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Environmental Risk Factors Associated with Intestinal Parasitic Infections and Respiratory Symptoms in Pregnant Women Residing in Low Income Neighborhoods in Bogotá, Colombia

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ABSTRACT

Background: Colombia is a country with high socioeconomic inequality, where women living in low-income vulnerable areas are exposed to environments that may negatively affect their health. The aim of this study was to identify the sociodemographic and environmental conditions associated with intestinal parasitic infections (IPI) and respiratory symptoms (RS), both health problems of unknown prevalence, in pregnant women residing in neighborhoods with low socioeconomic conditions in three districts of Bogotá.

Methods: A cross-sectional community-based study was done. For IPI prevalence, stool analyses by direct, concentration and qPCR techniques were made. For RS prevalence, questions from the European Community Respiratory Health Survey were applied. Based on a questionnaire and home visit, environmental and socioeconomic factors, as well as health, living and hygiene conditions were identified. As exposure variables for RS, we used residential proximity to greenness, and air pollution, indirectly determined by distance to closest streets and to a waste disposal site.

Results: Of 750 pregnant women invited to participate, 550 accepted and answered the questionnaire. For the IPI study, 331 participants were included since they gave at least one stool sample. The prevalence of any parasite was 41%, highest for *Blastocystis hominis* with 25%. Prevalence of pathogenic parasites and polyparasitism were 1.2% and 9%, respectively. Women who had never dewormed had a significantly higher prevalence of any parasite. Women from minority groups and those not having handwashing facilities in their homes had a higher not significant prevalence of polyparasitism. In 310 participants from Ciudad Bolivar, who provided their home address, the prevalence of physician-diagnosed asthma and rhinitis were 4.5% and 21%, respectively. We identified a significantly higher prevalence of rhinitis in areas with low access to greenness, and increased odds for rhinitis and asthma when participants lived further away from main streets.

Conclusions: In pregnant women living in vulnerable conditions, this study revealed a low prevalence of pathogenic intestinal parasites, and a lower prevalence of asthma and rhinitis, when compared with the general population in Bogota. Associated factors identified support generation of hypothesis for future mixed methods studies with active participation of local and community leaders. This research will require adequate sample size and total probabilistic selection to better establish associations affecting the health of women living in vulnerable conditions.

KEYWORDS: Pregnant women; Intestinal parasitic infections; Asthma; Rhinitis; Sociodemographic characteristics; Housing Conditions; Vulnerable populations; Green Spaces; Air Pollution; NDVI.

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1. INTRODUCTION

Social and environmental inequity (1) are determinant factors in the health of many communities in Colombia (2, 3). Colombia is an upper middle income country with high inequalities, with a Gini coefficient of 0.539 (4), where a Gini 0 means perfect equality and 1 means total inequality (5). As such, Colombia ranks 14th among 134 countries in which this coefficient has been estimated (3) and is socioeconomically the most unequal country in Latin America (6). This fact is shown by income being concentrated in a few and 20% of the population having at least one unsatisfied basic need (UBN) (7). Disparities occur in rural and urban settings (8) and are very noticeable in marginalized urban populations (9). Poverty (10), environmental pollution (2), food insecurity (11, 12), inadequate housing (13), and violence (6, 14) are, among others, inequitable dominant factors in many neighborhoods.

Bogotá is the most developed urban center in Colombia. However, 9% of its inhabitants (700,000 people approximately) have at least one UBN, represented by overcrowding, financial dependency, poor housing conditions, lack of sanitary services and out-of-school children (7). This city also has the highest population that has been forcefully displaced by conflicts from other regions of the country, affecting more than 300,000 inhabitants, most of them women arriving in the city as single mothers and without financial support (15). Regarding air pollution, inhabitants in Bogotá are exposed to high concentrations of PM_{10}, $PM_{2.5}$, O_3, and NO_2 (16). These urban living conditions expose inhabitants to risk factors that may increase the incidence of infectious and respiratory disorders, among others (2, 17, 18). Furthermore, climate change may be increasing urban vulnerability to diseases (19).

Social inequity affects health and is more noticeable in women, particularly those living in large urban centers (20) and during pregnancy (21, 22). Pregnant women living in vulnerable conditions or adverse urban settings can also be exposed to environmental factors that negatively affect not only their own health but also their offspring's health in the short and long term (23). Added to this, the relative physiological immunosuppression during pregnancy increases the susceptibility of pregnant women to environmental hazards that may favor various infectious diseases and allergic conditions, among others (24, 25). Pregnant women are prone to intestinal parasitic infections (IPI) (26-29). Also, during pregnancy, up to 10% of women worldwide may have asthma (30-32). Parasitic and respiratory disorders may affect the offspring's health. Maternal IPI can potentially cause lower birth weight (33) and may increase the risk of childhood soil-transmitted helminths (STH) (34), while maternal respiratory disorders could increase the risk of preterm birth, Low Birth Weight (LBW), and neonatal hospitalization, among others (32). This thesis focused on two health problems, intestinal parasitic infections (IPI) and respiratory symptoms (RS), in which the prevalence and environmental risk factors were unknown in pregnant women living in vulnerable neighborhoods in three districts of Bogotá. As both topics were addressed in the same study, they are described in parallel throughout this document.

1.1. The Physical Environment

In the districts of Ciudad Bolívar and Usaquén, the urban neighborhoods of strata 1 and 2 were developed on a mountainous topography containing brick factories and quarries, which attracted human settlements built on eroded and unstable terrain (35, 36). In the district of Kennedy, strata 1 and 2 neighborhoods are located around the Bogotá River, the most polluted in Colombia, and near the wetlands, with a high risk of flooding (37). In these three districts, housing belonging to strata 1 and 2 is predominantly self-built (38-40), which means that these houses have been built step by step, regardless of its quality and where overcrowding is common. It is usual that, as financial conditions allow, additional levels are built to rent and increase household income. Under these conditions, it is common for many families to share the kitchen, the sanitary facilities, and the living spaces (41). Therefore, the houses are a conglomeration of families who share financial limitations, each of which rents one or two rooms (42).

Regarding urban development, these neighborhoods have spread without order, and district planning only begins after the inhabitants have already built houses, walkways, and roads; therefore, vehicular access to properties is limited (43). In the mountainous areas of Usaquén and Ciudad Bolívar, houses are reached mainly through pedestrian staircases (44, 45). In Kennedy, with more access roads, homes in strata 1 and 2 are often accessed through unpaved streets that can be flooded and have potholes (39, 46). Due to these accessibility issues, surveillance and effective police response in vulnerable neighborhoods are restricted, since criminal activities cannot be permanently and easily monitored or controlled (44, 47, 48). Moreover, some abandoned places become garbage dumps or unsafe fields where drug dealing and criminal activities may occur. In the three districts, difficult-to-access houses can also be places where such illegal activities happen, becoming urban environments with an unsafe and violent social context (44, 47-49).

1.2. The Socio-Economic Environment

In addition to the physical environment mentioned above, people in these districts, often live with financial constraints that limit their basic needs, including food, housing, education, safety, and employment (44, 49, 50). The monthly income in 4%, 32% and 19% of households in Ciudad Bolívar, Kennedy, and Usaquén respectively, ranges between one and two minimum salaries (USD 260-522 per month) (51-53). Their nutrition is often rich in carbohydrates that are cheaper and generate satiety (50). Access to education is usually achieved through public schools. In this challenging environment, it is considered a real success if someone completes high school education and there are significant limitations to access to higher education programs (54). Furthermore, in these neighborhoods there are people who have been victims of forced displacement from other regions of Colombia, arriving in the city, with limited financial resources, to the homes of family or friends, and thus increasing overcrowding (55).

1.3. Pregnancy in Neighborhoods participating in the Study

Teen pregnancy is common (44, 49, 50), where young women give birth to babies in the same conditions of vulnerability. Although birth rates have declined the conditions in which pregnancies occur are not ideal in terms of food, physical and environmental security (50). Financial constraints limit the availability not only of proper and balanced nutrition but also of adequate and safe housing (50). Access to health services, although mandatory for prenatal care, is limited by the barriers inherent to the Colombian healthcare system (56).

Furthermore, pregnant women living in these socioeconomic conditions may be exposed to unsafe and violent neighborhoods (57). Some others were also forcefully displaced (55). Overall, pregnant women residing in vulnerable neighborhoods face daily uncertainty about their future and the wellbeing of their offspring. All these factors may generate stress, which combined with the physiologic immunosuppression of pregnancy (25) could increase their susceptibility to disorders that may affect them and their offspring.

1.4. Intestinal parasitic infections

1.4.1. Epidemiology of intestinal parasitic infections

IPI are particularly common in low- and middle-income countries. Some factors that contribute to this phenomenon are the location of many of these countries in tropical areas, where these parasites are endemic, the lack or low quality of sanitation services, deficient hygiene practices, and the low socioeconomic conditions that act as barriers to access health services (27, 58, 59). People living under the poverty line, especially young women, pregnant women, their infants and children in developing countries are at a high risk of entering a cycle of malnutrition–parasite infections: Inadequate nutrition is a condition that favors the development of IPI that increases nutritional problems and generates adverse health consequences (60, 61).

The most common intestinal parasites detected in human beings comprise soil-transmitted helminths (STH) and protozoa, including:

- Nematodes, such as *A. lumbricoides*, *T. trichiura*, *S. stercolaris*, *A. duodenale*, and *N. americanus*. Eggs present in contaminated soil transmit these parasites by human feces, in places where sanitation is inadequate or insufficient (62).
- Trematodes, such as *Schistosoma* and *Fasciola* species. These are transmitted through contact with polluted water (63, 64).
- Cestodes, such as *T. saginata*, *T. solium*, and *H. nana*. Their way of transmission to humans is complex, as these generally require several hosts (65, 66).
- Pathogenic protozoa, such as the amoeba *E. histolytica* and the flagellate *G. intestinalis*. These are transmitted from person to person by fecal contamination of food or hands (67, 68).
- Protozoa whose pathogenicity is still in dispute, such as *B. hominis*, *E. coli*, *E. nana*, and *I. buetschlii*. These can be transmitted to human beings as a cyst by the fecal-oral route (69, 70).

Among intestinal parasites, the World Health Organization (WHO) considers STH as the most common infections in vulnerable populations. The nematodes, *A. lumbricoides* and *T. trichiura* are the most prevalent helminthiasis (34). STH are considered Neglected Tropical Diseases (NTD) (71), a group of diseases prevalent in exposed, impoverished and vulnerable populations (72). The precise world distribution of STH and the number of people infected have not yet been established, as the quality of epidemiological data in different regions is difficult to ascertain (73).

In Latin American and Caribbean countries, a review done by the Pan American Health Organization (PAHO) in 2009 showed that only 8 out of 35 countries carry out parasitological surveys nationwide, with 18 countries reporting STH prevalence ranges as low as 0.01-16.3% in Mexico and up to 12.2-97% in Honduras (74), and the prevalence for Colombia reported to be between 11% and 50% (74). For children, STH prevalence in Latin American countries ranged between 20% and 50% (74). The most prevalent helminth was *A. lumbricoides* with 34% (Table 1.1). Among IPI, most common protozoa include *G. lamblia*, *E. histolytica* and *B. hominis* (27, 75), with varying reported prevalence (Table 1.2). *G. lamblia*, and *E. histolytica*, although globally distributed, are more prevalent in tropical and subtropical areas. In North America, *Giardia* is the most prevalent intestinal parasite in humans (76). The global prevalence of *B. hominis* varies widely (77), and its pathogenicity is still debated (69, 78).

Table 1.1 Prevalence data and health effects of Soil-Transmitted Helminths (STH)

Parasite Specific Name	Prevalence (%)				Effects
	World	Latin America	Colombia	Bogotá	
A. lumbricoides (Roundworm)	17.7 (79)	0.0-97 (74, 79)	33.6 (80)	1-9.5 (81, 82)	Diminished food intake and weight loss (60). In some cases, deficient absorption of fat, protein, vitamin A and lactose. Immune responses such as elevated IgE levels, eosinophilia, and increased production of Th2 cytokines. Influence of *A. lumbricoides* infection on the process of IgE sensitization to common allergens has been found, mainly due to house dust mites (17). Possible complications are related to hepatic, biliary and intestinal obstruction and pancreatitis (61).
N. americanus and *A. duodenale* (Hookworms)	11.5 (79)	0.0-97 (74, 79)	23 (80)	Not Reported	Damage of the intestinal mucosa and bleeding, loss of iron and anemia. Diminished food intake and weight loss (71). Slight to severe infections can cause maternal anemia and LBW (71).
T. trichiura (Whipworm)	10.7 (79)	0.0-97 (74, 79)	37.5 (80)	1-1.5 (81, 82)	Continuous decrease in food intake (71).

Table 1.2 Prevalence data and health effects of Protozoa

Parasite Specific Name	Prevalence (%)				Effects
	World	Latin America	Colombia	Bogotá	
G. lamblia	2-3 (industrialized world) (83) 20-30 (developing countries) (83)	8-67 (58, 75, 84, 85)	13-17 (76, 86, 87)	12.1-20[1] (81, 82, 88)	Significant gastrointestinal diseases and malnutrition (89). Deficient absorption of vitamin A, fat, protein and lactose (83).
E. histolytica	12 (90)	4.1 (91)	0.6-54 (87, 92, 93)	0-8[1] (81, 82, 88)	Causes 40,000-100,000 deaths annually (78, 94). Close to 12% of the world population is infected and approximately 10% of them present symptoms, most of them related to diarrhea (90).
B. hominis	0.3-54 (77)	22-67 (58, 75, 86)	6.1-36.4 (76, 86, 87)	2.8-10[1] (82, 88)	Its pathogenicity is still in dispute (95, 96). Risk factor for iron deficiency anemia during pregnancy (97).

