Banana\ Exposure_i$ to identify newborns exposed and not exposed to pesticides. As before, we do not find a significant effect of exposure to pesticides on birth weight when we consider the whole sample. However, columns (2) and (5) show a significant and very large coefficient when we focus on the effect of pesticides on newborn girls. Specifically, our results show that those girls highly exposed to pesticides during pregnancy have a birth weight that is 578 grams lower than their non-exposed female siblings. One explanation for this large coefficient is that girls exposed to pesticides during pregnancy had a gestation period that was two weeks shorter than that of their siblings (we don't present these result for simplicity), a situation that implies a profound effect on the birth weight. Taking this into account, the right-hand panel of Table 13 repeats the analysis, controlling for the number of gestational weeks. After this adjustment, we find that newborn girls exposed to pesticides in utero have a birth weight that is 346 grams lower than their non-exposed female siblings. This effect is still larger than the one we have found in the previous identification strategies. Note that in the first identification approach we consider the effects of the seasonal intensification of fumigations in a group of newborns that are all exposed to pesticides. In this case, by contrast, the identification consists in comparing siblings exposed and not exposed to pesticides. Therefore, the effect of pesticides is expected to be greater in this case.

Finally, it is important to mention that the different impact of pesticides on newborn girls and boys may be related to gender differences in the survival probability in front of adverse environmental conditions. The medical literature has shown that detrimental conditions during pregnancy increase the probability of spontaneous abortions, finding a smaller probability of abortions on female fetuses (Byrne et al., 1987; Hobel et al., 1999; Zaren et al. 2000; Ghosh et al., 2007; Del Fabro et al., 2011; Pongou, 2013; Buckberry et al., 2014). In accordance to this result, we observe that in the period examined the share of female siblings born in non-exposed areas was of around 48.5%, while their share in exposed areas was larger than 52%. This situation suggests that pesticides may reduce the survival probability of male fetuses in exposed area, but the birth weight of surviving newborn boys in exposed and non-exposed areas is not statistically different.

6. Conclusion

Aerial pesticide fumigation plays a key role in the agriculture industry, but its massive and uncontrolled use is causing important health problems in nearby populations. Our paper contributes to the existing economic, medical and environmental literature by examining the causal relationship between newborns' in utero exposure to pesticides and adverse health outcomes. In order to do this, we combine precise information on mother's residence during pregnancy, the perimerter of banana plantations and the volume and frequency of pesticide use in Ecuador.

Our analysis is based on a novel measure of newborns' exposure to pesticides. Using the exact address of the mothers during pregnancy and the perimeters of the plantations, we calculate 25-meter-radius buffers of fumigated plantations from the mother's residence up to 2.5 kilometers. Each buffer reflects the square meters of banana plantations affected by aerial fumigation. We then construct our individual exposure measure by weighting the 100 buffers according to a decaying function. Our baseline analysis reveals the existence of a negative relationship between high in utero exposure to pesticides and a set of health outcomes. More specifically, we find that exposure to pesticides during gestation is associated with a birth weight deficit of between 12 and 32 grams, a greater probability of low birth weight and a greater probability of a low Apgar score. The impact of pesticides occurs within the first 50 to 150 meters of the perimeter of the plantation and quickly decreases beyond that distance. We use the results of this initial study to construct an exposure measure that we use in our causal analysis. Specifically, we consider that mothers exposed to banana plantations are those with aggregated weighted buffers above the average level at 100 meters away, and that are located within 100 meters of the perimeter of the closest plantation.

We propose three identification strategies to examine the causal effect of pesticides on health at birth. First, we exploit the seasonal variation of aerial fumigations across provinces. For this, we identify the trimester of gestation that occurs during the months of intensive use of pesticides. Then, we estimate a DID model comparing the difference in birth weight of newborns exposed to pesticides in the high and low fumigation seasons, relative to newborns non-exposed to pesticides in the same two seasons. The results reveal that the effects of pesticides are stronger when the first trimester of gestation happens in the months of intensive use of pesticides. Specifically, we find that newborns exposed to pesticides have a birth weight deficit of between 39 and 89 grams if their first trimester of gestation coincides with the seasons of intensive fumigations. These estimates reflect the effect of the seasonal intensification of fumigations in the newborn that are exposed to pesticides, so the overall impact of pesticides on birth weight is expected to be higher.

The second identification strategy follows a DID model that exploits spatial variation in newborns' exposure to the fumigation of banana plantations and to the fumigation of other crops (rice, corn, cocoa). This model compares the difference in birth outcomes between newborns exposed and not exposed to the fumigations of banana plantations, relative to the difference for newborns exposed and not exposed to any other crops. The results drawn from this model suggest that exposure to fumigation of banana plantations generates a birth weight deficit of between 29 and 76 grams, compared to newborns whose mothers are exposed to the fumigation other crops. The effects are larger for newborn girls and for those with less educated mothers.

Finally, our third empirical strategy consists of a maternal fixed effects model, where we exploit changes of residential address reported by mothers who had two or more children in the period examined. We thus compare different pregnancies of the same mother, in which one newborn was exposed in utero to pesticides and the other not. The results show that newborn girls exposed in utero to pesticides have a birth weight deficit of between 250 and 578 grams, compared to their non-exposed female sibling. One explanation for the great size of the effect is that high exposure to pesticides in pregnancy shortens the gestation period by an average of 2 weeks. Once we adjust our regressions for the number of gestation weeks, we obtain a birth weight deficit of around 346 grams, which is still very relevant.

Our results are in accordance with the findings in medical and environmental papers that examine the effects of pollutants on health at birth. Our effects are much larger than the 30 grams obtained by Bozzoli and Quintana-Domeque (2014), when they analyzed the effects of the economic crisis in Argentina, or the 23 grams found by Range and Vogl (2019), who examined the effects of the fire pollution caused by sugar cane harvesting in Brazil. However, our findings are close to the 200-gram effect found for mothers that smoke (Kramer, 1987; Lindbohm et al., 2002) and to the 107-175-gram impact obtained by Burlando (2014) examining the consequences of an unexpected blackout in Tanzania. We also confirm the finding obtained in previous studies of air pollution showing a larger impact in the first trimester of gestation (Almond et al., 2011; Bozzoli and Quintana-Domeque, 2014; Burlando, 2014).

We believe that this research can help to improve the design of public policies regarding fumigation practices in different plantations across the world and can be used to enhance pregnancy protocols in affected regions. Our conclusions reinforce the argument that is necessary to modify the use of agrochemicals in agriculture and to increase the protection for neighboring populations and the plantation workers. We have shown that in Ecuador, aerial fumigations have a very relevant impact on the health of newborns born in close proximity to the banana plantations. Our results highlight the urgency of enforcing and reviewing the protection distances established in the country's legislation in 2012 and 2015, to safeguard the health of the population living near the plantations.

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Table 1 – Maternal characteristics by exposure to banana plantations and to other crops

Variable	Banana (1)	Rice (2)	Diff (3) (2) - (1)	Banana (4)	Corn (5)	Diff (6) (5) - (4)	Banana (7)	Cocoa (8)	Diff (9) (8) - (7)
Birth weight	3149.9	3051.47	-98.427***	3149.9	3085.82	-64.082***	3149.9	3132.77	-17.132
	(8.07)	(8.53)	(11.739)	(8.07)	(6.83)	(10.505)	(8.07)	(7.63)	(11.099)
Apgar score 1 minute	7.91	8	0.095***	7.91	8.01	0.102***	7.91	7.9	-0.011
	(0.02)	(0.02)	(0.025)	(0.02)	(0.01)	(0.021)	(0.02)	(0.01)	(0.022)
Mother's age	24.18	24.92	0.746***	24.18	24.17	-0.004	24.18	24.2	0.025
	(0.10)	(0.11)	(0.148)	(0.10)	(0.09)	(0.137)	(0.10)	(0.10)	(0.143)
Male newborn	0.52	0.51	-0.008	0.52	0.53	0.011	0.52	0.52	-0.003
	(0.01)	(0.01)	(0.011)	(0.01)	(0.01)	(0.010)	(0.01)	(0.01)	(0.011)
Female newborn	0.48	0.49	0.008	0.48	0.47	-0.011	0.48	0.48	0.003
	(0.01)	(0.01)	(0.011)	(0.01)	(0.01)	(0.010)	(0.01)	(0.01)	(0.011)
Mother's education Less than HS	0.47	0.42	-0.047***	0.47	0.43	-0.036***	0.47	0.44	-0.029***
	(0.01)	(0.01)	(0.011)	(0.01)	(0.01)	(0.010)	(0.01)	(0.01)	(0.011)
Mother's education HS or more	0.53	0.58	0.047***	0.53	0.57	0.036***	0.53	0.56	0.029***
	(0.01)	(0.01)	(0.011)	(0.01)	(0.01)	(0.010)	(0.01)	(0.01)	(0.011)
Local ethnic group "Montubio"	0.01	0.06	0.047***	0.01	0.01	0.006***	0.01	0.02	0.016***
	(0.00)	(0.00)	(0.004)	(0.00)	(0.00)	(0.002)	(0.00)	(0.00)	(0.003)
Mestizo	0.97	0.93	-0.039***	0.97	0.95	-0.016***	0.97	0.95	-0.019***
	(0.00)	(0.00)	(0.005)	(0.00)	(0.00)	(0.004)	(0.00)	(0.00)	(0.004)
Normal birth	0.55	0.44	-0.118***	0.55	0.53	-0.019*	0.55	0.52	-0.035***
	(0.01)	(0.01)	(0.011)	(0.01)	(0.01)	(0.010)	(0.01)	(0.01)	(0.011)
C-Section birth	0.45	0.56	0.118***	0.45	0.47	0.019*	0.45	0.48	0.035***
	(0.01)	(0.01)	(0.011)	(0.01)	(0.01)	(0.010)	(0.01)	(0.01)	(0.011)
Non marital union	0.41	0.34	-0.072***	0.41	0.36	-0.051***	0.41	0.4	-0.008
	(0.01)	(0.01)	(0.011)	(0.01)	(0.01)	(0.010)	(0.01)	(0.01)	(0.011)
Single	0.41	0.45	0.043***	0.41	0.44	0.032***	0.41	0.43	0.023**
	(0.01)	(0.01)	(0.011)	(0.01)	(0.01)	(0.010)	(0.01)	(0.01)	(0.011)
Married	0.14	0.18	0.042***	0.14	0.16	0.020***	0.14	0.13	-0.006
	(0.01)	(0.01)	(0.008)	(0.01)	(0.00)	(0.007)	(0.01)	(0.01)	(0.007)
Birth at a public hospital	0.86	0.82	-0.040***	0.86	0.88	0.018***	0.86	0.83	-0.028***
	(0.01)	(0.01)	(0.008)	(0.01)	(0.00)	(0.007)	(0.01)	(0.01)	(0.008)
Birth at a private hospital	0.14	0.18	0.040***	0.14	0.12	-0.018***	0.14	0.17	0.028***
	(0.01)	(0.01)	(0.008)	(0.01)	(0.00)	(0.007)	(0.01)	(0.01)	(0.008)
Number of births	2.29	2.23	-0.063**	2.29	2.19	-0.105***	2.29	2.19	-0.102***
	(0.02)	(0.02)	(0.031)	(0.02)	(0.02)	(0.030)	(0.02)	(0.02)	(0.031)
Number of children	2.33	2.27	-0.062*	2.33	2.21	-0.113***	2.33	2.22	-0.104***
	(0.02)	(0.02)	(0.032)	(0.02)	(0.02)	(0.030)	(0.02)	(0.02)	(0.032)
Prenatal control	5.89	6.4	0.505***	5.89	5.55	-0.345***	5.89	5.93	0.04
	(0.03)	(0.04)	(0.050)	(0.03)	(0.03)	(0.047)	(0.03)	(0.04)	(0.049)
Single birth	0.99	0.98	-0.003	0.99	0.99	0.002	0.99	0.99	0.001
	(0.00)	(0.00)	(0.003)	(0.00)	(0.00)	(0.002)	(0.00)	(0.00)	(0.002)
Observations	4,289	3,913	8,202	4,289	5,279	9,568	4,289	4,458	8,747

Significance levels: * p<0.1 ** p<0.05 *** p<0.01. Standard errors in parentheses

Table 2 – Effects of pesticide exposure on newborns' birth weight, 2015 to 2017

	Buffer 2.5 Km – Air fumigated plantations							
	Weighted square meters				Weighted logs of pesticides per square meters			
	b=4	b=6	b=10	b=15	b=4	b=6	b=10	b=15
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposure buffers – c=50	-0.0028**	-0.0041**	-0.0048**	-0.0049**	-2.0478*	-2.3972*	-2.6097*	-2.6559*
	(0.0013)	(0.0018)	(0.0021)	(0.0022)	(1.0528)	(1.2288)	(1.3392)	(1.3631)
Exposure buffers – c=100	-0.0006*	-0.0008**	-0.0009**	-0.0009**	-0.6543*	-0.7300*	-0.7657*	-0.7781*
	(0.0003)	(0.0004)	(0.0004)	(0.0004)	(0.3763)	(0.4047)	(0.4220)	(0.4285)
Exposure buffers – c=250	-0.0001	-0.0001*	-0.0001*	-0.0001*	-0.1414	-0.1804	-0.2019	-0.2100
	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.1316)	(0.1355)	(0.1389)	(0.1401)
Mother's Controls	X	X	X	X	X	X	X	X
Month x Year F.E.	X	X	X	X	X	X	X	X
Municipality F.E.	X	X	X	X	X	X	X	X
Observations	50,034	50,034	50,034	50,034	50,034	50,034	50,034	50,034
R2	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986

Notes: Each coefficient corresponds to the result of a different estimation of equation (2), where the dependent variable is the newborns birth weight. The left panel shows the results when *Exposure Buffer* is a continuous variable that represents the sum of the 100 weighted buffers with the square meters of the plantations close to the mothers' residences. The right panel shows the results when *Exposure Buffer* considers the sum of the 100 weighted buffers of the logs of the pesticides spread per square meter in the banana plantations. The values of *b* and *c* consider different parameter combinations for the weighting function in expression (1). The sample is limited to births by mothers living up to 2.5 kilometers from the plantations. The controls of child characteristics are indicators of single birth and sex. The controls of maternal characteristics are mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), ethnic group (mestizo, montubio, white, afroecuadorian, indigenous, other), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the municipality level and are shown in parentheses. The clusters number is 137 excluding single observations. The reported R–squared is the same for all the coefficients in each column. Significance levels: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 3 – Effects of the seasonal intensification of fumigations

	OLS fixed effects						Logit fixed effects		
	Birth weight	Gestation weeks	Apgar 1^{st}	LBW	Preterm	Low Apgar	LBW	Preterm	Low Apgar
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Banana Exposure	-2.7738	-0.0041	-0.0189	-0.0139	-0.0120*	0.0055	-0.2005	-0.1930	0.1259
	(16.4818)	(0.0619)	(0.0385)	(0.0104)	(0.0067)	(0.0083)	(0.1648)	(0.1286)	(0.1621)
Intense fumigation during 1^{st} Trimester	2.4741	0.0295	0.0152	0.0007	-0.0056	0.0027	0.0156	-0.1093*	0.0465
	(7.9533)	(0.0258)	(0.0165)	(0.0038)	(0.0036)	(0.0030)	(0.0577)	(0.0639)	(0.0605)
Intense fumigation during 2^{nd} Trimester	13.1523*	-0.0037	0.0116	-0.0018	-0.0028	-0.0038	-0.0123	-0.0632	-0.0775
	(7.3915)	(0.0267)	(0.0145)	(0.0038)	(0.0035)	(0.0036)	(0.0579)	(0.0621)	(0.0772)
Intense fumigation during 3^{rd} Trimester	-1.3288	-0.0259	0.0032	-0.0009	-0.0001	0.0006	-0.0102	-0.0034	0.0128
	(8.2477)	(0.0322)	(0.0145)	(0.0038)	(0.0037)	(0.0029)	(0.0601)	(0.0688)	(0.0569)
Banana Exposure x Intense fumigation during 1^{st} Trimester	-37.7412***	-0.0481	-0.0313	0.0230***	0.0063	-0.0011	0.3380***	0.1191	-0.0161
	(12.5942)	(0.0388)	(0.0327)	(0.0082)	(0.0070)	(0.0081)	(0.1248)	(0.1321)	(0.1639)
Banana Exposure x Intense fumigation during 2^{nd} Trimester	-16.3853	-0.0437	0.0643	0.0075	0.0043	-0.0044	0.1083	0.0626	-0.0803
	(16.1104)	(0.0603)	(0.0414)	(0.0057)	(0.0055)	(0.0079)	(0.0893)	(0.1183)	(0.1601)
Banana Exposure x Intense fumigation during 3^{rd} Trimester	-0.6532	0.0007	-0.0642	0.0132	0.0001	0.0181**	0.2038	-0.0017	0.3508***
	(17.8733)	(0.0373)	(0.0426)	(0.0099)	(0.0071)	(0.0079)	(0.1487)	(0.1343)	(0.1319)
Mother's control	X	X	X	X	X	X	X	X	X
Month x Year F.E.	X	X	X	X	X	X	X	X	X
Municipality F.E.	X	X	X	X	X	X	X	X	X
Observations	50,034	50,034	50,034	50,034	50,034	50,034	49,941	49,609	49,597
R2	0.0988	0.0900	0.0645	0.0911	0.0747	0.0183			
Pseudo – R2							0.1026	0.0967	0.0396

Notes: Each column shows the results of the estimation of equation (3) for a different health outcome. The interaction terms reflect the effect of the increase of fumigations in the exposed area in newborns that were in their k^{th} gestation trimester. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations. The controls of child characteristics are indicators of single birth and sex. The controls of maternal characteristics are mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), ethnic group (mestizo, montubio, white, afroecuadorian, indigenous, other), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the municipality level and are shown in parentheses. The clusters number is 137 in columns (1) to (6), 119 in column (7), 109 in column (8) and 106 in column (9), excluding single observations in all columns. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4 – Effects of the seasonal intensification of fumigations on birth weight: gestational trimester

	Birthweight				
	(1)	(2)	(3)	(4)	(5)
Banana Exposure	-23.5069**	-9.7596	-18.8087*	-31.0144***	-2.7739
	(11.1614)	(12.3109)	(10.3329)	(11.1821)	(16.4818)
Intense fumigation during 1st Trimester		0.1942			2.4742
		(7.3896)			(7.9533)
Intense fumigation during 2nd Trimester			13.8871**		13.1524*
			(6.5082)		(7.3915)
Intense fumigation during 3rd Trimester				-5.7726	-1.3288
				(7.3678)	(8.2477)
Banana Exposure x Intense fumigation during 1st Trimester		-37.3074***			-37.7412***
		(11.2294)			(12.5942)
Banana Exposure x Intense fumigation during 2nd Trimester			-11.4556		-16.3854
			(15.4356)		(16.1104)
Banana Exposure x Intense fumigation during 3rd Trimester				19.8484	-0.6532
				(15.2250)	(17.8732)
Mother's control	X	X	X	X	X
Month x Year F.E.	X	X	X	X	X
Municipality F.E.	X	X	X	X	X
Observations	50,034	50,034	50,034	50,034	50,034
R2	0.0986	0.0987	0.0987	0.0986	0.0988

Notes: The table shows the results of the estimation of equation (3) when the outcome variable is birth weight. Column (1) is the baseline model that considers the effect of exposure to pesticides on birth weight. Columns (2) to (4) consider the separate impact of the seasonal intensification of fumigations in the kth trimester of gestation. Column (5) reproduces column (1) in Table 3 and shows the effect of the seasonal intensification of fumigations when they affect newborns in the three trimesters of gestation. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations. The controls of child characteristics are indicators of single birth and sex. The controls of maternal characteristics are mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), ethnic group (mestizo, montubio, white, afroecuadorian, indigenous, other), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the municipality level and are shown in parentheses. The clusters number is 137 in all columns, excluding single observations. Significance levels: $^{*} p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$.

Table 5 – Effect of the seasonal intensification of fumigations on birthweight: Los Rios

	Los Rios province				
	Birthweight				
	(1)	(2)	(3)	(4)	(5)
Banana Exposure	-20.0924	-2.7876	7.8612	-27.2638	47.2821
	(27.4867)	(31.7891)	(26.3086)	(23.1008)	(42.7234)
Intense fumigation during 1st Trimester		-12.9257			-10.6355
		(25.9882)			(25.2770)
Intense fumigation during 2nd Trimester			38.8673**		38.9008**
			(15.9778)		(16.0743)
Intense fumigation during 3rd Trimester				13.7287	15.2558
				(31.2296)	(29.6694)
Banana Exposure x Intense fumigation during 1st Trimester		-30.3843**			-45.5294*
		(11.7539)			(23.8331)
Banana Exposure x Intense fumigation during 2nd Trimester			-44.5594**		-43.7245**
			(20.0411)		(20.8672)
Banana Exposure x Intense fumigation during 3rd Trimester				12.3316	-24.0424
				(15.9628)	(28.5529)
Mother's control	X	X	X	X	X
Month x Year F.E.	X	X	X	X	X
Municipality F.E.	X	X	X	X	X
Observations	20,246	20,246	20,246	20,246	20,246
R2	0.1104	0.1105	0.1107	0.1104	0.1109

Notes: The table shows the results of the estimation of equation (3) when the outcome variable is birth weight. Column (1) is the baseline model that considers the effect of exposure to pesticides on birth weight. Columns (2) to (4) consider the separate impact of the seasonal intensification of fumigations in the k^{th} trimester of gestation. Column (5) reproduces column (1) in Table 3 and shows the effect of the seasonal intensification of fumigations when they affect newborns in the three trimesters of gestation. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations located in Los Rios province. The controls of child characteristics are indicators of single birth and sex. The controls of maternal characteristics are mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), ethnic group (mestizo, montubio, white, afroecuadorian, indigenous, other), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the municipality level and are shown in parentheses. The clusters number is 42 in all columns, excluding singleton observations. Significance levels: $^{*} p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$.