[1] Reference 65: N=105 children, 70 with diarrhea and 35 healthy children

1.4.2. Worldwide environmental and socioeconomic conditions of IPI

Intestinal Parasitic Infections (IPI) develop when living conditions of human populations favor the life cycles of STH and protozoa (98) and may affect all population groups independent of geography and socioeconomic conditions. In low- and middle-income tropical countries, IPI are a public health problem, with a higher incidence among those living in poverty (27, 75), where poor sanitary conditions and low education levels limit good hygiene practices needed for prevention of fecal-oral, water or food contamination (99). Pregnant women share the same risk factors for IPI as the general population. However, parity has been identified as a specific risk factor, as having more children increases the risk of acquiring intestinal parasites (100).

Studies relating high altitude and parasites have been performed in Bolivia, a country with a high prevalence of STH and where geographical differences can allow comparative analysis according to altitude above sea level. In 2001, Flores *et al.* (101) published the first study on children STH prevalence at altitudes above 3,800 meters in the Bolivian *altiplano*. These authors found STH prevalence of 18% in school children and 24% in children living in the community, with *A. lumbricoides* 1-28% and *T. trichiura* 0-24%. More recently, a nationwide study by Chammartin *et al.* (102) mapped the geographical distribution of *A. lumbricoides*, *T. trichiura* and hookworms in Bolivian schoolchildren, and included altitude as an environmental variable, among others. Using geostatistical variable selection to identify important environmental predictors, these authors found that high-altitude had a protective effect against *T. trichiura* infection (OR 0.33-0.37), perhaps caused by the unsuitability of high-altitude conditions for parasite development and transmission.

Parasitism is linked with climate, as environmental conditions influence parasite life cycles and environmental thresholds limit parasite reproduction, survival and transmission. Overall, the prevalence of IPI may be determined by geographic and weather conditions including rainfall, humidity, temperature and vegetation that together may create permissive or deleterious environments for parasites, their eggs and larvae. For instance, high temperatures increase egg development of hookworms, *A. lumbricoides* and *T. trichiura*, with decreased egg viability when temperatures are too high. Decreased relative humidity, which occurs at high altitudes in South America, can affect larval survival in the soil (103). More recently, Chammartin *et al.* (104) performed a geostatistical meta-analysis based on STH prevalence reports from 13 South American countries and concluded that, overall, high altitude lowered *T. trichiura* infection risk, and that risks of STH infection have decreased in the last 15 years likely due to nationwide control programs and improved socioeconomic status.

1.4.2.1. Basic sanitary conditions

Among basic sanitary conditions reported to be associated with IPI, lack of drinking water or unsafe water supply favor water and food contamination by infesting parasitic forms (58, 59). A recent systematic review reported that Water, Sanitation and Hygiene (WASH) access and practices significantly reduced the risk of STH infections, specifically associated with the use of treated water (105). A National Health and Nutrition Examination Survey (NHANES) study found that seropositivity for *Cryptosporidium* was significantly increased in low-income households and in the absence of household water treatment (106). In populations that do not have basic services or adequate housing conditions, the prevalence of intestinal parasites is up to 96% (78, 94).

As a consequence of lack of access to improved sanitation, it is estimated that in Latin America, out of 163 million children (90), close to 34 million (21%) are at risk of developing STH infections (58). Romina Rivero *et al*. (107) found that Argentinian children living in houses with UBN had a higher risk of having intestinal parasitism and that deficient household WASH predicted parasitic infections. Using real-time PCR, Campbell *et al*. (108) found that the risk of developing an intestinal infection by *N. americanus* decreased when piped water supply was shared, and increased when the main water supply was surface water. Unsafe water conditions favoring IPI may include the extra-domiciliary collection of water supply, carrying water from its source to home or inadequate wastewater and solid waste disposal (75, 109-111).

1.4.2.2. Level of Education

In studies with pediatric populations, it has been established that the level of education of mothers is a factor in IPI development, with evidence showing that a higher level of education is a protective factor (110, 112-114). In Colombia, it has been reported that when mothers had less than 5 years of school education, there was a significant increase in intestinal polyparasitism in children under 2 years of age. A higher level of education presupposes better hygiene practices and may also be related to higher income and purchasing power that ensure better living and sanitary conditions. In pregnant women, the evidence is not conclusive, with some research studies showing associations between level of education and IPI incidence, but without confirmation by others.

1.4.2.3. Occupation

Studies show that farmers may show higher IPI prevalence, mainly STH, as their work may involve contact with untreated wastewater (115) and soil, in combination with poor sanitary conditions. In farms, these may include poor water treatment, infrequent hand washing, and unsafe stool disposal.

1.4.2.4. Forced Displacement

Mobilization of populations for economic, social or political reasons can create humanitarian emergencies that increase the risk of communicable diseases (116). High IPI prevalence has been identified in individuals who have been forcefully displaced or have migrated into urban areas (117). Both create socioeconomic vulnerability and expose them to substandard living conditions including overcrowding and living in poor infrastructure housing. Besides, food safety may be compromised due to lack of refrigeration and/or an increased risk of fecal-oral contamination (118).

1.4.2.5. Deworming

Massive deworming against STH in high-risk regions with vulnerable populations is a strategy that the WHO has identified to control IPI. However, although prophylactic deworming programs in children and women of reproductive age have been recommended (119), their effectiveness in health outcomes is unclear (120, 121). Also, their effects are short term because quick reinfection may occur as long as critical factors, such as basic sanitation, are not corrected (105). Colombia has parasite therapy prevention programs focused on sizeable primary school populations (122) and pregnant women living in endemic zones for hookworms (123).

1.4.2.6. Housing characteristics

Living conditions may favor the development of IPI, by promoting habitats supportive of parasite life cycles. These may include having dirt floors, poor wastewater management or using untreated water. Secondly, they can facilitate fecal-oral contamination through household overcrowding

(124), shared use of bathrooms by different families within the same house (125), barefoot walking (113) inadequate pre- and post-prandial handwashing with soap (29, 105), poor food handling (111), lack of boiling drinking water (110), unsatisfactory pet care (86), outdoor defecation, and poor home hygiene particularly in bathrooms and kitchens (111).

1.4.3. Colombian environmental and socioeconomic conditions of IPI

Colombia is located in the northwestern tropical region of South America, between the Pacific and Atlantic oceans, with an Andean mountainous topography that offers a wide altitude-based climatic range (126). Nearly 20% of the Colombian population of 47 million cannot afford one or more of their basic needs to live (7), with living conditions characterized by inadequate housing, poor or unsafe water supply, substandard sanitation, household overcrowding, unemployment and inaccessible education for their children (127). This country officially has two ways to calculate poverty, namely, household income and the Multidimensional Poverty Index (MPI) (128).

The poverty line is the minimum cost per capita to acquire a basic food basket that grants an average life standard in a specific country. In Colombia, the value is estimated to be half of the basic salary. In 2012 the per capita minimum income was USD 107 monthly. According to this, if a four-member house had an income lower than USD 428, it was classified under the poverty level (129). The extreme poverty line is the per capita minimum cost to acquire only the basic food basket that provides survival. Colombia’s extreme poverty level is USD 45 monthly. Thus, if the income of a four-member house is lower than USD 180, it is classified as extremely poor. In 2012 Colombia had, according to income classification, 32.7% of its population under the poverty level and 10.4% under the extreme poverty line. The GINI index, which estimates inequality on income distribution, was 0.539 (129).

The MPI measures the health conditions and the educational level of the household members, living conditions of childhood and youth, and access to public services. It calculates poverty using five factors and provides value from 0 to 100, where 0 corresponds to a household with no deprivations, and 100 corresponds to a household with all UBN. The households over 33 are considered poor (129). According to MPI, 27% of the Colombian population in 2012 was poor. Colombia has a social and economic stratification based on residence and neighborhood conditions. The strata range is from 1 (worst conditions) to 6 (best conditions). This system is used to apply differential rates in public services and taxes. People with higher income capacity (strata

5 and 6) pay more, while people with lower income capacity (strata 1, 2 and 3) get benefits. Stratum 4 is charged the real fare fixed by companies that are in charge of public services. Stratification is an approximate index of the living standard, inequality, and poverty. It is also used as a spatial index of population and areas. Geographically, strata are regions in which people share social and economic characteristics (130). Income level, percentage of UBN, and coverage of public services also have a close relation with socioeconomic stratification (Table 1.3).

Table 1.3 Household characteristics according to Colombian classification of socioeconomic strata

Stratum	% Poor homes according to income level (131)	% Poor homes according to UBN[1] (131)	% Water Supply Coverage (132)	% Sewage system coverage (132)	% Garbage collection coverage (132)
1. Very-Low	67.8	33.3	75.7	41.9	45.4
2. Low	51.8	11.9	91.9	75.9	79.0
3.Mid-Low	26.8	4.4	98.5	96.7	97.5
4. Mid	4.8	0.8	97.8	96.3	96.9
5.Mid-High	4.3	0.8	98.9	97.5	99.4
6. High	7.1	0.2	99.3	97.2	97.8

[1]UBN: Unsatisfied Basic Needs

The geo-economic features in Colombia lead to environmental conditions that favor the development of IPI. The prevalence of parasite infections among Colombian children is estimated to range between 0.6% and 89.7% (17, 76, 86, 133). This wide range is due to studies conducted in different populations of different regions of the country with a variety of environmental conditions that make the IPI prevalence change according to the region. Studies in Bogotá and other Colombian regions performed mostly with pediatric populations, have demonstrated that there are regional environmental variations in IPI prevalence. For instance, in tropical sea level locations, IPI by any parasite, geohelminthic IPI and polyparasitism are more prevalent (134). However, helminthic IPI have also been reported in Bogotá (82) and Tunja (133), both Colombian cities with similar climate and high altitude of 2,600-2,800 MASL. Intestinal parasites and nutritional micronutrient deficiencies are considered important causes of school absenteeism and dropouts that negatively affect children’s learning abilities (135).

Bogotá is the political capital and biggest city of Colombia. It is located at 2,630 meters above sea level and has an average temperature of 14°C (136). The city's population was 7,674,366 according to the projection for 2013 from the National Bureau of Statistics (DANE for its Spanish acronym) (137). Bogotá is divided into 20 districts that are political units with different features and resources. Health services are provided by public and private institutions. The public health system in each district is divided into different levels of attention, including Primary Care Units (UPA for its Spanish acronym) with a basic level of attention, and hospital units of medium and high complexity of second and third level. Antenatal basic care is done in UPA and second level hospitals.

Strata classification in Bogotá, just as in the rest of the country, is a hierarchical approximation to poverty and richness' conditions of the population. Homes under the poverty line and with unsuitable sanitary and household conditions concentrate in strata 1 and 2 (Table 1.4).

Table 1.4 Poverty and Unsatisfied Basic Needs distribution according to socioeconomic strata in Bogotá

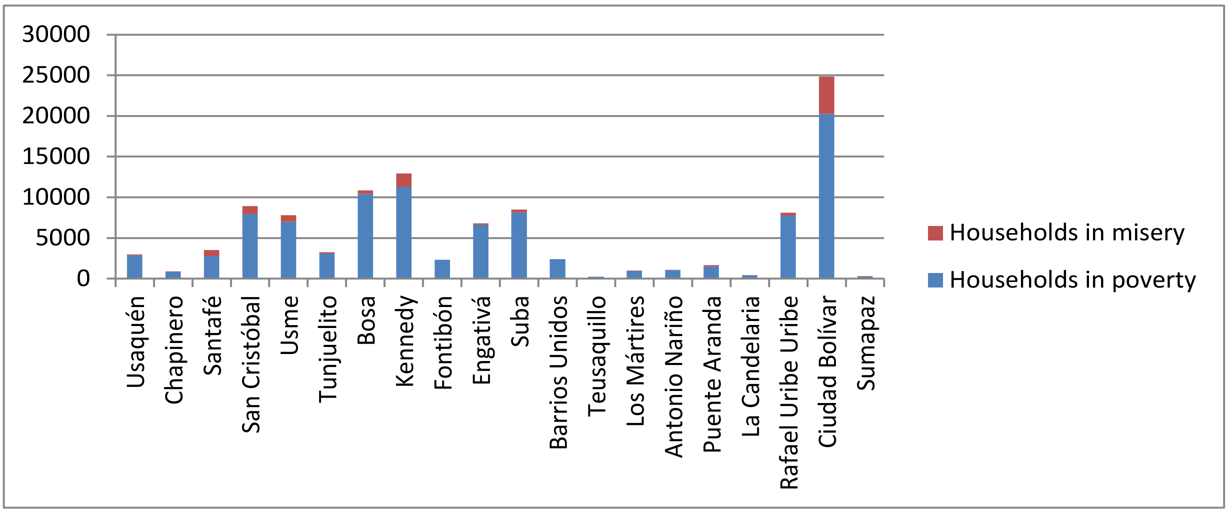
Stratum	% Population (138)	% Poor people per poverty line and UBN[1] (139)	% Households with overcrowding (139)	% Households with inadequate public services (139)	% Inadequate housing (139)
1. Very-Low	9.8	38.8	53.2	2.8	30.4
2. Low	41.4	23.6	64.2	1.6	6.8
3.Mid-Low	35.3	10.7	55.2	2.4	0.8
4. Mid	7.8	3.8	0	0	0
5.Mid-High	2.4	3.2	0	0	0
6. High	1.8	4.1	0	0	0
Unstratified[2]	1.5	21.7	26.7	49.9	87.3

[1] Unsatisfied Basic Needs

[2] Unstratified: Buildings with different use from residential are not stratified (140) nor are buildings constructed in unauthorized areas.