Table 6 – Effects of the seasonal intensification of pesticides on birthweight: Education and Gender

	Birthweight							
	Less educated mothers		More educated mothers		Girls		Boys	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Banana Exposure	-44.4518**	-26.7392	-3.3091	19.5911	-31.8603**	-16.2749	-19.0076	6.3221
	(20.1905)	(30.1091)	(12.9162)	(19.5710)	(14.4437)	(26.7013)	(18.1006)	(25.0906)
Intense fumigation during 1st Trimester		-20.4311		14.5180		13.6563		-6.6211
		(12.4873)		(10.3451)		(12.9564)		(11.2043)
Intense fumigation during 2nd Trimester		2.9774		15.9373*		12.0723		14.6678
		(11.9694)		(9.0687)		(10.8300)		(10.9628)
Intense fumigation during 3rd Trimester		6.4758		-6.1882		10.8593		-11.7099
		(11.5162)		(9.2212)		(11.5918)		(10.3801)
Banana Exposure x Intense fumigation during 1st Trimester		-16.8253		-50.2384***		-50.3446**		-26.2520
		(19.6080)		(18.2161)		(24.8278)		(21.4073)
Banana Exposure x Intense fumigation during 2nd Trimester		-17.3581		-14.3809		2.3782		-33.6492
		(36.5391)		(18.5945)		(20.9934)		(34.0670)
Banana Exposure x Intense fumigation during 3rd Trimester		-10.6241		2.8075		6.2714		-6.8944
		(32.0171)		(15.0813)		(19.5144)		(29.4750)
Mother's control	X	X	X	X	X	X	X	X
Month x Year F.E.	X	X	X	X	X	X	X	X
Municipality F.E.	X	X	X	X	X	X	X	X
Observations	19,403	19,403	30,619	30,619	24,247	24,247	25,777	25,777
R2	0.1071	0.1074	0.1000	0.1004	0.1011	0.1014	0.0836	0.0839

Notes: The table shows the results of the estimation of equation (3) when the outcome variable is birth weight. Columns (1) to (4) consider the mothers' education level and columns (5) to (8) the newborns' sex. Results present the differential impact that the seasonal intensification of fumigations have on each gestational trimester. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations, for all provinces. The controls of child characteristics are indicators of single birth and sex, except for columns (5) to (8). The controls of the maternal characteristics are mother's age, maternal education dummy (except for Columns (1) to (4)), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), ethnic group (mestizo, montubio, white, afroecuadorians, indigenous, other), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births, and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the municipality level and are shown in parentheses. The number of clusters in each sub-panel are 121, 131, 128, and 127, respectively. Significance levels: $^{*} p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$.

Table 7 – Exposure to banana plantations vs exposure to other crops: mother's education level

	All newborns	Less educated mothers	More educated mothers
	(1)	(2)	(3)
Banana exposure	-29.3733*	-76.9915***	24.9058
	(17.6771)	(27.8066)	(19.3826)
Exposure crops	7.2734	41.9596*	-33.8004
	(17.0594)	(24.5697)	(21.6661)
Mother's Controls	X	X	X
Month x Year F.E.	X	X	X
Municipality F.E.	X	X	X
Observations	50,034	19,403	30,619
R2	0.0986	0.1073	0.1001

Notes: The table shows the results of the estimation of equation (4) when the outcome variable is the birth weight. Column (1) compares the difference between newborns exposed to the fumigations of banana plantations and those not exposed, relative to the difference for newborns exposed and not exposed to any other crops (rice, corn and cocoa). Columns (2) and (3) repeat the analysis for less educated and more educated mothers. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations. The controls of child characteristics are indicators of single birth and sex. The controls of the maternal characteristics are mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school) (except for columns (2) and (3)), a dummy indicator of marital status (divorced, separated, widowed, married, single, in union), ethnic group (mestizo, montubio, white, afroecuadorians, indigenous, other), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births, and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the municipality level and are shown in parentheses. The number of clusters is 137 in column (1), 121 in (2) and 131 in (3). Significance levels: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 8 – Exposure to banana plantations vs exposure to other crops: gender and mothers' education level

	Girls	Boys	Less educated mothers	
			Girls	Boys
	(1)	(2)	(3)	(4)
Banana exposure	-25.4087	-33.9225	-71.7033**	-75.4684
	(24.7513)	(25.2623)	(34.1460)	(45.5576)
Exposure crops	-8.1384	18.1999	17.9215	57.8429*
	(23.1278)	(20.6558)	(29.8071)	(31.8525)
Mother's Controls	X	X	X	X
Month x Year F.E.	X	X	X	X
Municipality F.E.	X	X	X	X
Observations	24,247	25,777	9,411	9,986
R2	0.1011	0.0836	0.1178	0.0934

Notes: The table shows the results of the estimation of equation (4) when the outcome variable is the birth weight. All columns compare the difference between newborns exposed to the fumigations of banana plantations and those not exposed, relative to the difference for newborns exposed and not exposed to any other crops (rice, corn and cocoa). Columns (1) and (2) examine separately the effect on girls and boys, and Columns (3) and (4) repeat the analysis for less educated mothers. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations. The controls of child characteristics is the indicator of single birth. The controls for mothers' characteristics are mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school) (except for columns (2) and (3)), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), ethnic group (mestizo, montubio, white, afroecuadorians, indigenous, other), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births, and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the municipality level, and are shown in parentheses. The number of clusters is 128 in column (1), 127 in (2), 116 in (3) and 115 in (4). Significance levels: * p < 0.1, ** p < 0.05, *** p < 0.01.

Table 9 – Maternal fixed effect model: exposure buffers (square meters)

	Buffer 2.5 Km – Air fumigated plantations			
	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15
	(1)	(2)	(3)	(4)
Exposure buffers	-0.0023	-0.0031	-0.0095	-0.0148
	(0.0024)	(0.0036)	(0.0106)	(0.0172)
Mother's Controls	X	X	X	X
Mother F.E.	X	X	X	X
Month x Year F.E.	X	X	X	X
Municipality F.E.	X	X	X	X
Observations	3,095	3,095	3,095	3,095
R2	0.8474	0.8474	0.8474	0.8474

Notes: The table shows the results of the estimation of equation (5) when the outcome variable is the birth weight. We use *Exposure Buffers* to identify the effect of aerial fumigations on newborns health. *ExposureBuffer* is a continuous variable that considers the sum of the 100 weighted buffers reflecting the square meters of the plantations close to the mothers' residences. In columns (1) and (2) this variable is constructed assuming that c is equal to 100 and that b is equal to 4 and 15, respectively. Columns (3) and (4) consider that c is equal to 50 and b is equal to 4 and 15, respectively. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations and by mothers who had more than one pregnancy registered during the period 2015 to 2017. The controls of child characteristics are indicators of single birth and sex. The controls of the maternal characteristics are time variant: mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births, and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the mother level, and are shown in parentheses. The clusters number is 1,534, excluding singleton observations. Significance levels: $^{*} p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$.

Table 10 – Maternal fixed effect model: exposure buffers (square meters) and sex

	Girls – Buffer 2.5 Km				Boys – Buffer 2.5 Km			
	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposure buffers	-0.0158***	-0.0268***	-0.0800***	-0.1427***	0.0034	0.0052	0.0155	0.0253
	(0.0043)	(0.0063)	(0.0187)	(0.0318)	(0.0044)	(0.0060)	(0.0168)	(0.0254)
Mother's Controls	X	X	X	X	X	X	X	X
Mother F.E.	X	X	X	X	X	X	X	X
Month x Year F.E.	X	X	X	X	X	X	X	X
Municipality F.E.	X	X	X	X	X	X	X	X
Observations	852	852	852	852	892	892	892	892
R2	0.8950	0.8952	0.8952	0.8953	0.8885	0.8886	0.8886	0.8886

Notes: The table shows the results of the estimation of equation (5) when the outcome variable is the birth weight. We use *Exposure Buffers* to identify the effect of aerial fumigations on the health of newborn girls and boys. *ExposureBuffer* is a continuous variable that considers the sum of the 100 weighted buffers with the square meters of the plantations close the mothers' residences. Columns (1), (2), (5) and (6) calculate this variable assuming that *c* is equal to 100 and that *b* is equal to 4 and 15, respectively. Columns (3), (4), (7) and (8) assume that *c* is equal to 50 and *b* is equal to 4 and 15, respectively. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations and who had more than one pregnancy registered during the period 2015 to 2017. The controls of child characteristics is an indicator of single birth. The controls of the maternal characteristics are time variant: mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, in union), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births, and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the mother level, and are shown in parentheses. The clusters number is 422 in the left panel, and 444 in the right panel, excluding singleton observations. Significance levels: $^{*} p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$

Table 11 – Maternal fixed effect model: exposure buffers (log of pesticides per square meters)

	Buffer 2.5 Km – Air fumigated plantations			
	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15
	(1)	(2)	(3)	(4)
Exposure buffers	-5.3800	-6.2770	-14.5031	-17.3417
	(3.8156)	(4.3097)	(10.0628)	(12.1913)
Mother's Controls	X	X	X	X
Mother F.E.	X	X	X	X
Month x Year F.E.	X	X	X	X
Municipality F.E.	X	X	X	X
Observations	3,095	3,095	3,095	3,095
R2	0.8475	0.8475	0.8475	0.8475

Notes: The table shows the results of the estimation of equation (5) when the outcome variable is the birth weight. We use *ExposureBuffers* to identify the effect of aerial fumigations on the health of newborn girls and boys. *ExposureBuffe*r is a continuous variable that considers the sum of the 100 weighted buffers with the log of the gallons of pesticides spread for square meter in the plantations close to the mothers' residences. Columns (1) and (2) consider that this variable is constructed assuming that c is equal to 100 and that b is equal to 4 and 15, respectively. Columns (3) and (4) assume that c is equal to 50 and b is equal to 4 and 15, respectively. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations and who had more than one pregnancy registered during the period 2015 to 2017. The controls of child characteristics are indicators of single birth and sex. The controls of the maternal characteristics are time variant: mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births, and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the mother level, shown in parentheses. The clusters number is 1,534, excluding singleton observations. Significance levels: $^{*} p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$.

Table 12 – Maternal fixed effect model: exposure buffers (log of pesticides per square meters) and sex

	Girls – Buffer 2.5 Km				Boys – Buffer 2.5 Km			
	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposure buffers	-19.8378*** (7.2754)	-26.2669*** (7.5375)	-65.6192*** (16.2071)	-84.1711*** (18.8682)	-0.1693 (8.1443)	-0.6410 (8.6855)	1.0518 (18.4671)	2.4597 (20.9750)
Mother’s Contr	X	X	X	X	X	X	X	X
Mother F.E.	X	X	X	X	X	X	X	X
Month x Year F.	X	X	X	X	X	X	X	X
Municipality F.E	X	X	X	X	X	X	X	X
Observations	852	852	852	852	892	892	892	892
R2	0.8945	0.8947	0.8949	0.8951	0.8883	0.8883	0.8883	0.8883

Notes: The table shows the results of the estimation of equation (5) when the outcome variable is the birth weight. We use *Exposure Buffers* to identify the effect of aerial fumigations on the health of newborn girls and boys. *ExposureBuffer* is a continuous variable that considers the sum of the 100 weighted buffers with the log of the gallons of pesticides spread for square meter in the plantations close to the mothers’ residences. Columns (1), (2), (5) and (6) consider that this variable is constructed assuming that *c* is equal to 100 and that *b* is equal to 4 or 15, respectively. Columns (3), (4), (7) and (8) assume that *c* is equal to 50 and *b* is equal to 4 or 15, respectively. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations and who had more than one pregnancy registered during the period 2015 to 2017. The controls of child characteristics are indicators of single birth and sex. The controls of the maternal characteristics are time variant: mother’s age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births, and indicator of type of birth (c-section or normal labor). Standard errors are clustered at the mother level, and are shown in parentheses. The clusters number is 422 in the left panel and 444 in the right panel, excluding singleton observations. Significance levels: $^{*} p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$.

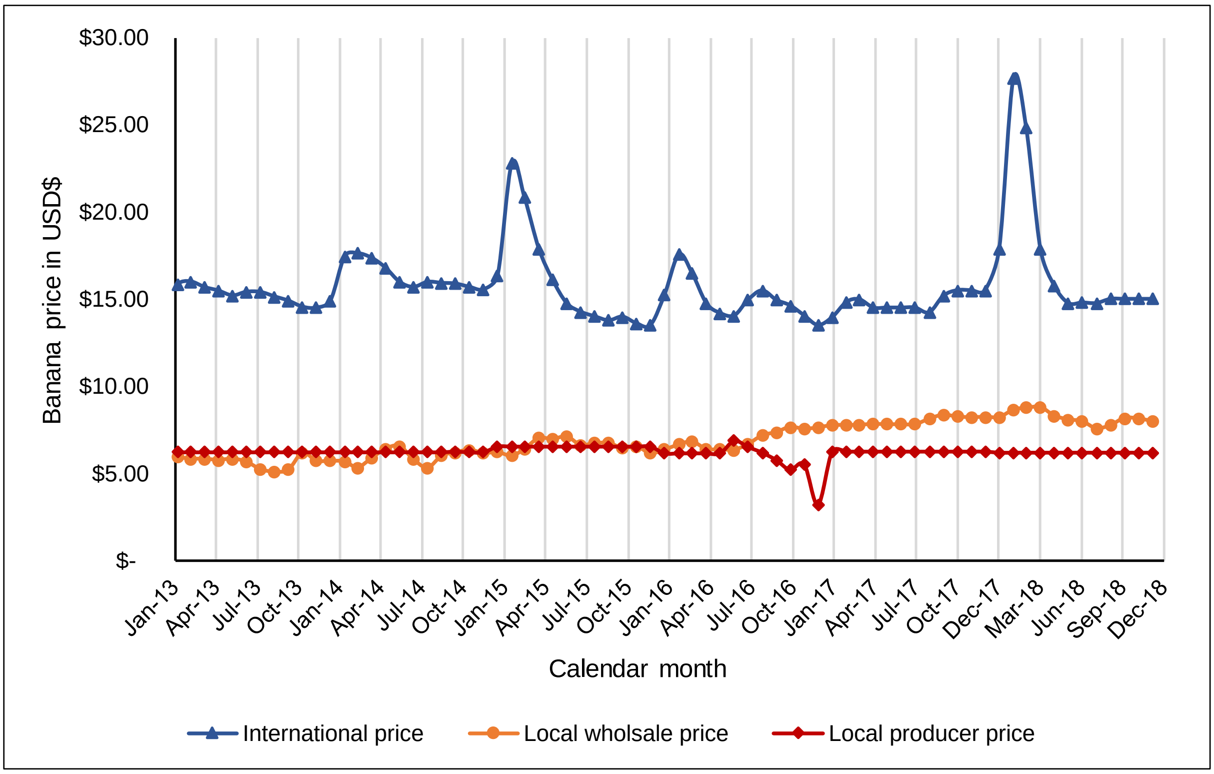
Table 13 – Mothers' fixed effect model: Exposure dummy

	Birthweight					
	All newborns	Girls	Boys	All newborns	Girls	Boys
	(1)	(2)	(3)	(4)	(5)	(6)
Banana Exposure	-31.7435	-578.108***	189.6304	18.5966	-346.8251**	202.1836*
	(93.3755)	(166.1983)	(130.481)	(78.8927)	(158.5531)	(114.3709)
Gestation weeks	-	-	-	X	X	X
Mother's controls	X	X	X	X	X	X
Mother F.E.	X	X	X	X	X	X
Month x Year F.E.	X	X	X	X	X	X
Municipality F.E.	X	X	X	X	X	X
Observations	3,095	852	892	3,095	852	892
R2	0.8474	0.8984	0.8921	0.8950	0.9185	0.9203

Note: The table shows the results of the estimation of equation (5) when the outcome variable is the birth weight. We use the variable *Banana Exposure* to identify the group of newborns exposed to the use of pesticides. *Banana Exposure* is a dummy variable that takes the value of 1 for mothers who reside within the 100 meters to the perimeters of the plantations and have a weighted buffer above the average for the mothers living within this distance. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations and by mothers who had more than one pregnancy registered during the period 2015 to 2017. The right panel includes a control for weeks of gestation. The controls of child characteristics are indicators of single birth and sex (except for columns (2) (3) (5) and (6). The controls of the maternal characteristics are time variant: mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births, and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the mother level, and are shown in parentheses. The clusters number for columns (1) and (4) is 1,534, for columns (2) and (5) is 422, and for columns (3) and (6) is 444. Significance level: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Appendix A: Banana prices

Figure A1 – Local and international banana box price



Source: MAGAP – SIPA

Appendix B – Aerial fumigations and wind intensity

Pesticides are applied following strict conditions regulated by law. Specifically, fumigations cannot be applied during high temperatures, humidity conditions, or when wind speed is greater than 8 km/h. We next analyze the relationship between aerial fumigations and severe weather events. Information on temperature, wind and rainfall are obtained from the meteorological institute of Ecuador, "INAMHI", which has 260 weather stations across the country. We focus on 26 stations located in the region of the banana plantations. We combine the 2014 register of aerial fumigation activity and information from INAMHI. We estimate the following model:

$$Y_{jdm} = \theta \, Wind_{jdm} + \mu_j + \psi_m + \varepsilon_{jdm} \tag{6}$$

where Y_{jdm} shows the number of pesticides applied in municipality j, on day d, of month m. $Wind_{idmt}$ is a dummy variable that takes the value 1 for days with an average wind speed greater than 8 km/h, which is the maximum wind speed that the Ecuadorian legislation allows to fumigate. Note that wind speed can change during the day, generating time intervals in which fumigations may be applied. The model also includes municipality fixed effects, μ_j, and month fixed effects, ψ_m. Finally, we assume the error term ε_{jdm} to be iid and normally distributed. The coefficient θ shows the estimated effect of high wind speed on the number of pesticide applications.

The fumigation register shows that on average each municipality has 3 fumigations per day, although the number of fumigations is higher in the plantations located in Los Rios, El Oro and Guayas. Table B1 shows the results of our analysis on the effect of high-speed winds on aerial fumigations. We estimate a linear regression and a Poisson regression to model count outcomes, given that we do not have zero counts on the outcome variable.[22] The results we obtain show that in days with high-speed winds the frequency of air fumigation is reduced. The OLS analysis in column (4) includes day and month fixed effects and shows that on days with high wind speeds the number of aerial fumigations by an average of 2. Column (8) repeats the analysis with a Poisson model and confirms the negative impact of high wind speeds on fumigations frequency. In terms of magnitudes, we find that on days of high wind speeds fumigations are reduced by 47%, i.e. $(1 - e^{-0.63}) * 100 = 47\%$.

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[22] Farmers' decision to fumigate depends mostly on the weather conditions and on the agricultural calendar. Aerial fumigations does not necessarily happen every day, and the registry does not record days with zero air fumigation.

Table B1 – Higher wind speed effects on number of pesticides air fumigation

	OLS – Fixed effects				Poisson – Fixed effects			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Wind	-2.1828**	-2.2050**	-2.1897**	-2.2151**	-0.6211***	-0.6295***	-0.6237***	-0.6332***
	(1.0767)	(1.0860)	(1.0855)	(1.0944)	(0.2161)	(0.0348)	(0.0377)	(0.2208)
Day F.E.		X		X		X		X
Month F.E.			X	X			X	X
Observations	10,844	10,844	10,844	10,844	10,844	10,844	10,844	10,844
R2	0.0264	0.0297	0.0281	0.0316				
Pseudo R2					0.0123	0.0142	0.0133	0.0152

Note: Each coefficient represents a separate regression. Left panel uses an OLS fixed effects estimation. Right panel uses a Poisson fixed effects estimation. Standard errors are clustered at the municipality level, shown in parentheses. The number of clusters is 90 for all columns, excluding singleton observations. Significance at $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$ level.

Appendix C – Methodology used to construct the exposure measures

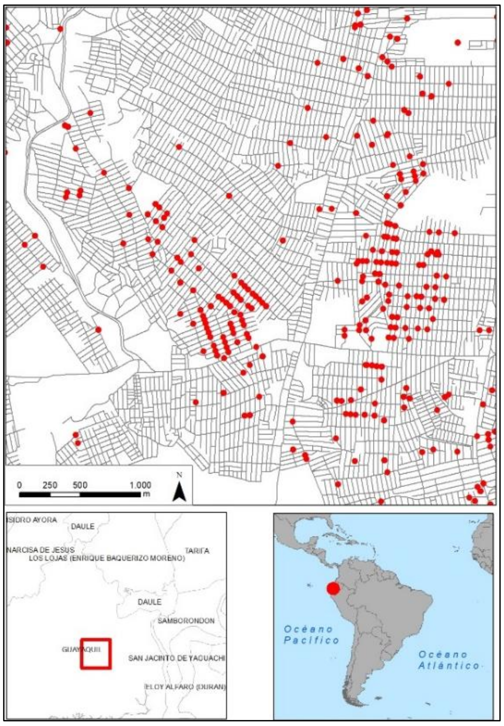
This section explains the methodology used to obtain: (1) the distance from the mothers' households to the crop plantations; (2) the measure of exposure to the crop plantations (banana, cocoa, rice, corn); (3) the measure of exposure to aerially fumigated banana plantations. The software used in these calculations are ArcGis and Qgis.

Distance from the plantations. To calculate the distance from the plantations we first convert the alphanumeric table containing the postal addresses of the mothers into spatial information. We use the API of Google Maps and successfully geolocate the residences of 495,887 newborns out of a total of 955,941 for the period 2015-2017 (Figure C1).

We then calculate the distance from the mother's residence to the closest plantation. For this, we use the *Near* tool of ArcGis. As a result, two new fields are generated in the layer, one that indicates the code of the closest plantation and another one that shows the distance in meters (Figure C2).