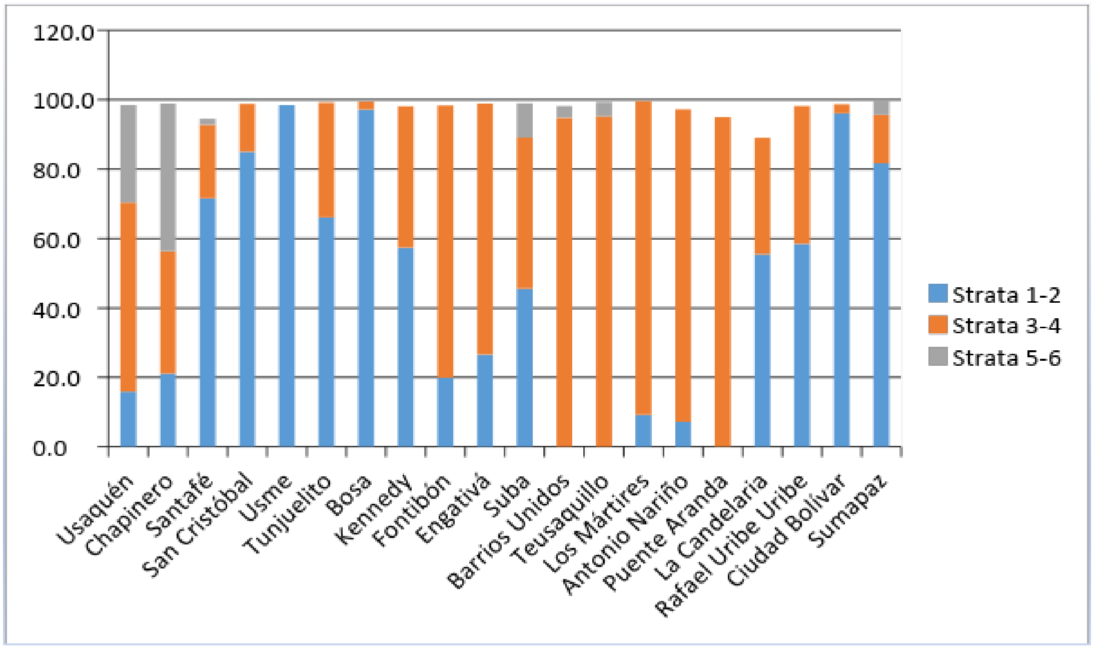
Some districts have a bigger number of inhabitants in poverty conditions than others (Figure 1.1). Each district is divided into different neighborhoods where inhabitants share the same stratum and socioeconomic features. Thus, within a district, different kind of strata can be found (Figure 1.2.).

Figure 1.1: Distribution of homes per districts according to Unsatisfied Basic Needs



Households in misery: households that have two or more UBN (141)
Households in poverty: households that have at least one UBN (141)

Figure 1.2: Distribution of strata in each of the Districts in Bogotá



Adapted from *statistics about the population by socioeconomic stratum by districts in Bogotá* (138)

There is a lack of scientific evidence addressing IPI in pregnant women in Bogotá. Studies with children living in low socioeconomic neighborhoods of the city have shown variable prevalence of any intestinal parasites ranging from 7% to 44%. In Arabia and Jerusalén, two marginalized neighbourhoods of Bogotá, Arias and Gonzalez (88) found a 10-39% IPI prevalence in 70 symptomatic *versus* 7-22% in 35 asymptomatic children aged 3-60 months. Similarly, Bonilla (142), in 48 pre-school children living in strata 1 and 2 areas of Usaquén, reported a 44% IPI prevalence. Also, a 2012-2013 cross-sectional study with children aged 4-70 months living in El Codito, a low socioeconomic community in Bogotá, showed an overall 39% IPI prevalence, mostly due to protozoal infections ranging from 1 to 19%, and low helminthic IPI not surpassing 1% prevalence (82). In the general population, Agudelo *et al.* (143) reported that in marginalized communities of Bogotá living in poor environmental conditions, a 0-64 year old population showed prevalence ranges of 1-31% for geohelminths and 8-31% for protozoal IPI.

Although Bogotá is the most developed city in Colombia, there are socioeconomic and environmental conditions that affect the risk of developing IPI:

- 9.2% (706,000) of the population of Bogotá cannot afford one or more of their basic needs (7).
- According to income, in 2012 the number of people in poverty was 11.6% (890,000) and 2% in extreme poverty (154,000).
- The Gini index of 0.497 (129) indicates high social inequality.
- The MPI showed that 11.9% (913,000) of the population in Bogotá is poor (128) and almost 53% (4,070,000) of its inhabitants belong to strata 1 and 2 (138).
- 15% (49,000) of adolescent women from 15 to 19 years of age in Bogotá have been pregnant at least once (50), and most of them are under the poverty line (144).
- Bogotá has the highest percentage of the migrant population in Colombia. It is estimated that more than 300,000 displaced Colombians live in the city (15).
- Most of the displaced people are living in inadequate sanitary and overcrowding conditions (145), which favor the development of IPI. Many individuals share the same bathroom and kitchen with improper ventilation and high level of humidity. Besides these environmental conditions, habits such as not washing hands before and after eating or using the toilet, and unclean household conditions increase the possibility of suffering IPI (146).
- With an average temperature of 14ºC and average annual humidity of 80%, climate conditions in Bogotá are not as favorable for IPI development when compared with tropical Colombian locations. Climate conditions in Bogotá are however permissive to parasitic

life cycles, particularly protozoal. Yet, both protozoal and helminthic IPI have been reported in populations of Bogotá (Table 1.1) and it is assumed that inadequate urban socioeconomic factors outweigh climate conditions as risk factors.

In summary, although Bogotá is the city with the highest economic progress in Colombia, it has sociodemographic and living conditions favoring the development and dissemination of IPI, with climatic conditions permissive for protozoal more than helminthic IPI.

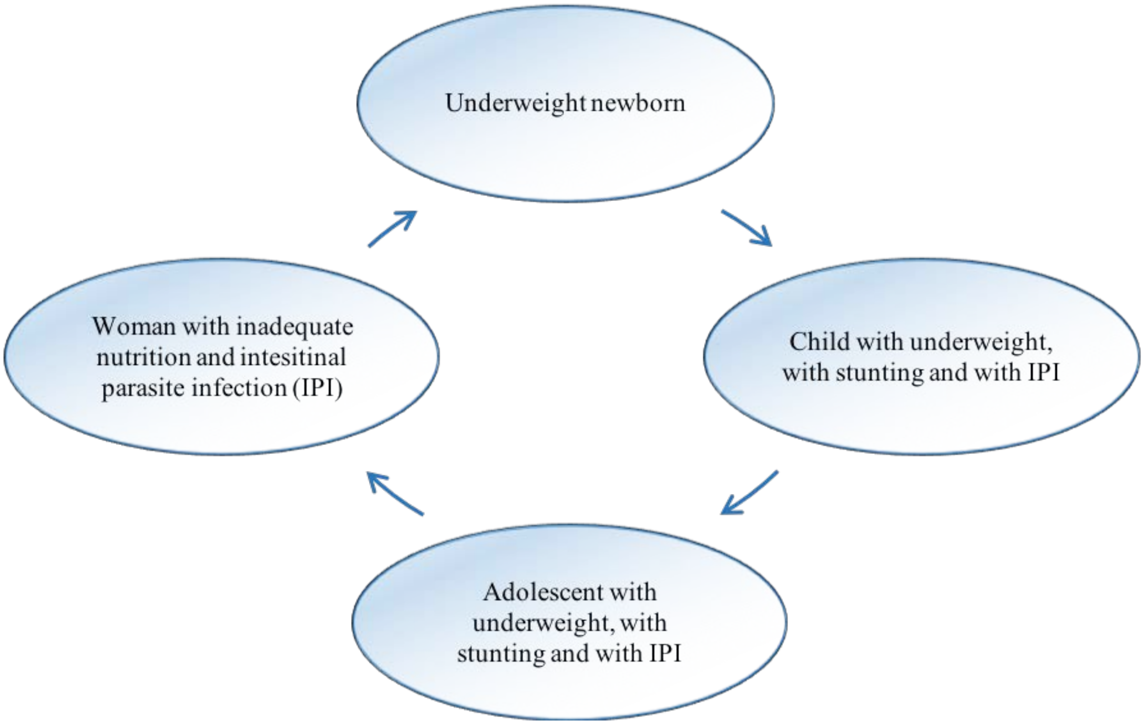
1.4.4. IPI in pregnant women and the consequences in their offspring

Pregnant women are an especially vulnerable subgroup for IPI, mainly because during pregnancy there is a physiological state of relative immunosuppression that may result in susceptibility to various diseases including parasitic infections (27, 147). In general, the clinical manifestations of intestinal parasite infections in pregnant women are the same as those present in other periods of life, depending on the type of parasite: diarrhea, flatulence, dysentery, anal itching, rectal prolapse, malabsorption syndrome, anemia, and malnutrition. The same situation applies to the complications: hepatic, biliary and intestinal obstruction and pancreatitis, in the case of *A. lumbricoides* infection; poor absorption of fat, protein, vitamin A and lactose, in *G. lamblia* and/or *A. lumbricoides* infection; the hookworms can cause and aggravate anemia of pregnancy (148). Pregnant women are more prone to biliary *Ascaris* infection because progesterone alters or relaxes the motility of the sphincter of Oddi (149). *E. histolytica* infection might cause a liver abscess in pregnancy, which can generate preterm labor (150). *Giardia* infection is one of the most frequent causes of intestinal parasitism in pregnant women worldwide (89).

1.4.4.1. Effect of parasitic infection in pregnant women and their offspring

IPI in pregnant women may cause iron deficiency anemia (27, 60, 61, 97, 151-153) which in turn may lead to pregnancy complications related to blood loss and insufficient supply of nutrients necessary for erythropoiesis. LBW in the offspring (151) is a consequence of this. Iron deficiency and low Apgar scores occur in infants with LBW who may have more intestinal and respiratory infections, frequent hospitalizations and higher mortality rates than children with normal birth weight. Moreover, adults who had LBW are at a higher risk of developing cardiovascular and metabolic diseases (152). It has been determined that LBW infants are at risk of reduced growth and development during childhood and adolescence. Slow growth leads to underweight and stunting, which in women with early pregnancies could cause deliveries of infants with LBW. This situation, especially in developing countries, could generate a cycle where that problem can continue from one generation to the next (60) (Figure 1.3).

Figure 1.3: Cycle of inadequate nutrition and intestinal parasite infections



Adapted from *Cycle of adverse events throughout life associated with undernutrition and infectious diseases. (60)*

On the other hand, it has been found that newborns of mothers with intestinal parasites infections have higher levels of plasma IL-10 than those of uninfected mothers. Besides, offspring from mothers with helminthic infections are more vulnerable to also having IPI (34). Research studies have shown a worsening in STH infection after immunization of infants through oral (154, 155) and parenteral vaccines (156, 157) when exposure to the infection has occurred in utero or during early childhood (158).

Factors associated with parasitism in pregnant populations are in general the same for people in other periods of life. Studies carried out in pregnant women reported risk factors such as irregular use of soap (159), living in a rural area, multiparity, walking barefoot inside the house, living in a house with wood or dirt floor (148), lack of sanitary facilities, and low level of schooling (160). A study found that living with pets and farm animals was a risk factor (148), while another one did not consider it as determinant (160). Out of these, the only specific risk considered in pregnant women is multiparity; all the other ones are the same as in the rest of the population.

Finally, the fetal programming theory (161) states that "the biological systems of the human being are programmed for adult life according to environmental characteristics over very specific periods of prenatal development" (162). It can be thus assumed that damage suffered by the child in the womb may be insurmountable, which would justify a timely intervention in pregnant women to solve this problem.

1.4.4.2. Treatment of intestinal parasite infections during pregnancy

Literature reports deficient knowledge of some obstetrician/gynecologist physicians about the correct treatment of intestinal parasitic diseases during pregnancy. For instance, a survey among 521 specialists in the US showed that 42% incorrectly answered when asked about a safe treatment for giardiasis within the first trimester of pregnancy (163). Even though treatments with anti-parasitic drugs are not entirely safe during pregnancy, only a few of them has absolute contraindications. When it is necessary to use them, it is crucial to take into account the pregnancy week and the risk-benefit ratio (164).

In the case of *A. lumbricoides* treatment, studies report successful results with a single or two doses of albendazole after 14 weeks of pregnancy (cure rate 92% and 100% respectively) (165). Evidence indicates that deworming with mebendazole during pregnancy can be safe, and it could be included in antenatal care programs in hookworms-endemic areas (152, 166). Its use is recommended during the second and third trimester (167).

IPI are common in developing countries. This kind of infections has been studied mainly in children. However, pregnant women in vulnerable conditions, are an important population to be considered in these studies. Colombia and particularly Bogotá D.C., the capital city, offers the appropriate conditions to acquire intestinal parasites, but the prevalence of IPI in pregnant women residing in this city is undetermined. Knowing the prevalence and risk factors associated with IPI allows for preventive measures and timely treatment.