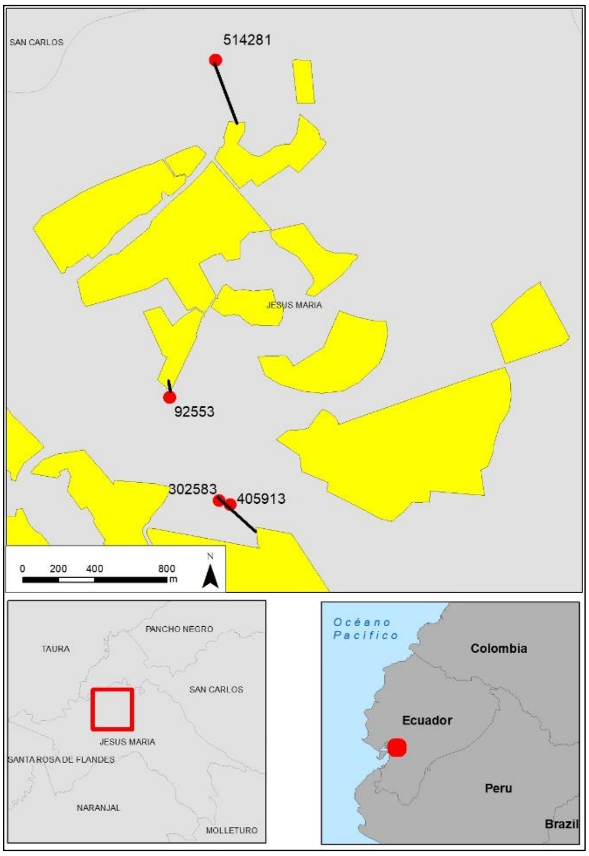
Figure C1 – Newborns' alphanumeric data (left) and spatial information of addresses (right)

ID	Street address
260444	Batallon YY y la Y
405444	Vacas Galindo entre YY y YY
179444	Sedalana entre la YY y YY
471444	Suburbio LA YY y la Y



Source: Author's elaboration. Data from the newborns registry and the geographic street map.

Figure C2 – Analysis of the closest plantation



ID newborn	Distance (m)	ID Plantation
92553	35.2	3925
302583	187.7	2495
405913	219.2	2495
514281	347.3	2874

Source: Author's elaboration, Data from the newborns registry and the banana plantations census.

Exposure to the crop plantations. We calculate the area of the plantations that are close to the mothers' households using intervals of 25 meters up to a distance of 2,500 meters (additional analyses have been performed up to 5,000 meters, but the results of our analysis do not change). This process has been repeated for several crops (banana, rice, corn, cocoa). In the case of banana plantations, we also calculate separate measures for plantations that apply aerial and manual fumigations. The analysis requires four steps, combining Qgis and ArcGis software (figure C3):

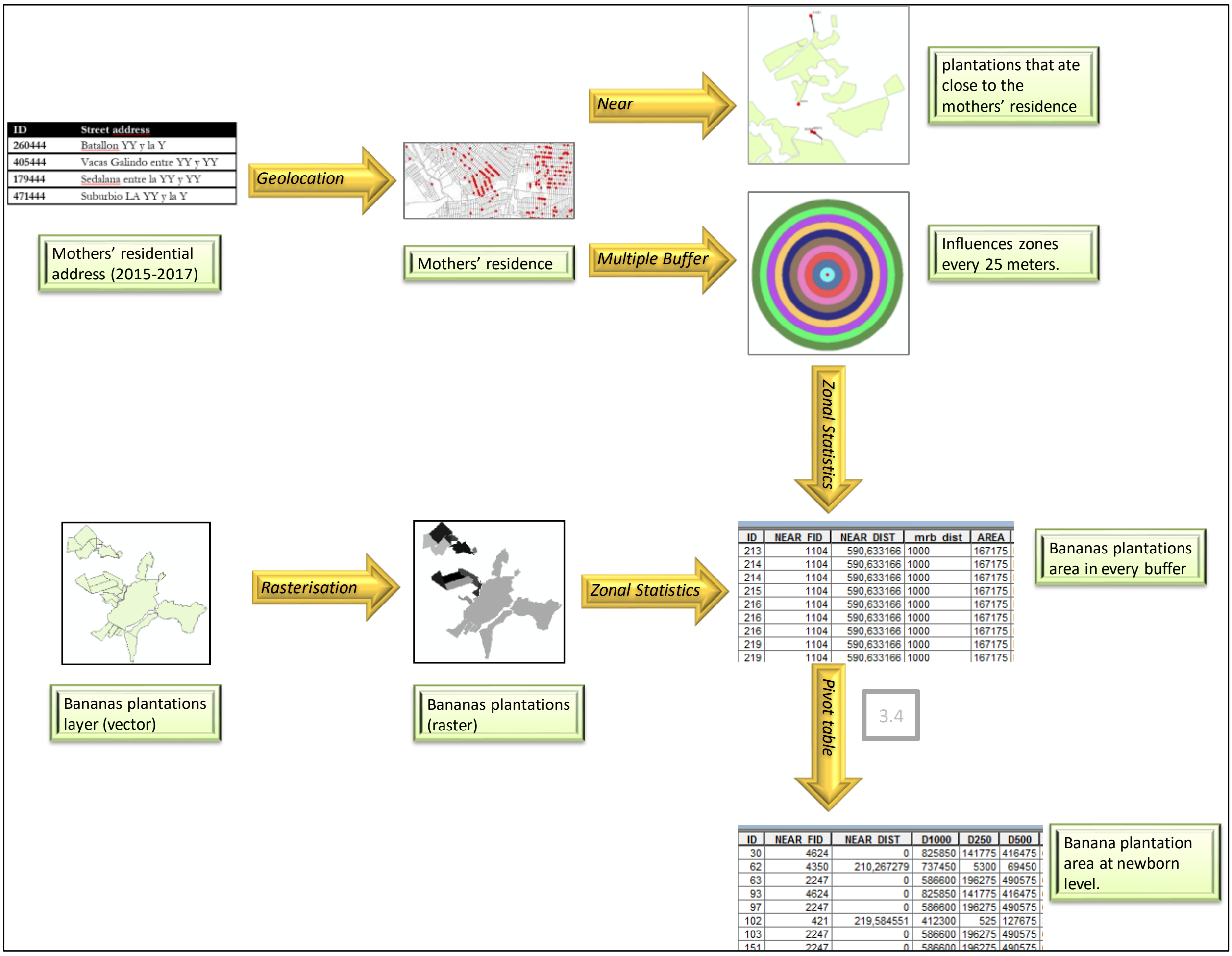
1. Generate influence zones (buffers) every 25 meters from the identified address, up to 2,500 meters. We use the Multi Ring Buffer tool of Qgis to create donut buffers (i.e., non-cumulative buffers every 25 meters).

2. As the plantation layer is a vector, we need to transform the plantations layer to a raster format. The plantations layer has to be rasterized with a resolution of 5 meters x 5 meters for each cell to obtain maximum precision for the exposure variable. The process can be used with the Rasterization tool of Qgis, or with the Polygon to Raster tool of ArcGis.

3. Once the plantations are rasterized, we run the *Zonal Statistics* tool of Qgis (the ArcGis software did not work correctly, due to the high number of elements we had to process). This tool gives us the number of pixels of the plantations that are within each 25-meter buffer. When this process is completed, the resulting layer offers a new column that calculates the plantations'

surface within each buffer (the number of pixels are multiplied by 25 since they have an area of 5 x 5 meters on each plantations' raster cell). Finally, we transform the information at the subject level using the Pivot tool of ArcGis.

Figure C3 – Exposure analysis



ID	Street address
260444	Batallon YY y la Y
405444	Vacas Galindo entre YY y YY
179444	Sedalana entre la YY y YY
471444	Suburbio LA YY y la Y

ID	NEAR FID	NEAR DIST	mrb dist	AREA
213	1104	590,633166	1000	167175
214	1104	590,633166	1000	167175
214	1104	590,633166	1000	167175
215	1104	590,633166	1000	167175
216	1104	590,633166	1000	167175
216	1104	590,633166	1000	167175
216	1104	590,633166	1000	167175
219	1104	590,633166	1000	167175
219	1104	590,633166	1000	167175

ID	NEAR FID	NEAR DIST	D1000	D250	D500
30	4624	0	825850	141775	416475
62	4350	210,267279	737450	5300	69450
63	2247	0	586600	196275	490575
93	4624	0	825850	141775	416475
97	2247	0	586600	196275	490575
102	421	219,584551	412300	525	127675
103	2247	0	586600	196275	490575
151	2247	0	586600	196275	490575

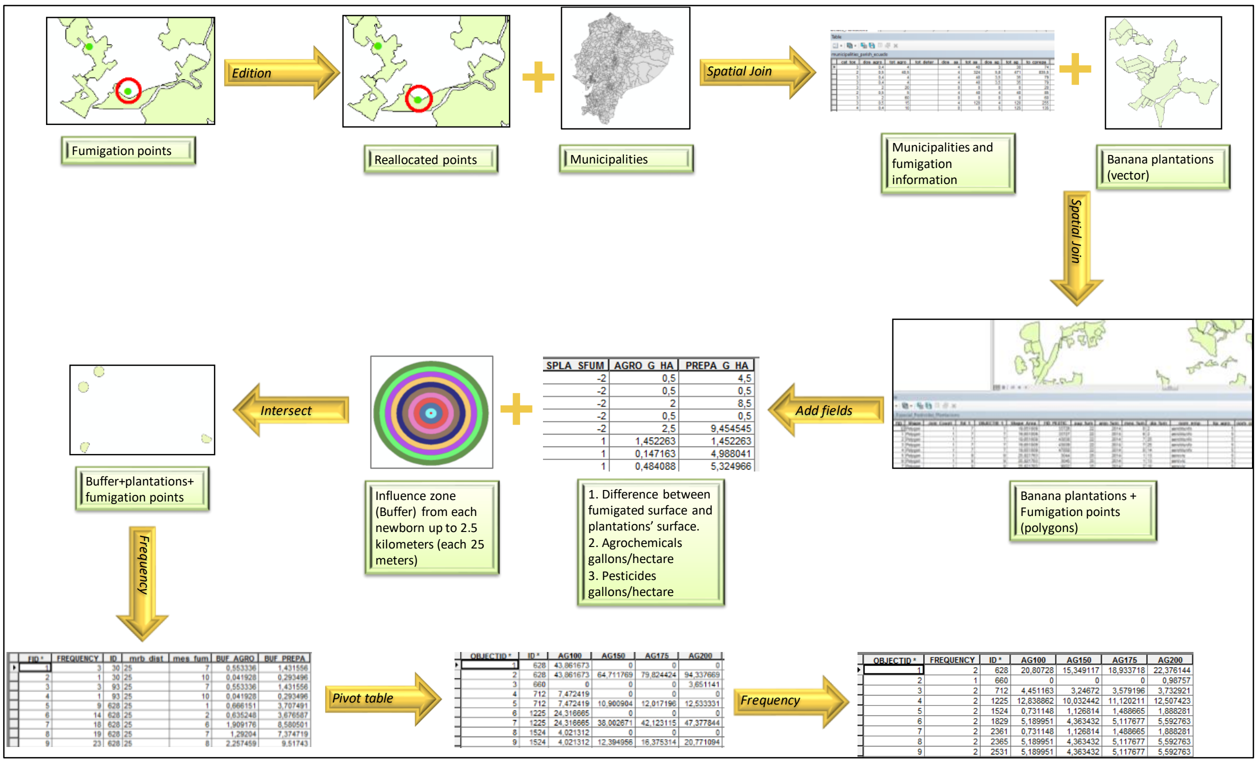
Exposure to fumigated banana plantations. We calculate the amount of pesticides affecting each mother during the gestation period. For this, we determine the pesticides applied in each of the 25-meter buffers calculated for each mother. Due to the absence of data for the period 2015-17, we use the data from the 2014 Register of Aerial Fumigations (General Directorate of Civil Aviation) and create monthly fumigation patterns for each municipality, which are then used for the period 2015-17. The construction of the exposure measure involves the following steps (Figures C4 and C5):

1. We consider the 2014 aerial fumigation points, as provided by the 2014 Register of Air Fumigations. First, we check that the fumigation points spatially coincide with the plantations, finding that 2,317 (3.1%) of the fumigation points do not coincide with the fumigated plantations. Most of the points are repositioned manually taking into account the proximity to a plantation and the coherence between the plantation surface and the fumigation surface. Even so, some fumigation points are ruled out, either because there are no plantations near the points or because the distance to the closest newborns is greater than 5,000 meters.