Intestinal protozoan disease during pregnancy is controlled by symptomatic treatment in most cases. Specific therapy should be postponed after delivery. Severe cases require immediate, specific chemotherapy, which may be dangerous for the fetus due to toxic and teratogenic potentials. Knowing maternal travel history is essential for timely diagnosis and treatment of protozoan disease during pregnancy and the first stage of the newborn's life (168). WHO guidelines suggest that prophylactic anti-helminthic drugs should be included in regular antenatal care in areas where hookworm prevalence is higher than 20% to 30% (152). Despite this policy, Colombian law does not seek the diagnosis of intestinal parasites during pregnancy, and its treatment is considered only in hookworm-endemic areas. When the prevalence of these parasites is between 20% and 30%, a single dose of pyrantel pamoate is recommended, and in areas with prevalence greater than 50%, two doses are needed (123).

In summary, pregnant women are a particularly vulnerable group to develop intestinal parasitic diseases. Because of these infections, there are significant consequences for both women and their offspring. Risk factors associated with the development of intestinal parasites in pregnant women are generally the same as for the rest of the population. Although therapy with anti-parasitic drugs is not desirable during pregnancy, it is possible to treat pregnant women with IPI as long as contraindications are into account at each gestational stage. Finally, to achieve preventive measures and timely treatments in pregnant women with IPI, it is necessary to know the prevalence and risk factors associated with these infections.

1.5. Respiratory symptoms

1.5.1. Epidemiology of respiratory symptoms: asthma, wheezing and allergic rhinitis at the worldwide, regional, national and local level

In 2014, the Global Initiative for Asthma (GINA) redefined asthma as "a heterogeneous disease, usually characterized by chronic airway inflammation. It is defined by the history of RS such as wheeze, shortness of breath, chest tightness and cough that vary over time and in intensity, together with variable expiratory airflow limitation" (169). The Global Burden of Disease Study estimated that, by 2016 counts, asthma affected around 339.4 million people worldwide (170). This number is probably higher due to underdiagnosis, estimated to range between 20% and 73% in adult and pediatric populations with current asthma (171). Prevalence can also be affected by the difficulty to differentiate asthma from chronic obstructive pulmonary disease at older ages, termed as the "asthma-COPD overlap syndrome" (172).

In Latin America, the International Study of Asthma and Allergies in Childhood (ISAAC) reported geographical variations in asthma prevalence, in the context of socioeconomic inequality, poverty, ethnicity and climatic diversity characteristic of this region (173). Overall, among Latin American children age 13-14, 13.6% reported asthma ever, 15.9% current wheeze and 2.6% sleep disturbance from wheeze. These symptoms were highest in Lima, Peru (33.1%), San Salvador, El Salvador (30.8%) and Vitoria da Conquista, Brazil (6.1%), respectively. This ISAAC study also collected information from Colombian children living in three major cities, who reported 14.2% asthma ever (9.5% in Bogotá), 11.8% current wheeze (8.5% in Bogotá) and 1.9% sleep disturbance from wheeze (0.7% in Bogotá).

In Colombia, the asthma prevalence studies have included patients living in urban settings, used questionnaires, some have used spirometry and IgE blood levels. The first large cross sectional study that aimed to determine asthma prevalence in Colombia was published in 1992, was conducted in Cartagena, a tropical coastal city in northern Colombia, and included 4,000 local residents. The participants were considered to have asthma if "they had consulted their physicians for shortness of breath accompanied by wheezing during the last year and had received asthma medication". The point prevalence of asthma in Cartagena was 8.8% (174). In 2004, a cross-sectional study conducted in six cities of Colombia, including Bogotá, determined the prevalence of asthma when participants answered "yes" to either of two questions: "Have you had wheezing (whistling) in the chest during the past year?" or "Has your physician ever told you that you have asthma?". In this study, the overall prevalence of asthma in adults 19- 59 years old was 7.6%. In Bogotá, the prevalence of asthma in adults was 9.4%, ranking fifth among the six cities scrutinized (175). In 2010, a cross sectional study by the same group reported an asthma prevalence of 9.68% in 4,026 Colombian adults age 18-59 (176). The most recent cross-sectional study, in 2015, determined the prevalence of asthma in 5,539 adults 40-93 years old in Colombia. Asthma definition in this study was established by a positive answer to the question ''Have you ever had two or more wheezing attacks that caused you shortness of breath?'' and a post-bronchodilator FEV_1/FVC ratio higher than 70%. With these criteria, the average prevalence of asthma in Colombia was 9%, higher than physician-diagnosed asthma of 6.5%. For Bogotá, clinical asthma was 11.9%, higher than in previous reports (177).

Asthma is one of several allergy-related diseases, which usually overlap. Nasal congestion or inflammation is one of the common symptoms of rhinitis along with frequent sneezing, itching, and rhinorrhea (178). As with asthma, rhinitis is more prevalent in infants than in the adult population. In adults, a multinational cross-sectional survey of Ear, Nose and Throat (ENT) specialists published in 2018 reported prevalence of rhinitis between 10% and 30% (179). A follow-up of 9,156 participants of the European Community Respiratory Health Survey (ECRHS) concluded that rhinitis prevalence increased from 21.6% to 30.9% in 18 years among Swedish adults. This prevalence was determined with questions about the symptoms included in the "Global Allergy and Asthma European Network", by asking the participants "Do you have any nasal allergies, including hay fever?". Participants answered the questionnaire in 1990 and then again in 2008 (180). A study that evaluated the prevalence of RS through the Spanish version of the International study of Asthma and Allergies in Childhood (ISAAC) questionnaire reported that 41.6% of school-age participants in the province of Oropeza in Bolivia had rhinitis (181). In Colombia, the cumulative prevalence of rhinitis was 31.3% in a study with 6,507 participants, while in Bogotá, the point prevalence of rhinitis was 21.6% (175). Determining the actual status of this condition can be challenging for two main reasons: first, differential diagnosis of rhinitis is extensive and, second, there is no one universally accepted definition of the disease.

Wheezing is a continuous high-pitched sound with a frequency of 400 Hz or more that manifests itself in patients of various diseases and not only in asthmatics (182). A 2018 meta-analysis reported the prevalence of childhood wheezing and recurrent wheezing of 36.06% and 17.41%, respectively. This frequency varied from one continent to another. For European countries, the wheezing prevalence was 30.68%, while for Latin America it was 40.55% and 15.97% in Africa (183). In Colombia, the prevalence of wheezing was 16.9% in adults and 22.7% in all participants from Bogotá (175).

Allergy-related diseases such as asthma, wheezing, and rhinitis are responsible for reducing active days and increasing the use of hospital services. The socio-economic burden of asthma was analyzed in European countries in 2008 when 1,152 asthmatic adults participated in the ECRHS-II and reported the number of active days reduced and the use of hospital services due to asthma symptoms. In this survey, 14% of participants reported a large number of days with reduced activity. This heavy burden was associated with the severity of the disease and the worsening of life quality (184). Wheezing and rhinitis are also related to hospital visits, school, and work absence and career-decision making (185).

The prevalence of respiratory symptoms during pregnancy has been reported in studies from Sweden, Australia, United States, Nigeria and Tanzania. One of these, longitudinally identified a

22% prevalence of rhinitis in Swedish women, higher in women who smoked while pregnant (186). Another Swedish study, based on a cohort, used health registry data and identified a 9% asthma prevalence, associated with complications during pregnancy (187). A cross-sectional Australian study found a self-reported asthma prevalence of 13% (188). In the United States, a cohort-based study estimated a 7% prevalence of physician-diagnosed asthma, with age, educational level, ethnicity and smoking as associated factors (189). A Nigerian cross-sectional study reported prevalence of 2% for physician-diagnosed asthma and 6% for rhinitis, with family history of these conditions associated to both, and monthly income associated to rhinitis (190). Finally, a study in Tanzania identified prevalence of 11% for wheezing and 4% for asthma (191).

1.5.2. Respiratory symptoms in pregnant women and the consequences in their offspring

The onset of asthma in pregnant women varies depending on their previous health status. Suboptimal controlled asthma can lead to maternal and fetal complications. Pregnant women are encouraged to continue asthma therapy with inhalers during gestation and lactation, but some studies have shown that, during pregnancy, women report poor adherence to inhaled corticosteroids due to fear of adverse effects, among other causes. However, when pregnant women enrolled in an asthma management program, adherence improved from 28 to 46% (192).

On the other hand, although the inappropriate use of inhalers is quite common in pregnant women (64.4%), this does not result in adverse clinical results of the mothers or their offspring (193, 194). Patients who experienced acute asthma exacerbation during pregnancy had a higher risk of cesarean section (195), preeclampsia, gestational diabetes, placenta previa and placental abruption (196). Regarding the consequences for the offspring, asthma during pregnancy was associated with a significantly higher risk of congenital malformations, cleft lip and/or palate, neonatal death and hospitalization (197).

1.5.3. Environmental conditions associated with respiratory symptoms: Greenness, housing conditions and air pollution in the general population and during pregnancy

Asthma, wheezing, and rhinitis can be triggered by environmental conditions. These conditions are reported to be influenced by a combination of several factors including environment, socioeconomic status, lifestyle, and genetics (198). Environmental conditions such as access to green spaces, living characteristics and air quality have been studied as factors of these respiratory conditions (199-201).

The rapid urbanization of cities has lessened human contact with natural environments affecting global health in different aspects. Closeness and access of city dwellers to urban green spaces have been reported to have beneficial effects for, among others, mental health, adult body mass index, birth weight and child development (202). Green spaces may positively affect health outcomes through mitigation, restoration and instoration (203). Mitigation or harm-reducing paths refer to diminishing exposure to environmental stressors such as air pollution, excessive heat, and noise. Restoration mainly promotes the recovery of human capacities such as attention and mental health, and instoration considers building capacities such as encouraging physical activity and facilitating social cohesion (203). In contrast, potential adverse effects of greenness on health may relate to the presence of allergenic pollen and disease vectors, safety issues leading to crime-prone areas, excessive solar exposure and risk of exposure to pesticides (203).

Specific relationships between greenness and allergy-related diseases have been studied thoroughly with different results (204). Regarding asthma, an ecological study in England reported reductions in asthma hospitalizations associated with neighborhood green spaces, domestic gardens and tree density (205). However, the significance of these associations was dependent on the level of outdoor air pollution. Asthma in Australian children living in areas with high traffic-related air pollution was reported to be lower in areas with high green space coverage (206). In contrast, using Normalized Difference Vegetation Index (NDVI), a satellite image-based vegetation index (201), reported a positive association of childhood asthma with residential proximity to parks, and none with residential surrounding greenness or proximity to forests. A cohort of 5,803 children in Germany, using NDVI too, but segregated by the place of residence in rural northern and southern urban regions, reported that the effect of greenness varied between areas. In the urban southern region, there was a significant association between greenness and rhinitis, as well as eyes and nose symptoms, whereas in the rural northern area every outcome was significantly lower on all studies (200).

Living and housing conditions must be considered when studying respiratory symptoms. Low income communities, where poor housing conditions occur, show increasing prevalence of non-atopic and severe asthma (207). In children, associations between inadequate living conditions and respiratory allergies have been identified. For instance, Maluleke and Worku (208) found that in a poor South African community, significant predictors of childhood asthma included household exposure to smoke and lack of access to flush toilets, the latter considered a proxy socioeconomic status indicator (208). Barreto *et al.* (209) identified that, in non-atopic Brazilian children, wheezing was significantly associated with low frequency of room cleaning and presence of rodents in the house. Colombian children in the department of Cesar had more respiratory symptoms when exposed to indoor tobacco or firewood smoke, living in housing with walls made of adobe, damp house and living with pets (210). In Colombian adults, indoor exposure to wood smoke was associated with asthma and wheezing (177). To contrast, increased levels of urbanization, higher socioeconomic status, and a more urban lifestyle were associated with a higher prevalence of asthma in transitional communities in Ecuador (211), and in children living in peri-urban settings when compared to their rural counterparts in Peru (212). When studying surface materials in a house, frequent considerations are the relationship with components that can be harmful to health by generating potential chemical emissions, favoring the growth of microorganisms or exposure to allergens. A study in Russia, a high income country, identified the use of linoleum floors, synthetic carpet and new furniture as risk factors for asthma, wheezing and allergies (213). A Colombian study identified that the material of the walls are associated with respiratory symptoms (210).

Hygiene at home has been studied in association with respiratory disorders, with inconclusive research evidence. On the one hand, it has been argued that households where hygienic conditions are not rigorous favor early exposure to microorganisms that stimulate immunologic maturation. For instance, in European countries, a lower prevalence especially of atopic asthma and allergic disease was observed in farmers' children with higher levels of exposure to microorganisms (214, 215). Also, inverse associations between family size and risk of allergies led to the formulation of the hygiene hypothesis. This association was initially explained by early exposure to infection transmitted from older to younger siblings. More recently, this hypothesis has been supplemented with evidence relating to bacteria signaling, balance between type 1 and 2 of T-helper cells, the role of immunoregulation and *in utero* programming of postnatal immune function. All these mechanisms may partially explain the prevalence of allergy-related diseases according to hygiene (216). On the other hand, in the Americas, including inner city areas of the United States where non-atopic asthma is more prevalent, lower hygiene levels were associated with a higher prevalence of the disease (217). In this context, increased stress levels associated with urban violence were hypothesized as the underlying reason (218, 219).