2. The fumigation points are intersected with the fumigated plantations (both aerial and manual fumigation). Due to capacity limitations, this process is performed with the *Intersection* tool of Qgis. The result is a layer that contains all the alphanumeric information of the plantations and the fumigations. We then use the *Spatial Join* tool of ArcGis to move the result of the intersection to the plantations, joining the elements that share the space. This results in a layer containing the information of the number gallons of pesticides per hectare. We repeat this process for the unmatched points mentioned in step 1, in which each fumigation point is intersected with the municipality. Next, we execute the *Frequency* tool to get the sum of pesticides per municipality. Similarly, we calculate the frequency of total plantation' surface within each municipality. Both outputs are combined by using the *Spatial Join* tool in ArcGis, which offers a table with the average number of gallons of pesticides per hectares per municipality.

3. We use the previous results to create a new intersection with the results of pesticides applications and the plantation buffers. As a result, we obtain a new layer with the pesticides applied in each plantation in each buffer. Specifically, we obtain three measures: (1) area of each plantation in each buffer (square meters); (2) volume of pesticides (agrochemicals) for each plantation in each buffer (we multiplying the area and the gallons per hectare of agrochemicals); (3) number of gallons with the mixed composition of pesticides for each plantation in each buffer (multiplying the area by the gallons per hectare of agrochemicals). We finally use the *Frequency* tool of ArcGis to obtain a table with the values of the newborn's ID, distance, and fumigation month, gallons of agrochemicals, and gallons of the mixed preparation.

Figure C4 – Exposure to fumigated plantations



SPLA SFUM	AGRO G HA	PREPA G HA
-2	0,5	4,5
-2	0,5	0,5
-2	2	8,5
-2	0,5	0,5
-2	2,5	9,454545
1	1,452263	1,452263
1	0,147163	4,988041
1	0,484088	5,324966

1. Difference between fumigated surface and plantations' surface.
2. Agrochemicals gallons/hectare
3. Pesticides gallons/hectare

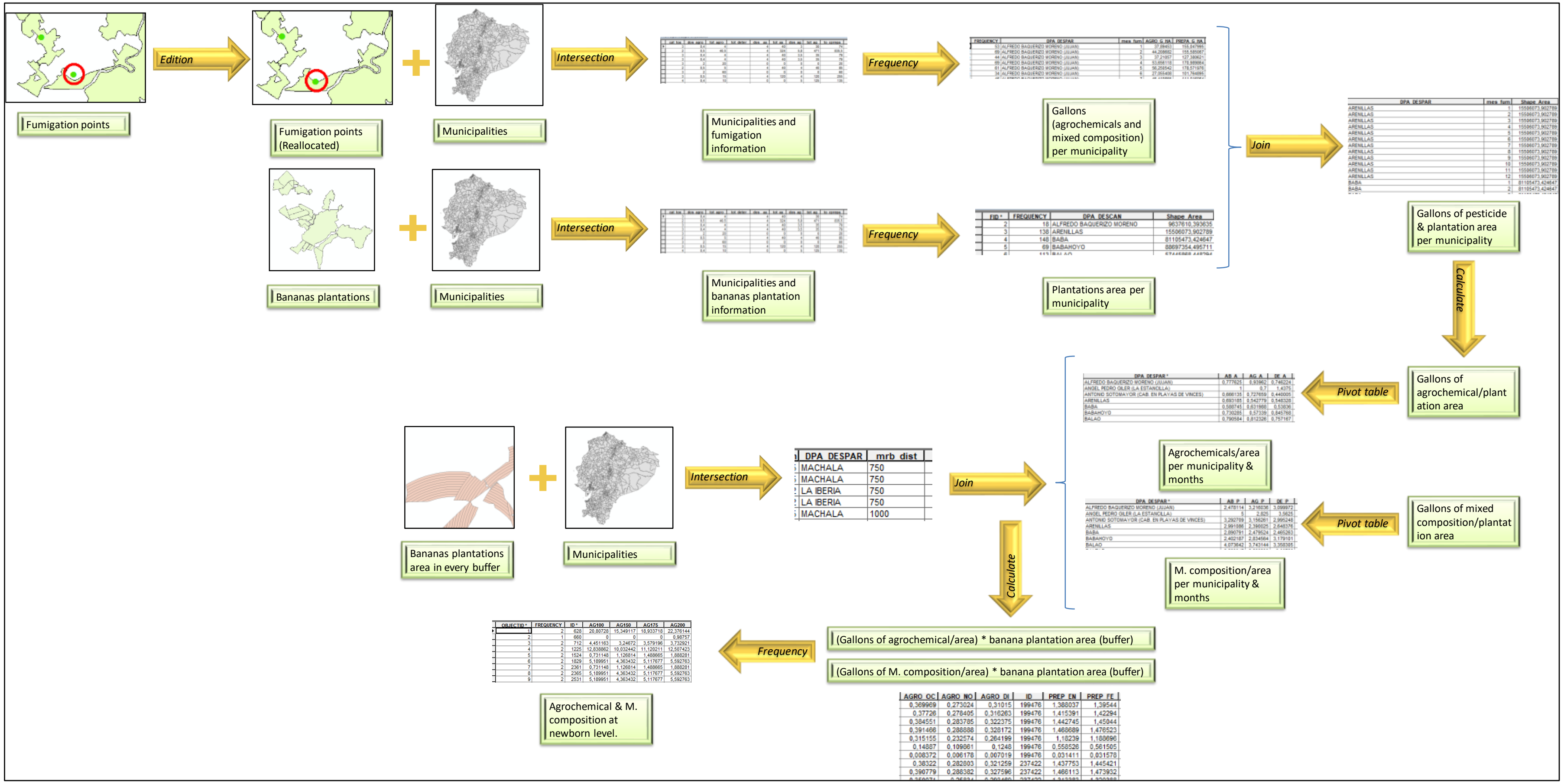
Influence zone (Buffer) from each newborn up to 2.5 kilometers (each 25 meters)

FID *	FREQUENCY	ID	mrb dist	mes fum	BUF AGRO	BUF PREPA
1	3	30	25	7	0,553336	1,431556
2	1	30	25	10	0,041928	0,293496
3	3	93	25	7	0,553336	1,431556
4	1	93	25	10	0,041928	0,293496
5	9	628	25	1	0,666151	3,707491
6	14	628	25	2	0,635248	3,676587
7	18	628	25	6	1,909176	8,580501
8	19	628	25	7	1,29204	7,374719
9	23	628	25	8	2,257459	9,51743

OBJECTID *	ID *	AG100	AG150	AG175	AG200
1	628	43,861673	0	0	0
2	628	43,861673	64,711769	79,824424	94,337669
3	660	0	0	0	3,651141
4	712	7,472419	0	0	0
5	712	7,472419	10,900904	12,017196	12,533331
6	1225	24,316665	0	0	0
7	1225	24,316665	38,002671	42,123115	47,377844
8	1524	4,021312	0	0	0
9	1524	4,021312	12,394956	16,375314	20,771094

OBJECTID *	FREQUENCY	ID *	AG100	AG150	AG175	AG200
1	2	628	20,80728	15,349117	18,933718	22,376144
2	1	660	0	0	0	0,98757
3	2	712	4,451163	3,24672	3,579196	3,732921
4	2	1225	12,838862	10,032442	11,120211	12,507423
5	2	1524	0,731148	1,126814	1,488665	1,888281
6	2	1829	5,189951	4,363432	5,117677	5,592763
7	2	2361	0,731148	1,126814	1,488665	1,888281
8	2	2365	5,189951	4,363432	5,117677	5,592763
9	2	2531	5,189951	4,363432	5,117677	5,592763

Figure C5 – Exposure to fumigated plantations



FID *	FREQUENCY	DPA_DESCAN	Shape_Area
2	18	ALFREDO BAQUERIZO MORENO	9637610,393635
3	138	ARENILLAS	15506073,902789
4	148	BABA	81105473,424647
5	69	BABAHOYO	88697354,495711

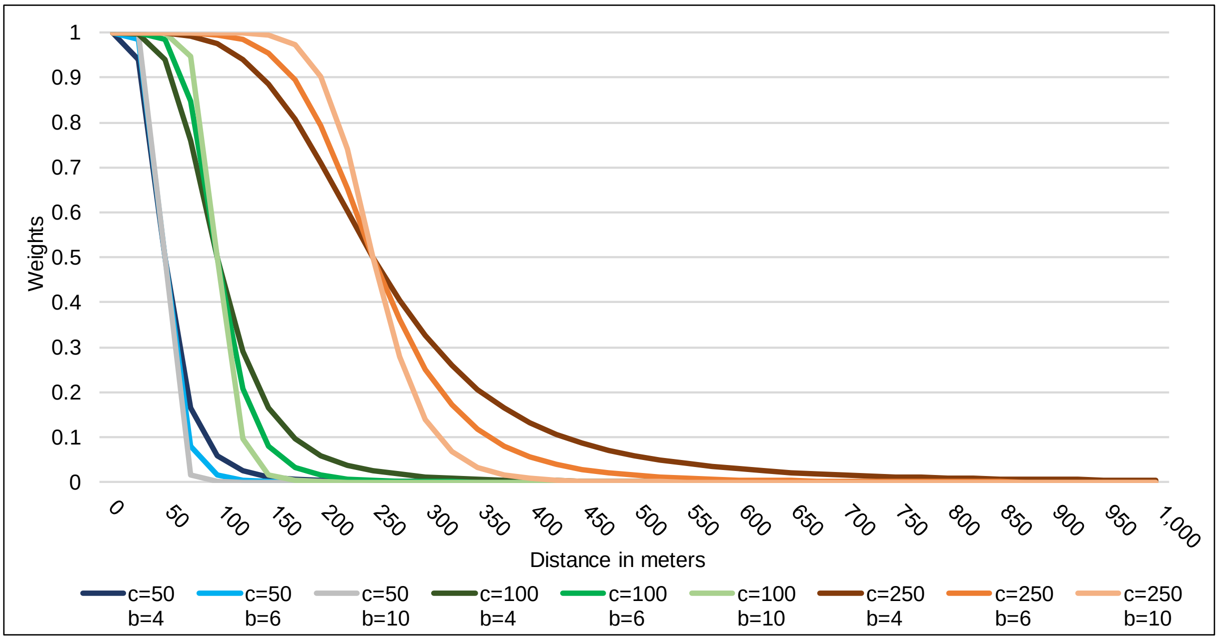
DPA_DESPAR	mes_fum	Shape_Area
ARENILLAS	1	15506073,902789
ARENILLAS	2	15506073,902789
ARENILLAS	3	15506073,902789
ARENILLAS	4	15506073,902789
ARENILLAS	5	15506073,902789
ARENILLAS	6	15506073,902789
ARENILLAS	7	15506073,902789
ARENILLAS	8	15506073,902789
ARENILLAS	9	15506073,902789
ARENILLAS	10	15506073,902789
ARENILLAS	11	15506073,902789
ARENILLAS	12	15506073,902789
BABA	1	81105473,424647
BABA	2	81105473,424647