Air pollution is also a context-dependent variable. Indoor air quality can be negatively affected by tobacco smoke, cooking fumes, airborne mold, bacterial products and dust, that increase the risk of developing asthma and other allergic respiratory conditions (220). Anthropogenic outdoor air pollution is well established as a cause of increased asthma incidence, emergency visits and hospitalizations (221, 222). In Latin America and the Caribbean, a recent meta-analysis found a positive association between childhood asthma prevalence and outdoor air pollution levels (223). Bogotá was reported as one of the top three cities, among 125 in the world, with the largest pediatric asthma incidence associated with NO_2 exposure, an air pollution proxy (224). Regarding rhinitis, a cross-sectional study with South African schoolchildren reported a relationship between prevalence of self-reported rhinitis and the frequency of trucks passing near their residence (225).

The prevalence of respiratory symptoms is increasing worldwide, and environmental factors are more liable to have an effect on that increase than the genetic ones. Overall, not all the factors are known or how they interact with each other and with the genes, in a person developing respiratory symptoms. The differential impact of all these factors in high-income countries and low and middle-income countries remains to be examined (170).

2. MATERIALS AND METHODS

2.1. Study design

A cross-sectional population-based study was carried out. Reasons for this type of study design were:

- This type of study design is useful to measure the prevalence of IPI and RS in a specific and restricted time span like pregnancy, and at the same time to measure environmental associated factors.
- This design of study allows reach a greater cohort than designs that requires following across the time.
- The high rate of housing rotation due to the socio-economic conditions of pregnant women residing in strata 1 and 2 neighborhoods and safety reasons, would make it difficult to follow up this cohort longitudinally.

2.2. Target population

Pregnant women from strata 1 and 2 who resided in Bogotá in the districts of Ciudad Bolívar, Kennedy and Usaquén formed the target population. According to data obtained from the Health Care Units of these districts, the number of pregnant women who attended the units during 2012 for the first time (first antenatal examination) was 5,900 in Ciudad Bolívar, 4,314 in Kennedy and 985 in Usaquén, totaling 11,199 pregnant women. Most of the inhabitants of the chosen districts, except Usaquén, belong to strata 1 and 2 (Table 2.1). In Usaquén only 16% (73,838) of its population resides in strata 1 and 2.

Table 2.1 Strata 1 and 2 distribution by districts included in the study

District	Number of inhabitants	Inhabitants in Socioeconomic Strata			
		1		2	
		N	%	N	%
Ciudad Bolívar	616,455	360,082	58.4	232,319	37.7
Kennedy	937,831	17,414	1.7	555,335	55.7
Usaquén	464,656	21,344	4.6	52,494	11.3

Source: Alcaldía Mayor de Bogotá (138)

2.3. Sample size calculation

For sample size calculation of the IPI section, we used the Statcalc utility of Epi Info™ 7.2 software (CDC, Atlanta, GA, USA) (226). For unmatched cohort and cross-sectional studies, with 80% of statistical power and a level of accuracy of 95%, we calculated different sample sizes according to the prevalence of IPI described by three studies. Based on a Venezuelan study conducted in children and adolescents that evaluated helminths and protozoa (75), we took the reported prevalence in those living in conditions favoring the development of parasites, for example not having bathroom facilities, as “exposed”, in contrast to those “unexposed” groups who did not have such conditions. Using two published Colombian studies, one evaluating the prevalence of *Giardia* in children (89), and another evaluating helminths and protozoa in the general population (227), in which only general prevalence was reported, we assumed at least double difference (OR 2) for the exposed and unexposed population (Table 2.2).

Table 2.2 Sample sizes with 80% Statistical Power

Prevalence %		Statistical Power		
		80%		
Exposed group[1]	Unexposed group	OR	Exact size	Plus 20% NR[5]
54[2]	35	2.18	232	278
43[2]	33	1.53	776	931
42[2]	33	1.47	950	1,140
40[2]	32	1.42	1,178	1,414
36[2]	21	2.12	308	370
12[3,4]	6	2.14	778	934
9.5[3]	4.5	2.23	894	1,073

[1]Participants in the reference studies who lived in conditions favoring the development of IPI. Prevalence of all parasites reported by [2]Solano *et al*. (75) according to different risk factors; Prevalence of *G. lamblia* reported by [3]Agudelo *et al*. (228) and [4]Chaves *et al*. (89); Prevalence of *A. lumbricoides* reported by [3]Agudelo *et al*. (228); [5]NR: Non-response.

Considering that the study by Agudelo *et al*. (228), conducted on marginalized population in Bogotá, reported the prevalence of two parasites that were expected to be found (*A. lumbricoides* and *G. lamblia*), we selected the sample according to the estimations based on this study. Consequently, a minimum of 1,073 pregnant women (with a 20% non-response rate) should have been invited. Considering that, at the time of the study, 30,422 pregnant women were reported living in the three districts, and based on this calculated sample size, this study would be evaluating 3.5% of the target population. (50, 138, 229, 230)

For the RS section, we worked with a subset of the sample from our IPI section, including participants residing in the district of Ciudad Bolívar who had provided their full residential address. Of the 399 pregnant women in this district who accepted our invitation to participate in the study, 310 provided sufficient residential information required to geocode their homes. Considering the prevalence in Bogotá of physician-diagnosed asthma, wheezing and rhinitis reported by Dennis *et al.* (176), assuming an OR of 1.5, and using the formula to calculate the power of the OR difference between two groups(231), the power of the sample of 310 participants in this study to estimate what happens in the study population was of 27% for asthma, 65% for wheezing and 87% for rhinitis.

2.4. Data Collection

2.4.1. Data Collection Procedures

Fieldwork was carried out between May 2015 and July 2016. Because of Colombian legislation on personal data protection, we were not able to establish the sampling frame, as the primary health care units are forbidden from providing access to contact information of pregnant women. These centers can only use this information for treatment but not for research purposes. Thus, the recruitment of participants was performed as follows:

- Six research assistants with experience in community work were trained in data collection procedures, including the ethical and logistical aspects of the planned fieldwork.
- In the districts of Usaquén and Kennedy, research assistants invited pregnant women who attended to antenatal courses in different primary health care centers to participate in the study. Besides, in Usaquén, research assistants invited pregnant women by door-to-door visits.
- In the district of Ciudad Bolívar, the last place where the fieldwork was done, two primary health care centers were selected, as 80% of all pregnant women in this district attended antenatal care there. Here, research assistants invited all pregnant woman who arrived at both centers during opening hours, from 7 am to 4 pm.
- Once the woman agreed to participate, the process was as follows:
  - Explanation and signing of informed consent.
  - If she was at the Primary Health Care, the first part of the questionnaire was completed, including information that she would directly provide on sociodemographic characteristics, as well as her past and current pregnancies. She was then given a stool sampling kit, and an appointment would be set for the assistant to pick up the sample and finalize the second part of the questionnaire that would require observations of their housing and living conditions.
  - For women whose recruitment was accomplished at their home in Usaquén, both parts of the questionnaire were completed at once and an appointment to pick up stool samples was set.
  - During interviews, research assistants emphasized to each participant the importance of accuracy in their answers to better assess the variables of the study.
- Once the questionnaire and assessments were completed, participants were given specific and general recommendations regarding their pregnancy. This activity promoted a closer

relationship between participants and research assistants beyond the mere response of the questionnaire and the collection of samples (Appendix 1).

- During interviews, research assistants explained to each participant the importance of not telling the questions to other potential participants to reduce bias in the investigation.
- Once the laboratory completed parasite detection in stools, participants received the test results so they could be shared with their physician.

For the IPI study, recruitment in Usaquén took place between May and August 2015 and was later suspended due to safety concerns from research assistants during fieldwork, resulting in only 24 out of 550 participants in this district. Recruitment in Kennedy was done from May to September 2015 and was suspended because we were doing a selective sampling, focusing on pregnant women who attended antenatal courses, resulting in 127 out of 550 participants in this district. Considering the experiences in the two previous districts and that according to DANE, in this district 59% of the inhabitants live in stratum 1 and 38% in stratum 2 (138), we decided to focus recruitment efforts, between May 2016 to July 2016, on inhabitants of Ciudad Bolívar where 73% (399) of the study participants resided (Figure 2.1).

For the RS study all participants lived in Ciudad Bolívar District. From 523 participants of this district that were invited to participate, only 310 accepted, answered the questionnaire and gave complete home address information. Due to safety concerns, in 170 out of the 310 participants, the questionnaires were answered during interviews at the UPA, but the data collected during home visits about housing construction materials were missing (Figure 2.2). These missing data were imputed for the final analysis.

Figure 2.1 Flow Chart of Recruitment and Response for IPI

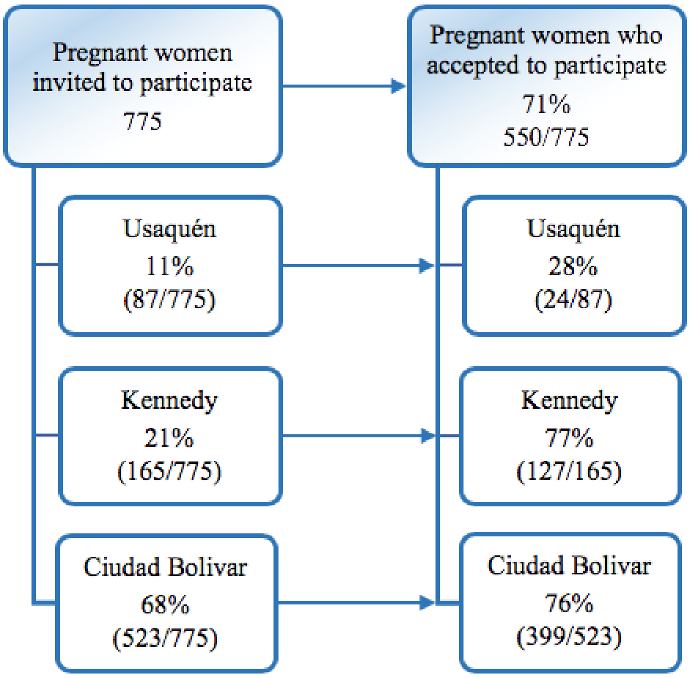
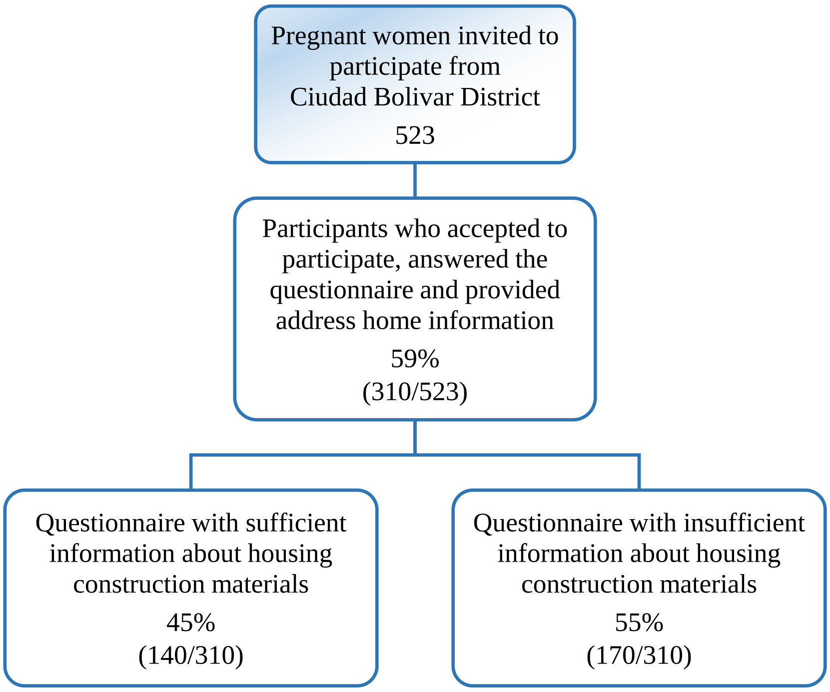


Figure 2.2 Flow Chart of Participation for RS



2.4.2. Questionnaire

For the IPI research questions, we created a questionnaire to identify the association between environmental risk factors and IPI. To do so, we adopted questions about sociodemographic, household, and hygiene characteristics from the Demographic and Health Surveys (DHS) (232), which is a validated international survey created by the United States Agency for International Development (USAID) and implemented by the Inner-City Fund International (ICF-International). Furthermore, some questions about parity and trimester of pregnancy were taken from Centro Latinoamericano de Perinatologia/Salud de la Mujer y Reproductiva (CLAP/SMR study) and the PAHO survey called “Pregnant Women in Primary Health Care” (233). Questions regarding waste management, exposure to potential parasitic vectors, and household pets, were adopted from the form “Elementary Family Characteristics” (234), prepared by Salud Distrital de Bogotá (the Secretary of Health of Bogotá), which is used by health organizations in each of the selected districts. We also included questions about home address, assigned socioeconomic stratum and date of the last deworming treatment. Since according to Colombian laws, at least one hematocrit and hemoglobin test should be performed to each pregnant woman every trimester during regular antenatal check-ups (123), we obtained a copy of the blood tests done during regular prenatal check-ups for hematocrit and hemoglobin evaluation, to correlate them with IPI prevalence. Besides, for the RS section, we also included questions on wheezing without a cold in the past 12 months, ever having asthma, a physician diagnosis of asthma or nasal allergy, including rhinitis. The questions used were adopted from the ECRHS (235).

In order to improve the clarity, comprehension, and duration of the survey, a pilot survey was conducted by three fifth-year medical students from Universidad del Rosario, Bogotá, who were trained to apply the survey by two researchers (Angela Espinosa and Angela Pinzon). Pilot interviews were carried out by the medical students to ten volunteer pregnant women in the district of Usaquén, Bogotá. Once they gave their informed consent, these pregnant women were interviewed and not included as participants in the study. Based on their feedback, minor adjustments were made to the survey, mainly about sociodemographic characteristics. The questionnaire had four parts: General characteristics of pregnant women, household characteristics, general characteristics of pregnancy and hygienic habits~~.~~ (Appendix 2).

2.4.3. Parasite detection in stool samples

Each of the pregnant participants provided one or two stool samples, following instructions for proper and safe collection and preservation. Since the diagnostic sensitivity of the stool sample examination increases when different diagnostic methods are combined, a "combined microscopy technique" was used, analyzing each sample not only through direct wet mount microscopy but also through Ritchie's formalin-ether concentration. This combined technique can detect helminths such as *A. lumbricoides*, *T. trichiura*, *H. nana* and hookworms, as well as protozoa including *G. lamblia*, *B. hominis*, *E. coli*, *E. nana* and *E. histolytica/dispar complex*. Using this combined technique, the reported range to identify nematodes reached sensitivity ranges from 85.7% to 94.7% (236). In addition to combining detectin methods, diagnostic sensitivity also improves when taking more than one independent stool sample. Cartwright *et al.* (237) reported increased sensitivity from 75.9% with one sample to 92% with two samples, using stools fixed with 10% formalin or polyvinyl alcohol. The microscopic test has a higher specificity to detect protozoa, while the concentration method has more sensitivity to diagnose intestinal helminths [187].

Similarly, Mendoza *et al.* (238) reported that *G. lamblia* identification increased proportionally to the number of samples analyzed. In places with a high prevalence of intestinal parasites, more than one stool sample should be enough for a correct diagnosis (237, 239). In this study, two stool samples were considered adequate for epidemiologic research. In order to improve the diagnosis technique, a combination of different methods was used (240).

We instructed each participant to collect two serial stool samples during two different days. Considering the high sensitivity of quantitative Polymerase Chain Reaction (qPCR), this technique was used to detect parasitic nucleic acids in a sub-group of 50 participants, and compare its agreement in parasite prevalence with the combined microscopy technique. These samples were taken from participants residing in Ciudad Bolívar district and were selected chronologically by order of arrival at the laboratory. Comparison between the two techniques was performed for both tests in the same participant. Since financial constraints did not allow the use of PCR in all participants, it was instead used to assess the diagnostic agreement between the molecular and microscopic techniques. PCR was ~~were~~ carried out at the Microbiology laboratory of Universidad del Rosario in Bogotá, where DNA was extracted from ethanol-fixed stool samples using a Norgen Stool DNA Isolation kit (Norgen Biotek Corporation, Thorold, Canada). PCR mixtures were prepared with 2.0 microliters sample DNA, 3.5 microliters of Taqman Mastermix (Applied Biosystems, Foster City, CA, USA) and 1.5 microliters of parasite-specific primers. The samples were processed in an Applied Biosystems 7500 Fast Real-Time PCR system for 40 cycles with a 3s denaturation time at 95^{o}C and a 30s-extension time at 60^{o}. The results of the qPCR were considered negative if the cycle threshold values were higher than 38. The PCR primers used were reported by Mejia *et al.* (2013) (241) and Stensvold *et al.* (2012) (242) as specific for *B. hominis*, *G. lamblia*, *Cryptosporidium*, *E. histolytica*, *A. duodenale*, *N. americanus*, *A. lumbricoides*, and *T. trichiura*. Positive controls were included for each parasite, as well as a reference *G. duodenalis* WB strain. Negative controls included stool samples from healthy non-infested children.

2.4.4. Data Control

1. A pilot test of the questionnaire was conducted.
2. To apply the questionnaire: The principal researcher and local supervisor trained the research assistants and accompanied them during the first five household visits, and then, based on the preliminary results of these visits, improved the questionnaire.
3. Stool sample collection: The principal researcher and research assistants explained to each pregnant woman the correct way of collecting and keeping the stool sample (243). To accomplish this, a brochure with images and instructions was designed and given to the participants (Appendix 3).
4. To analyze stool samples: Expert bacteriologists from a national reference lab analyzed the stool samples, and 10% of samples were re-analyzed by a specialist in microbiology (Universidad del Rosario). We then evaluated the concordance between both reports.
5. Two research assistants separately made a double data entry. The principal researcher was responsible for checking and solving discrepancies between both databases. When these were identified, the principal researcher verified the questionnaire and indicated the correct answer.
6. Database Storage: Data storage was done in two computers and two flash drives with password protection.

2.5. Variable Definition

2.5.1. IPI

The laboratory reported the presence of any parasite form (trophozoites, cysts, eggs, or larvae) with the direct and concentration techniques, separately and combined, for each parasite. Based on these data, we created one dichotomous variable for each parasite. When no parasite form was reported, the variable was defined as negative and assigned the value = 0. Otherwise, when any parasite form was reported, the variable was defined as positive and the value = 1 assigned.
After estimating the prevalence of each parasite with each of the techniques, a pooled analysis was generated with both techniques, creating a combined variable for each parasite. When a parasite was reported by either technique, the variable for this parasite was defined as positive and assigned the value = 1.

Following the same pooled procedures, we created three outcome variables: the presence of any parasite, the presence of any pathogenic parasite, and the presence of more than one parasite ("polyparasitism") (244, 245). For each outcome, one compound variable was created. When no forms of parasites were detected with the combined microscopy technique, the variable was defined as negative and assigned the value = 0. Otherwise, when parasite forms were detected with the combined microscopy technique, the variable was defined as positive and the value = 1 assigned.

In the subset of stool samples that were analyzed by qPCR, compound variables were created as described above. Then, the prevalence for each parasite and any parasite was estimated by combining the microscopy technique and qPCR to compare agreement between both techniques.

2.5.2. Respiratory Symptoms

We took questions from the ECHRS for assessing RS: wheezing without a cold in the past 12 months OR wheezing or whistling in the chest sometime in the last 12 months (no vs. yes), physician diagnosis of asthma (no vs. yes) and nasal allergies, including rhinitis (no vs. yes) (Table 2.3).

Table 2.3 Outcome variables for Respiratory Symptoms

Variable	Questionnaire of Study			Values
	Original Question	**Response Options**		
Rhinitis	Do you have any nasal allergies, including rhinitis?	1: No		1: No
		2: Yes		2: Yes
Wheezing	Q1: Have you had wheezing or whistling in your chest sometime in the past 12 months? Q2: Have you had wheezing or whistling without having a cold?	Q1	Q2	Q1 or Q2
		1: No	1: No	1: No
		1: No	2: Yes	2: Yes
		2: Yes	1: No	
		2: Yes	2: Yes	
Asthma	Has your physician ever told you that you have asthma?	1: No		1: No
		2: Yes		2: Yes

2.5.3. Sociodemographic characteristics

Based on the questionnaire, for the IPI section we built the variables about sociodemographic characteristics and pregnancy conditions (Table 2.4).

Table 2.4 Variables of sociodemographic characteristics and pregnancy conditions for the IPI study

Variable	Type of variable	Questionnaire of Study		Values
		Original Question	**Response Options**	
City district of Bogotá	Exposure	Code of survey	Uxxxx[1]	1: Usaquén
			Kxxxx[1]	2: Kennedy
			CBxxxx[1]	3: Ciudad Bolívar
Stratum	Exposure	Stratum	1	1: One
			2	2: Two
Ethnicity	Exposure	According to your culture, do you consider yourself:	1: Afro-Colombian	1: Minority group
			2: Indigenous	
			3: Rom Gypsy[2]	
			4: Raizal[3]	
			5: None	2: Majority group
Occupation	Exposure	Currently, what is your main occupation?	1: Homemaker	1: Homemaker
			2: Student	2: Student
			6: Sales and services worker	3: Sales and services
			3: Agricultural worker	4: Other
			4: Technician	
			5: Office worker	
			7: Professional	
			8: Manager	
			9: Skilled laborer	
			10: Unskilled laborer	

Variable	Type of variable	Questionnaire of Study		Values
		Original Question	Response Options	
Level of education	Exposure	What is your educational level?	1: Elementary school	1: Elementary school
			2: Secondary school	2: Secondary school
			3: Technical education	3: Higher education
			4: University	
Civil status	Exposure	What is your civil status?	1: Single	1: Single
			3: Divorced/Separated	
			5: Widow	
			2: Married	2: Married or cohabiting
			4: Free Union	
Health insurance coverage	Exposure	What is your health care system?	5: Not affiliated	1: No
			3: Temporarily linked	
			4: Special regime	2: Yes
			2: Subsidized regime	
			1: Contributory regime	
Forced displacement	Exposure	Are you a victim of forced displacement?	1: No	1: No
			2: Yes	2: Yes
Monthly income	Exposure	How much is your household's monthly income?	1: Less than one monthly minimum wage	1: ≤1 Minimum wage
			2: One monthly minimum wage	
			3: More than one monthly minimum wage	2: >1 Minimum wage
			4: More than two monthly minimum wages	
Parity	Exposure	Number of live births	0	1: Nulliparous
			1⁺	2: Parous
Trimester of pregnancy	Exposure	What pregnancy week are you in?[4]	1–12	1: First
			13-26	2: Second
			27⁺	3: Third
Last deworming of participant	Potential confounder	When was your last deworming treatment?	1: Currently	1: Less than 1 year ago
			2: One month ago	
			3: Two months ago	
			4: Three months ago	
			5: Six months ago	
			6: One year ago	
			7: More than one year ago	2: More than 1 year ago
			8: Never	3: Never
Age	Exposure	Q1: Questionnaire Date	DD/MM/YY	Q1 - Q2 Questionnaire Date – Date of birth (years)
		Q2: What is your date of birth?	DD/MM/YY	

[1] xxxx: corresponding consecutive four-digit number starting with 0001

[2] Gypsies with ascendance from Eastern European immigrants

[3] Afro-Caribbean with ascendance from San Andres and Providence archipelago

[4] Pregnancy week was corroborated with the date of the last menstrual period

Based on the questionnaire, for the RS section, we built the variables for sociodemographic characteristics and pregnancy conditions (Table 2.5).

Table 2.5 Variables of Sociodemographic characteristics for the RS study

Variable	Type of variable	Questionnaire of Study		Values
		Original Question	**Response Options**	
Age	Exposure and potential confounder	Q1: Questionnaire Date Q2: What is your date of birth?	Q1 - Q2	
			≤20	1: ≤20
			21-30	2: 21-30
			31^{+}	3: 31^{+}
Single mother	Exposure and potential confounder	What is your civil status?	2: Married	1: No
			4: Free Union	
			1: Single	2: Yes
			3: Divorced/Separated	
			5: Widow	
Forced displacement	Exposure and potential confounder	Are you a victim of forced displacement?	1: No	1: No
			2: Yes	2: Yes
Number of pregnancies	Exposure and potential confounder	Indicate the number of pregnancies	0	1:1st
			1^{+}	2: 2^{+}
Trimester of pregnancy	Exposure and potential confounder	What pregnancy week are you in?[1]	1-12	1: First
			13-26	2: Second
			27^{+}	3: Third

[1] Pregnancy week was corroborated with the date of the last menstrual period

2.5.4. Living conditions and hygienic habits

Based on the questionnaire, for the IPI section we built the variables about living conditions and hygienic habits (Table 2.6).