DPA_DESPAR	mrb_dist
MACHALA	750
MACHALA	750
LA IBERIA	750
LA IBERIA	750
MACHALA	1000

OBJECTID *	FREQUENCY	ID *	AG100	AG150	AG175	AG200
1	2	628	20,80728	15,349117	18,933718	22,376144
2	1	660	0	0	0	0,98757
3	2	712	4,451163	3,24672	3,579196	3,732921
4	2	1225	12,838862	10,032442	11,120211	12,507423
5	2	1524	0,731148	1,126814	1,488665	1,888281
6	2	1829	5,189951	4,363432	5,117677	5,592763
7	2	2361	0,731148	1,126814	1,488665	1,888281
8	2	2365	5,189951	4,363432	5,117677	5,592763
9	2	2531	5,189951	4,363432	5,117677	5,592763

AGRO_OC	AGRO_NO	AGRO_DI	ID	PREP_EN	PREP_FE
0,369969	0,273024	0,31015	199476	1,388037	1,39544
0,37726	0,278405	0,316263	199476	1,415391	1,42294
0,384551	0,283785	0,322375	199476	1,442745	1,45044
0,391468	0,288888	0,328172	199476	1,468689	1,476523
0,315155	0,232574	0,264199	199476	1,18239	1,188696
0,14887	0,109861	0,1248	199476	0,558526	0,561505
0,008372	0,006178	0,007019	199476	0,031411	0,031578
0,38322	0,282803	0,321259	237422	1,437753	1,445421
0,390779	0,288382	0,327596	237422	1,466113	1,473932

Figure C6. Decaying weight function



Note: The graphic illustrates the weight function in expression (1) for different values of the parameters *b* and *c*. For simplicity, we restrict the exposition to the first kilometer.

Appendix D – Auxiliary summary statistics and results

Table D.1 – Maternal characteristics by exposure to banana plantations and to other crops: Guayas province

Variable	Banana (1)	Rice (2)	Diff (3) (2) - (1)	Corn (4)	Diff (5) (4) - (1)	Cocoa (6)	Diff (7) (6) - (1)
Birth weight	3181.37	3039.42	-141.953***	3135.03	-46.348***	3131.97	-49.400***
	(11.31)	(9.84)	(14.964)	(9.46)	(14.644)	(13.66)	(17.882)
Apgar score 1 minute	7.93	8.05	0.115***	8.01	0.075***	7.91	-0.022
	(0.02)	(0.02)	(0.032)	(0.02)	(0.029)	(0.03)	(0.035)
Mother’s age	24.22	25.16	0.935***	23.86	-0.357*	24.19	-0.031
	(0.14)	(0.12)	(0.185)	(0.13)	(0.189)	(0.17)	(0.224)
Male newborn	2.34	2.25	-0.092**	2.3	-0.046	2.22	-0.118**
	(0.03)	(0.02)	(0.039)	(0.03)	(0.043)	(0.04)	(0.050)
Female newborn	2.38	2.29	-0.086**	2.32	-0.058	2.24	-0.130***
	(0.03)	(0.02)	(0.040)	(0.03)	(0.043)	(0.04)	(0.050)
Mother’s education Less than HS	5.82	6.43	0.610***	4.79	-1.029***	5.74	-0.084
	(0.05)	(0.04)	(0.064)	(0.05)	(0.065)	(0.07)	(0.079)
Mother’s education HS or more	0.99	0.98	-0.004	0.99	0.003	0.99	0.004
	(0.00)	(0.00)	(0.004)	(0.00)	(0.003)	(0.00)	(0.004)
Local ethnic group “Montubio”	0.51	0.52	0.004	0.55	0.033**	0.53	0.019
	(0.01)	(0.01)	(0.014)	(0.01)	(0.014)	(0.01)	(0.017)
Mestizo	0.49	0.48	-0.004	0.45	-0.033**	0.47	-0.019
	(0.01)	(0.01)	(0.014)	(0.01)	(0.014)	(0.01)	(0.017)
Normal birth	0.48	0.44	-0.036***	0.49	0.016	0.46	-0.02
	(0.01)	(0.01)	(0.014)	(0.01)	(0.014)	(0.01)	(0.017)
C-Section birth	0.52	0.56	0.036***	0.51	-0.016	0.54	0.02
	(0.01)	(0.01)	(0.014)	(0.01)	(0.014)	(0.01)	(0.017)
Non marital union	0.01	0.06	0.052***	0.01	-0.001	0.02	0.009**
	(0.00)	(0.00)	(0.005)	(0.00)	(0.003)	(0.00)	(0.004)
Single	0.97	0.92	-0.050***	0.98	0.007	0.95	-0.019***
	(0.00)	(0.00)	(0.006)	(0.00)	(0.005)	(0.01)	(0.006)
Married	0.6	0.43	-0.168***	0.53	-0.075***	0.57	-0.034**
	(0.01)	(0.01)	(0.014)	(0.01)	(0.014)	(0.01)	(0.016)
Birth at a public hospital	0.4	0.57	0.168***	0.47	0.075***	0.43	0.034**
	(0.01)	(0.01)	(0.014)	(0.01)	(0.014)	(0.01)	(0.016)
Birth at a private hospital	0.37	0.31	-0.060***	0.3	-0.068***	0.36	-0.01
	(0.01)	(0.01)	(0.013)	(0.01)	(0.013)	(0.01)	(0.016)
Number of births	0.44	0.47	0.025*	0.51	0.065***	0.46	0.013
	(0.01)	(0.01)	(0.014)	(0.01)	(0.014)	(0.01)	(0.017)
Number of children	0.15	0.2	0.050***	0.15	0.001	0.15	0
	(0.01)	(0.01)	(0.010)	(0.01)	(0.010)	(0.01)	(0.012)
Prenatal control	0.92	0.81	-0.112***	0.89	-0.037***	0.84	-0.084***
	(0.01)	(0.01)	(0.009)	(0.01)	(0.008)	(0.01)	(0.010)
Single birth	0.08	0.19	0.112***	0.11	0.037***	0.16	0.084***
	(0.01)	(0.01)	(0.009)	(0.01)	(0.008)	(0.01)	(0.010)
Observations	2,319	2,968	5,287	2,598	4,917	1,475	3,794

Significance levels: * p<0.1 ** p<0.05 *** p<0.01. Standard errors in parentheses

Table D.2 – Maternal characteristics by exposure to banana plantations and to other crops: El Oro province

Variable	Banana (1)	Rice (2)	Diff (3) (2) - (1)	Cocoa (4)	Diff (5) (4) - (1)
Birth weight	3210.67	3231.58	20.907	3202.93	-7.741
	(26.69)	(160.56)	(119.116)	(28.98)	(39.538)
Apgar score 1 minute	8.24	7.95	-0.29	8.13	-0.105
	(0.06)	(0.14)	(0.236)	(0.07)	(0.087)
Mother's age	25.01	25.89	0.883	24.22	-0.787
	(0.36)	(1.42)	(1.576)	(0.39)	(0.534)
Male newborn	2.09	1.84	-0.243	2.1	0.018
	(0.07)	(0.23)	(0.285)	(0.08)	(0.101)
Female newborn	2.11	1.84	-0.272	2.14	0.022
	(0.07)	(0.23)	(0.294)	(0.08)	(0.104)
Mother's education Less than HS	6.65	7.47	0.826	6.11	-0.534***
	(0.12)	(0.60)	(0.536)	(0.13)	(0.178)
Mother's education HS or more	0.99	1	0.006	0.99	-0.001
	(0.00)	(0.00)	(0.018)	(0.01)	(0.007)
Local ethnic group "Montubio"	0.55	0.47	-0.078	0.53	-0.026
	(0.03)	(0.12)	(0.118)	(0.03)	(0.041)
Mestizo	0.45	0.53	0.078	0.47	0.026
	(0.03)	(0.12)	(0.118)	(0.03)	(0.041)
Normal birth	0.34	0.26	-0.08	0.39	0.05
	(0.03)	(0.10)	(0.112)	(0.03)	(0.039)
C-Section birth	0.66	0.74	0.08	0.61	-0.05
	(0.03)	(0.10)	(0.112)	(0.03)	(0.039)
Non marital union	0	0	-0.003	0	0.001
	(0.00)	(0.00)	(0.012)	(0.00)	(0.005)
Single	0.96	0.89	-0.061	0.97	0.011
	(0.01)	(0.07)	(0.050)	(0.01)	(0.016)
Married	0.45	0.32	-0.13	0.49	0.047
	(0.03)	(0.11)	(0.117)	(0.03)	(0.041)
Birth at a public hospital	0.55	0.68	0.13	0.51	-0.047
	(0.03)	(0.11)	(0.117)	(0.03)	(0.041)
Birth at a private hospital	0.45	0.32	-0.136	0.45	0.001
	(0.03)	(0.11)	(0.117)	(0.03)	(0.041)
Number of births	0.27	0.47	0.207*	0.36	0.090**
	(0.02)	(0.12)	(0.105)	(0.03)	(0.037)
Number of children	0.18	0.16	-0.027	0.16	-0.027
	(0.02)	(0.09)	(0.091)	(0.02)	(0.031)
Prenatal control	0.82	0.89	0.079	0.89	0.078***
	(0.02)	(0.07)	(0.091)	(0.02)	(0.029)
Single birth	0.18	0.11	-0.079	0.11	-0.078***
	(0.02)	(0.07)	(0.091)	(0.02)	(0.029)
Observations	341	19	360	272	613

Significance levels: * p<0.1 ** p<0.05 *** p<0.01. Standard errors in parentheses

Table D.3 – Maternal characteristics by exposure to banana plantations and to other crops: Los Rios province

Variable	Banana (1)	Rice (2)	Diff (3) (2) - (1)	Corn (4)	Diff (5) (4) - (1)	Cocoa (6)	Diff (7) (6) - (1)
Birth weight	3092.19	3095.35	3.155	3069.04	-23.147	3125.17	32.977*
	(12.66)	(19.35)	(22.840)	(13.61)	(18.571)	(12.11)	(17.519)
Apgar score 1 minute	7.8	7.7	-0.097**	7.78	-0.017	7.73	-0.070**
	(0.03)	(0.04)	(0.047)	(0.03)	(0.038)	(0.02)	(0.034)
Mother’s age	23.91	23.91	0.005	23.89	-0.02	24.1	0.189
	(0.17)	(0.24)	(0.296)	(0.17)	(0.240)	(0.16)	(0.230)
Male newborn	2.26	2.2	-0.058	2.14	-0.121**	2.25	-0.009
	(0.04)	(0.05)	(0.063)	(0.04)	(0.051)	(0.04)	(0.050)
Female newborn	2.29	2.22	-0.067	2.17	-0.124**	2.28	-0.007
	(0.04)	(0.05)	(0.064)	(0.04)	(0.052)	(0.04)	(0.052)
Mother’s education Less than HS	5.84	6.24	0.402***	6.05	0.206***	5.93	0.091
	(0.05)	(0.07)	(0.095)	(0.05)	(0.076)	(0.06)	(0.078)
Mother’s education HS or more	0.99	0.99	0.001	0.99	0.004	0.99	0
	(0.00)	(0.00)	(0.005)	(0.00)	(0.004)	(0.00)	(0.004)
Local ethnic group “Montubio”	0.53	0.51	-0.016	0.52	-0.01	0.5	-0.02
	(0.01)	(0.02)	(0.022)	(0.01)	(0.018)	(0.01)	(0.017)
Mestizo	0.47	0.49	0.016	0.48	0.01	0.5	0.02
	(0.01)	(0.02)	(0.022)	(0.01)	(0.018)	(0.01)	(0.017)
Normal birth	0.49	0.38	-0.106***	0.45	-0.037**	0.49	0.005
	(0.01)	(0.02)	(0.022)	(0.01)	(0.018)	(0.01)	(0.017)
C-Section birth	0.51	0.62	0.106***	0.55	0.037**	0.51	-0.005
	(0.01)	(0.02)	(0.022)	(0.01)	(0.018)	(0.01)	(0.017)
Non marital union	0.01	0.04	0.036***	0.03	0.026***	0.04	0.032***
	(0.00)	(0.01)	(0.006)	(0.00)	(0.005)	(0.00)	(0.005)
Single	0.97	0.95	-0.020**	0.95	-0.017**	0.94	-0.025***
	(0.00)	(0.01)	(0.009)	(0.01)	(0.007)	(0.01)	(0.007)
Married	0.51	0.43	-0.080***	0.5	-0.012	0.51	0.004
	(0.01)	(0.02)	(0.022)	(0.01)	(0.018)	(0.01)	(0.017)
Birth at a public hospital	0.49	0.57	0.080***	0.5	0.012	0.49	-0.004
	(0.01)	(0.02)	(0.022)	(0.01)	(0.018)	(0.01)	(0.017)
Birth at a private hospital	0.47	0.44	-0.031	0.48	0.015	0.43	-0.043**
	(0.01)	(0.02)	(0.022)	(0.01)	(0.018)	(0.01)	(0.017)
Number of births	0.39	0.42	0.039*	0.39	0.008	0.45	0.070***
	(0.01)	(0.02)	(0.022)	(0.01)	(0.018)	(0.01)	(0.017)
Number of children	0.11	0.11	-0.003	0.1	-0.012	0.09	-0.023**
	(0.01)	(0.01)	(0.014)	(0.01)	(0.011)	(0.01)	(0.010)
Prenatal control	0.77	0.82	0.046**	0.79	0.017	0.77	0
	(0.01)	(0.01)	(0.018)	(0.01)	(0.015)	(0.01)	(0.014)
Single birth	0.23	0.18	-0.046**	0.21	-0.017	0.23	0
	(0.01)	(0.01)	(0.018)	(0.01)	(0.015)	(0.01)	(0.014)
Observations	1,607	736	2,343	1,444	3,051	1,757	3,364

Significance levels: * p<0.1 ** p<0.05 *** p<0.01. Standard errors in parentheses

Table D.4 – Effects of pesticides exposure on newborn girls birth weight: whole sample and normal birth

	Girls – Buffer 2.5 Km				Girls – normal birth – Buffer 2.5 Km			
	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposure buffers	-0.0006*	-0.0011*	-0.0034*	-0.0061**	-0.0014**	-0.0023**	-0.0071**	-0.0129**
	(0.0004)	(0.0006)	(0.0017)	(0.0028)	(0.0007)	(0.0010)	(0.0030)	(0.0051)
Mother's Controls	X	X	X	X	X	X	X	X
Month x Year F.E.	X	X	X	X	X	X	X	X
Municipality F.E.	X	X	X	X	X	X	X	X
Observations	24,247	24,247	24,247	24,247	12,028	12,028	12,028	12,028
R2	0.1011	0.1011	0.1011	0.1011	0.1060	0.1061	0.1061	0.1062

Notes: Each coefficient corresponds to the result of a different estimation of equation (2), where the dependent variable is the newborns' birth weight. The left panel shows the results with the whole sample of newborn girls and the right panel with newborn girls that had a normal birth. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations. *Exposure Buffer* is a continuous variable that considers the sum of the 100 weighted buffers with the square meters of the plantations close the mothers' residences. The table shows results for different values of the parameters *b* and *c* for the weighting function in expression (1). The controls of child characteristics are indicators of single birth. The controls of the maternal characteristics are mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), ethnic group (mestizo, montubio, white, afroecuadorians, indigenous, other), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births, and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the municipality level and are shown in parentheses. The clusters number is 128 in the left panel, and 112 in the right panel, excluding singleton observations. The reported R–squared is the same for all the coefficients in each column. Significance levels: * p < 0.1, ** p < 0.05, *** p < 0.01.

Table D.5 – Effects of pesticides exposure on newborn boys birth weight: whole sample and normal birth

	Boys – Buffer 2.5 Km				Boys – normal birth – Buffer 2.5 Km			
	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposure buffers	-0.0005	-0.0009	-0.0027	-0.0045	-0.0011**	-0.0018**	-0.0055**	-0.0099**
	(0.0004)	(0.0007)	(0.0021)	(0.0035)	(0.0005)	(0.0008)	(0.0024)	(0.0040)
Mother's Controls	X	X	X	X	X	X	X	X
Month x Year F.E.	X	X	X	X	X	X	X	X
Municipality F.E.	X	X	X	X	X	X	X	X
Observations	25,777	25,777	25,777	25,777	12,449	12,449	12,449	12,449
R2	0.0836	0.0836	0.0836	0.0836	0.0928	0.0929	0.0929	0.0929

Notes: Each coefficient corresponds to the result of a different estimation of equation (2), where the dependent variable is the newborns' birth weight. The left panel shows the results with the whole sample of newborn boys and the right panel with the newborn boys that had a normal birth. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations. *Exposure Buffer* is a continuous variable that considers the sum of the 100 weighted buffers with the square meters of the plantations close the mothers' residences. The table shows results for different values of the parameters *b* and *c* for the weighting function in expression (1). The controls of child characteristics are indicators of single birth. The controls of the maternal characteristics are mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), ethnic group (mestizo, montubio, white, afroecuadorians, indigenous, other), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births, and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the municipality level and are shown in parentheses. The clusters number is 127 in the left panel, and 116 in the right panel, excluding singleton observations. The reported R–squared is the same for all the coefficients in each column. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table D.6 – Effects of pesticides exposure on newborns' birth weight: mothers' education level

	Less educated mothers – Buffer 2.5 Km				More educated mothers – Buffer 2.5 Km			
	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposure buffers	-0.0012**	-0.0019***	-0.0060***	-0.0106***	0.0001	0.0001	0.0004	0.0009
	(0.0005)	(0.0007)	(0.0022)	(0.0037)	(0.0004)	(0.0006)	(0.0017)	(0.0027)
Mother's Controls	X	X	X	X	X	X	X	X
Month x Year F.E.	X	X	X	X	X	X	X	X
Municipality F.E.	X	X	X	X	X	X	X	X
Observations	19,403	19,403	19,403	19,403	30,619	30,619	30,619	30,619
R2	0.1071	0.1071	0.1071	0.1071	0.1000	0.1000	0.1000	0.1000

Notes: Each coefficient corresponds to the result of a different estimation of equation (2), where the dependent variable is the newborns' birth weight. The left panel shows the results with newborns from less educated mothers and the right panel with more educated mothers. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations. *Exposure Buffer* is a continuous variable that considers the sum of the 100 weighted buffers with the square meters of the plantations close the mothers' residences. The table shows results for different values of the parameters *b* and *c* for the weighting function in expression (1). The controls of child characteristics are indicators of single birth and sex. The controls of the maternal characteristics are mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), ethnic group (mestizo, montubio, white, afroecuadorians, indigenous, other), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births, and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the municipality level and are shown in parentheses. The clusters number is 121 in the left panel, and 131 in the right panel, excluding singleton observations.. The reported R–squared is the same for all the coefficients in each column. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table D.7 – Effects of pesticides exposure on newborn girl birth weight: mothers' education level

	Girls - Less educated mothers – Buffer 2.5 Km				Boys - Less educated mothers – Buffer 2.5 Km			
	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15	c=100, b=4	c=100, b=15	c=50, b=4	c=50, b=15
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposure buffers	-0.002***	-0.003***	-0.0090***	-0.0150***	-0.0005	-0.0011	-0.0032	-0.0066
	(0.0006)	(0.0010)	(0.0028)	(0.0047)	(0.0008)	(0.0012)	(0.0037)	(0.0062)
Mother's Controls	X	X	X	X	X	X	X	X
Month x Year F.E.	X	X	X	X	X	X	X	X
Municipality F.E.	X	X	X	X	X	X	X	X
Observations	9,411	9,411	9,411	9,411	9,986	9,986	9,986	9,986
R2	0.1180	0.1179	0.1180	0.1180	0.0929	0.0930	0.0930	0.0930

Notes: Each coefficient corresponds to the result of a different estimation of equation (2), where the dependent variable is the newborn girls birth weight. The left panel shows the results for newborn girls from less educated mothers and the right panel from more educated mothers. The sample is limited to births by mothers living up to 2.5 kilometers from the plantations. *Exposure Buffer* is a continuous variable that considers the sum of the 100 weighted buffers with the square meters of the plantations close the mothers' residences. The table shows results for different values of the parameters *b* and *c* for the weighting function in expression (1). The controls of child characteristics are indicators of single birth. The controls of the maternal characteristics are mother's age, maternal education dummy (less than high school and no diploma, equal to or higher than high school), a dummy indicator of marital status (divorced, separated, widowed, married, single, civil union), ethnic group (mestizo, montubio, white, afroecuadorians, indigenous, other), dummy indicator of place of birth (public or private hospital), indicator of total number of children, indicator of total births, and indicator of type of birth (c-section or normal delivery). Standard errors are clustered at the municipality level and are shown in parentheses. The clusters number is 116 in the left panel, and 115 in the right panel, excluding singleton observations. The reported R–squared is the same for all the coefficients in each column. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.