Table 2.6 Variables of Living conditions and hygienic habits for IPI study

Variable	Questionnaire of Study			Values
	Original Question	**Response Options**		
Water supply	What public services do you have in your home?	Water supply	☐	1: No
		Water supply	☒	2: Yes
Sewage	What public services do you have in your home?	Sewage	☐	1: No
		Sewage	☒	2: Yes
		2^{+}		1: >2 times per week

Variable	Questionnaire of Study: Original Question	Response Options		Values	
Garbage collection frequency	How many times per week does garbage collection occur in your home?	≤2		2: ≤2 times per week	
Presence of pests	Q1: Flies	1: No	2: Yes	1: No, if none of Q is yes	2: Yes, if any Q is yes
	Q2: Mosquitoes	1: No	2: Yes		
	Q3: Houseflies	1: No	2: Yes		
	Q4: Fleas	1: No	2: Yes		
	Q5: Lice	1: No	2: Yes		
	Q6: Ticks	1: No	2: Yes		
	Q7: Cockroaches	1: No	2: Yes		
	Q8: Pigeons	1: No	2: Yes		
	Q9: Rats	1: No	2: Yes		
	Q10: Other	0: No	1: Yes		
Boiling water before drinking	What do you do to make the water potable?	7: Nothing		1: No	
		6: Filter			
		5: Strain through a cloth			
		4: Add ashes			
		3: Chlorinate			
		2: Ozonize			
		9: Other			
		1: Boil		2: Yes	
Washing fruits and vegetables	What do you do to fruits and vegetables prior to consumption?	1: Nothing		1: No	
		2: Washing with water		2: Yes	
		3: Washing with water and soap			
		4: Washing with water and disinfectant			
		6: Other			
Place for washing hands at home	Please show me the place where your family members most often wash their hands	1: Bathroom sink		1: Sink	
		2: Kitchen sink		2: Other place	
		3: Laundry sink			
		4: No specific place			
Water availability for washing hands at home	Where do you get water to wash your hands?	2: From tap water		1: From tap water	
		3: From a water tank		2: From a water tank	
		1: No water available		7: Not applicable	
		4: Other			
Washing hands before eating	Do you wash your hands before eating?	1: No		1: No	
		2: Yes		2: Yes	
Washing hands after going to the toilet	Do you wash your hands after using the toilet?	1: No		1: No	
		2: Yes		2: Yes	
	Do you walk barefoot at home?	1: Never		1: No	
		2: Sometimes		2: Yes	

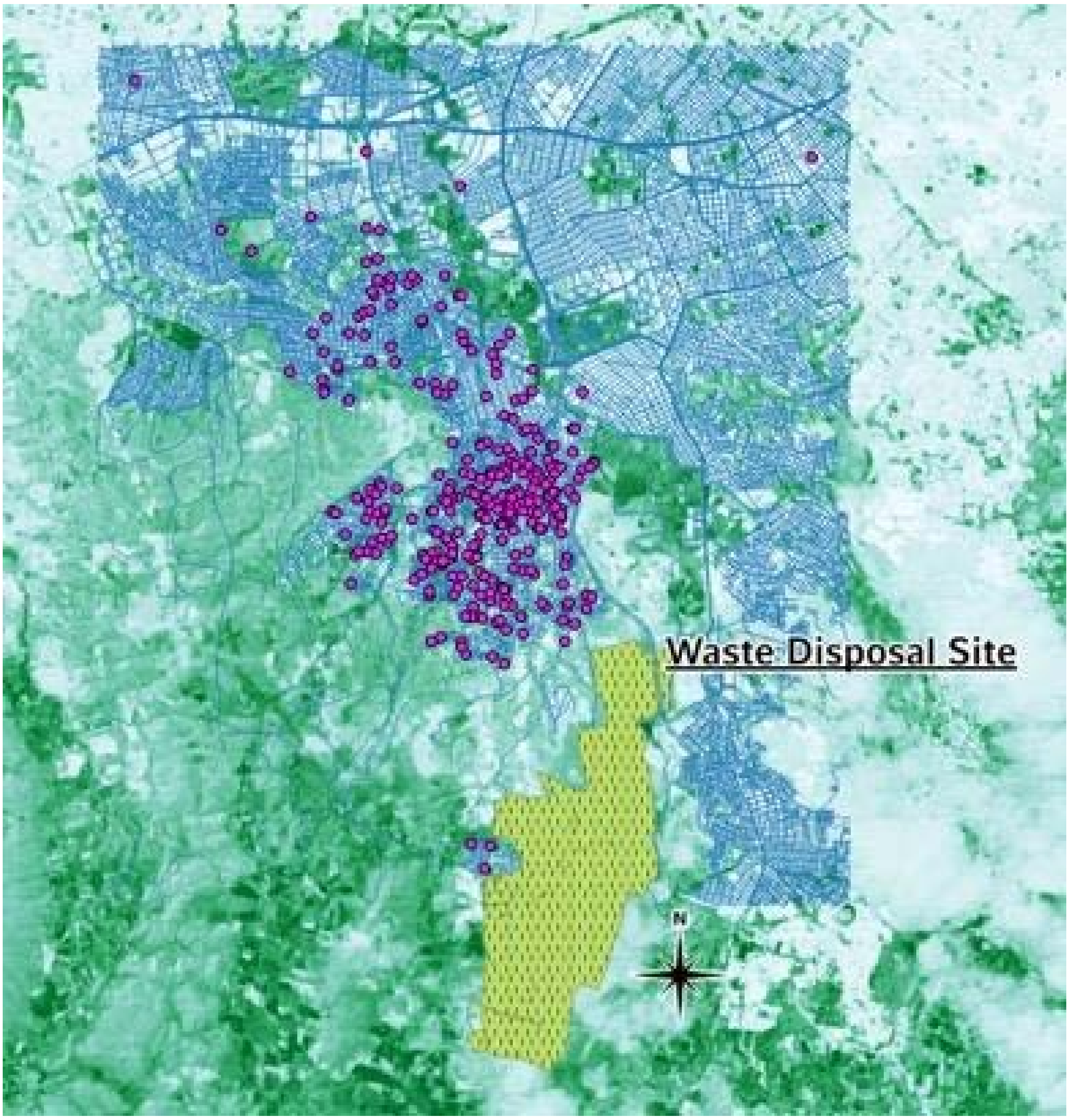
Variable	Questionnaire of Study		Values
	Original Question	**Response Options**	
Walking barefoot at home		3: Always	

All variables of this table are considered exposure variables

2.5.5. Greenness

Greenness was an exposure variable used for the RS section, with geocoded participants' residences using the Google Maps API. With these geocodes, we assessed the exposure to natural and green areas around each home address using the NDVI, a satellite image-based vegetation index. NDVI represents the ratio of the difference between the NIR and RR divided by the sum of both measures (246-248). Index values of 1.0 indicate dense green vegetation, while values closer to zero represent built-up concrete urban settings, and index values of -1.0 indicate water. Cloud-free satellite images from Landsat 5 Thematic Paper (249) taken on April 15, 2017, were used (Figure 2.4). With this information, an average NDVI was estimated in a 100m radius buffer around each participants' address using a 30x30 meter resolution. We chose a 100m radius buffer because Ciudad Bolívar is densely populated, has a high concentration of population in specific areas, and is located on a mountainous region. This smaller radius is recommended in studies like ours, where greenness is assessed along roadsides and in residential locations, and when access and mobility to settings studied are limited (203). Later in the analysis, access to greenness was categorized using NDVI quartiles.

Figure 2.3: Spatial distribution of residential addresses of participants in 2016



Spatial distribution of residential addresses of participants in 2016.
A dot represents each participant. Green areas represent NDVI calculations. Lines represent the main streets.

2.5.6. Air pollution

Air pollution was an exposure variable used for the RS section. We used two measures as indicators of air pollution:

- The distance to the nearest streets as an indicator of exposure to traffic pollution. We calculated the distance between each residential address and the nearest street using the OpenStreetMap (OMS) Tool plugin (2.1.1) in QGIS.

- The distance between each participant's house to the main waste disposal site in Bogotá called "Relleno Sanitario Doña Juana", located on the southwest side of the Ciudad Bolívar district. The shapefile of the disposal site was obtained from the city's official geoinformation website (250).

2.5.7. Indices of housing factors

The indices of housing and hygiene characteristics were considered as exposure variables used for the RS section. We used 18 items from the questionnaire that directly or as proxy were related to residential hygiene, sanitation, and housing infrastructure. Based on these, we created three indices (Table 2.7).

Table 2.7 Indices of housing factors and associated variables for RS Study

Index	Variable	Questionnaire of Study			Values
		Original Question	Response Options		
Access to public services	Water supply	What public services do you have in your home?	Water supply	☐	1: No
			Water supply	x	2: Yes
	Sewage	What public services do you have in your home?	Sewage	☐	1: No
			Sewage	x	2: Yes
	Electricity	What public services do you have in your home?	Electricity	☐	1: No
			Electricity	x	2: Yes
	Natural gas	What public services do you have in your home?	Natural gas	☐	1: No
			Natural gas	x	2: Yes
	Land phone	What public services do you have in your home?	Land phone	☐	1: No
			Land phone	x	2: Yes
	Cellphone	What public services do you have in your home?	Cellphone	☐	1: No
			Cellphone	x	2: Yes
	Internet connection	What public services do you have in your home?	Internet connection	☐	1: No
			Internet connection	x	2: Yes
	Garbage collection	What public services do you have in your home?	Garbage collection	☐	1: No
			Garbage collection	x	2: Yes
	Garbage collection frequency	How many times per week does garbage collection occur in your home?	2^+		1: >2 times per week
			≤ 2		2: ≤ 2 times per week
Housing conditions	Availability of bathrooms at home	What type of sanitary facilities exist in your home?	5: No sanitary facilities		1: No bathroom
			4: Latrine		
			3: Toilet without connection		

Index	Variable	Questionnaire of Study		Values
		Original Question	Response Options	
			2: Toilet connected to septic well	
			1: Toilet connected to sewage system	2: Bathrooms available
	One toilet at home	How many toilets are there in your home?	1	1: One toilet
			2^{+}	2: More than one toilet
	Bathroom shared with other families	Exclusive use toilets?	1: No	1: Bathroom shared with other families
			2: Yes	2: Exclusive use bathroom
	Availability of sink	Does your home have a bathroom sink?	1: No	1: No sink
			2: Yes	2: Sink available
	Sink shared with other families	Exclusive use bathroom sinks?	1: No	1: Sink shared with other families
			2: Yes	2: Exclusive use sink
	Kitchen shared with other spaces of the house	Where do you usually prepare your food?	2: Kitchen shared with other rooms	1: No separate kitchen
			1: Kitchen in an independent space	2: Separate kitchen
Housing Materials	Ceiling material	Select the main material the house ceiling is made of	1: Concrete	1: Concrete
			3: Zinc roof tile	2: Zinc roof tile
			2: Wood	3: Other
			4: Clay roof tile	
			5: Paperboard	
			6: Fibre cement (Eternit)	
			7: Other	
	Walls material	Select the main material the house walls are made of	1: Brick	1: Brick
			2: Prefabricated material	2: Non-brick
			3: Wood	
			4: Clay	
			5: Paperboard	
			6: Tin	
			7: Other	
	Floor material	Select the main material the house floors are made of	3: Tile	1: Tile
			2: Concrete	2: Concrete
			4: Ceramic tablet	3: Ceramic tablet
			1: Soil	4: Other
			5: Rough wood	
			6: Polished wood	
			7: Carpet	
			8: Other	

All variables of this table are considered exposure variables

The process of creating the indices was:

- Using the R FactoMine package (251) we carried out multifactorial analysis within these three categories.
- Using the missMDA package (252), we imputed missing data.
- Once the index was obtained, we converted it to a scale from 0 to 100, with higher values indicating the worst conditions.
- Each index was then dichotomized, using the fourth quartile as the cut-off point.

2.6. Ethical aspects

According to Colombian laws (253), this study was considered to be "without risk", because no invasive interventions were performed on the participants. Each participant was asked for written informed consent (Appendix 4). The project was submitted for review and approved by the Ethics Committees of Universidad del Rosario (CEI-ABN026-000343) and Ludwig-Maximilians University (LMU), Munich (231-15).

In Colombia, when research studies include participants under the age of 18, parents or guardians must sign the informed consent (Appendix 5) and the participants themselves must provide written consent. In case of single parents, only one signature is necessary. This study followed these procedures.

To protect the identity of the participants, considering that Colombian Laws demands signature and name in the informed consent, the research director, as well as the research assistants, signed a non-disclosure agreement in which they committed to keep the names of the participants anonymous and to use the information obtained solely for research purposes. The informed consent forms were kept safe by the research director in a locked cabinet.

The identity of participants was protected by replacing their names with an identification code, and subsequently using this code for their corresponding questionnaire and stool analysis. A database with the codes, names, and addresses of each participant was created with the purpose of notifying them about the results of their stool examination; afterward, the study was carried out pseudonymously. This information was saved in an Excel file with a password only available to the principal investigator and the research assistants.

2.7. Analysis of results

All data were double entered and corrected for errors. For IPI data analysis was performed using IBM SPSS Statistics version 24 software (Armonk, NY, USA). Based on the variable definition for IPI described in the previous section, we estimated the prevalence of each parasite, any parasite, and polyparasitism. The percentage of agreement between combined microscopy technique and qPCR was later determined following the formula given by the US Food and Drug Administration (254):

- The positive agreement percentage was estimated as the ratio of the number of parasites detected by the combined microscopy technique and identified by qPCR over the total number of parasites detected by qPCR.

  The negative agreement percentage was estimated as the ratio of the number of stool samples reported as negative for parasites by the combined microscopy technique and identified by qPCR over the total negative cases detected by qPCR.

Based on outcomes and exposure variables we made univariate, bivariate and multivariate analysis. Table 3.8 summarizes the analysis done for the IPI section.

Table 2.8 Variables and type of analysis for IPI study

Variables	Analysis	Measures
• Each parasite, any parasite, any pathogenic parasite and polyparasitism[1] • Sociodemographic and pregnancy characteristics[2] • Living and hygiene conditions[2]	Univariate	– Absolute and relative frequencies
• Sociodemographic and pregnancy characteristics, when comparing subgroups of participants (with questionnaires only vs. participants with questionnaires and stool samples)	Bivariate	– Exact Chi^2-tests – Fisher test – Mann-Whitney test
• Any parasite vs: sociodemographic characteristics, living conditions and hygiene habits • "Polyparasitism" vs sociodemographic characteristics, living conditions, and hygiene habits	Bivariate	– Exact Chi^2-tests – Fisher test – Mann-Whitney test
• Any parasite form	Univariate	– Prevalence by combined microscopy technique – Prevalence by qPCR technique
	Bivariate	– Positive agreement – Negative agreement
• Polyparasitism vs: sociodemographic characteristics[3], living conditions[3], and hygiene habits[3] • Any parasite vs: sociodemographic characteristics[3], living conditions[3], and hygiene habits[3]	Multivariate	– Logistic regression

[1] Outcomes variables.

[2] Exposure variables. Within these, the last deworming was considered potential confounder

[3] The variables with a $p<0.1$ during the bivariate analysis were included in the logistic regression models

For the RS section, Doctor Ronald Herrera (RH) performed statistical analyses in R V.3.4.3 and geographical calculations using QGIS 2.18.15 Las Palmas (QGIS Development Team) (255). Univariate, bivariate and multivariate analysis were done. In Table 2.9 we summarize the analysis done for the RS section.

Table 2.9 Variables and type of analysis for RS study

Variables	Analysis	Measures
• Socio-demographic[1], pregnancy[1] and housing characteristics[1] • RS[2]	Univariate	– Absolute and relative frequencies – Median and interquartile ranges
• Greenness[1] vs RS • Hygiene indices[1,3] vs RS • Markers of air pollution[1] vs RS	Bivariate	– Logistic regression models
• Greenness, hygiene indices, markers of air pollution vs RS	Multivariate	Logistic regression models: – For potential confounders, we estimated gross and adjusted odds ratios (CI 95%)[4] – The adjusted models included NDVI, environmental covariates, and hygiene indices. –

[1] Exposure Variables. Within these, age, single mother, gestational age, number of pregnancy and forced displacement were considered as a potential confounder

[2] Outcomes variables

[3] Given the presence of missing data in variables used to construct the indices, RH imputed missing data with the package missMDA (252). Considering that the missing data was not random, multiple imputation was not done (256).

[4] The sociodemographic variables were included in the adjusted models when the unadjusted odds ratio had a $p<0.10$, and were additionally included in the logistic regression models

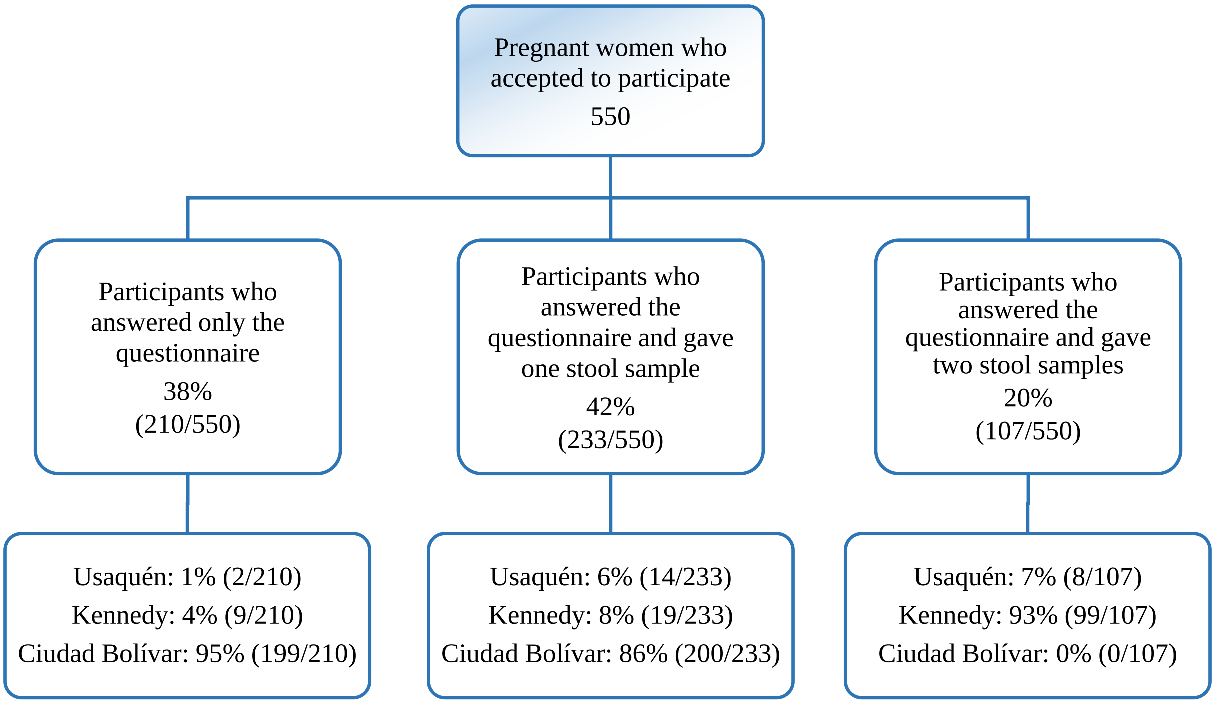
3. RESULTS

3.1. Intestinal Parasitic Infections Results

3.1.1. Recruitment and participation

Participation in this study had three variations: first, pregnant women who only answered the questionnaire (38% of participants), second, pregnant women who aside from answering the questionnaire gave one stool sample (42% of participants), and third, pregnant women who answered the questionnaire and gave two stool samples (20% of participants). In the first variation, the less ideal according to the research project plan, 95% of participants lived in Ciudad Bolívar, while only 1% and 4% of participants lived in Usaquén and Kennedy, respectively. In the second variation, an intermediate option, 86% of participants lived in Ciudad Bolívar, followed by 8% participants from Kennedy and 6% from Usaquén. In the third variation, the ideal option, 93% of participants lived in Kennedy, with the remaining 7% participants from Usaquén (Figure 4.1).

Figure 3.1 Participation in the IPI study: Questionnaire and stool sample



Sociodemographic characteristics and pregnancy information were summarized and compared between participants only responding to the questionnaire and those additionally providing at least one stool sample (Table 3.1). Statistically significant differences were found in the variables for the district where they lived, socioeconomic stratum, health insurance coverage, monthly income and age. No statistical significance was found in all other variables. By districts, statistical differences in participation were only found in pregnant women living in Ciudad Bolívar, showing a higher proportion of those who only answered the questionnaire when compared with those who additionally provided a stool sample (95% vs 59%, p<0.01). Regarding socioeconomic stratum, the 80% of participants who only answered the questionnaire lived in stratum 1, while among those who also provided a stool sample, 51% lived in stratum 1 (p<0.01). Differences regarding health insurance coverage were found in women who were not affiliated, 20% of whom only answered the questionnaire and 12% who also provided a stool sample (p=0.01). For monthly income, a difference was found in women earning less than 1 minimum wage, with a statistically higher proportion of those who answered the questionnaire and provided a stool sample, compared with those who only answered the questionnaire (76% vs 67%, p=0.03) (Table 3.1). Regarding age, participants who only answered the questionnaire were statistically younger (median age 21, range 15-41 years) than those who also provided a stool sample (median age 22, range 14-43 years), p=0.03.

Table 3.1. Comparison of characteristics between participants who answered the questionnaire and participants who additionally provided a stool

	Questionnaire only			Questionnaire and stool sample[1]			pChi[2] exact
	Total: 210			Total: 340			
Characteristic	**$N_{missing}$**	**N**	**%**	**$N_{missing}$**	**N**	**%**	
City district of Bogotá							
Ciudad Bolívar		199	94.8		200	58.8	
Kennedy	0	9	4.2	0	118	34.7	0.00
Usaquén		2	1.0		22	6.5	
Stratum[2]							
One	0	168	80.0	0	172	50.6	0.00
Two		42	20.0		168	49.4	
Ethnicity							
Minority group[3]	0	14	6.7	1	24	7.1	0.86
Majority group		196	93.3		315	92.9	
Occupation							
Homemaker		156	74.3		265	77.9	
Student	0	19	9.0	0	35	10.3	0.44
Sales and services		19	9.0		22	6.5	
Other		16	7.6		18	5.3	

	Questionnaire only			Questionnaire and stool sample[1]			pChi[2] exact
	Total: 210			Total: 340			
Characteristic	$N_{missing}$	N	%	$N_{missing}$	N	%	
Level of education							
Elementary school	0	35	16.7	0	38	11.2	0.12
Secondary school		147	70.0		243	71.5	
Higher education		28	13.3		59	17.4	
Civil status							
Single	0	67	31.9	0	103	30.3	0.70
Married or cohabiting		143	68.1		237	69.7	
Health insurance coverage							
Yes	0	168	80.0	0	300	88.2	0.01
No		42	20.0		40	11.8	
Forced displacement							
Yes	0	41	19.5	0	66	19.4	1.00
No		169	80.5		274	80.6	
Monthly income[4]							
≤1 Minimum wage	48	108	66.7	18	245	76.1	0.03
>1 Minimum wage		54	33.3		77	23.9	
Parity							
Nulliparous	2	100	48.1	1	185	54.6	0.16
Parous		108	51.9		154	45.4	
Trimester of pregnancy							
First	13	43	21.8	6	63	18.9	0.20
Second		74	37.6		152	45.5	
Third		80	40.6		119	35.6	
Last deworming of participant							
Less than 1 year ago	31	28	15.7	32	62	20.1	0.20
More than 1 year ago		77	43.0		109	35.4	
Never		74	41.3		137	44.5	

[1] Questionnaire stool sample corresponds to the participants who answered the questionnaire and provided at least one stool sample

[2] Socioeconomic classification in Colombia

[3] Afro-Colombian and native ethnic people

[4] Minimum monthly Colombian income (for 2016) = USD 233

Recruitment was performed by convenience in the districts of Usaquén and Kennedy, and systematic in the district of Ciudad Bolívar. Best participation was in Usaquén and Kennedy, where a higher proportion answered the questionnaire and provided a stool sample, when compared with those who only answered the questionnaire (41% vs 5%, p<0.01). (Table 3.2.)

Table 3.2.Sensitivity analysis according to method of sample collection

	Questionnaire only			Questionnaire and stool sample[1]			pChi2 exact
Method of sampling	$N_{missing}$	N	%	$N_{missing}$	N	%	
Sistematic (Ciudad Bolívar District)	0	199	94.8	0	200	58.8	<0.01
Convenience (Usaquén+Kennedy Districts)		11	5.2		140	41.2	

[1] Questionnaire stool sample corresponds to the participants who answered the questionnaire and provided at least one stool sample

In the sensitivity analysis, when participation according to sampling method was assessed, statistical differences were only found in the trimester of pregnancy variable, with first trimester women providing the lowest proportion of stool samples (Table 3.3). Statistical differences were not found between sampling method and outcome variables (any parasite, any pathogenic parasite and more than one parasite (Table 3.4).

Table 3.3 Sensitivity analysis according to method of sample collection of sociodemographic and pregnancy characteristics IPI variables

	Sample collection by convenience							Systematic sample collection						
	Questionnaire only			Questionnaire and stool sample[1]			pChi^2 exact	Questionnaire only			Questionnaire and stool sample[1]			pChi^2 exact
	11			140				199			200			
Characteristic	N_m	N	%	N_m	N	%		N_m	N	%	N_m	N	%	
Stratum														
One	0	1	9.1	0	13	9.3	1	0	167	83.9	0	159	79.5	0.3
Two		10	90.9		127	90.7			32	16.1		41	20.5	
Ethnicity														
Minority group	0	0	0	1	8	5.8	0.64	0	14	7	0	16	8.0	0.85
Majoritygroup		11	100		131	94.2			185	93		184	92.0	
Occupation														
Homemaker	0	9	81.9	0	111	79.3	0.6	0	147	73.9	0	154	77.0	0.36
Student		2	18.2		13	9.3			17	8.5		22	11.0	
Sales and services		0	0		11	7.9			19	9.5		11	5.5	
Other		0	0		5	3.6			16	8		13	6.5	
Level of education														
Elementary school		1	9.1		10	7.1			34	17.1		28	14.0	
Secondary school	0	9	81.8	0	102	72.9	0.79	0	138	69.3	0	141	70.5	0.63
Higher education		1	9.1		28	20			27	13.6		31	15.5	

	Sample collection by convenience							Systematic sample collection						
	Questionnaire only			Questionnaire and stool sample[1]			pChi[2] exact	Questionnaire only			Questionnaire and stool sample[1]			pChi[2] exact
	11			140				199			200			
Characteristic	N_m	N	%	N_m	N	%		N_m	N	%	N_m	N	%	
Civil status														
Single	0	3	27.3	0	47	33.6	0.75	0	64	32.2	0	56	28.0	0.38
Married or cohabiting		8	72.7		93	66.4			135	67.8		144	72.0	
Health insurance coverage														
Yes	0	11	100	0	139	99.3	1.00	0	157	78.9	0	161	80.5	0.71
No		0	0		1	0.7			42	21.1		39	19.5	
Forced displacement														
Yes	0	2	18.2	0	21	15.0	1.00	0	39	19.6	0	45	22.5	0.54
No		9	81.8		119	85.0			160	80.4		155	77.5	
Monthly income[3]														
≤1 Minimum wage	0	10	90.9	1	116	83.5	0.7	48	98	64.9	17	129	70.5	0.29
>1 Minimum wage		1	9.1		23	16.5			53	35.1		54	29.5	
Parity														
Nulliparous	0	8	72.7	1	78	56.1	0.35	2	92	46.7	0	107	53.5	0.19
Parous		3	27.3		61	43.9			105	53.3		93	46.5	
Trimester of pregnancy														
First		6	54.5		22	15.8			37	19.9		41	21	
Second	0	1	9.1	1	71	51.1	0.03	13	73	39.2	5	81	41.5	0.8
Third		4	36.4		46	33.1			76	40.9		73	37.4	
Last deworming of participant														
Less than 1 year ago		1	9.1		29	22			27	16.1		33	18.8	
More than 1 year ago	0	2	18.2	8	21	15.9	0.66	31	75	44.6	24	88	50	0.3
Never		8	72.7		82	62.1			66	39.3		55	31.3	

$N_m = N_{missing}$

[1] Questionnaire stool sample corresponds to the participants who answered the questionnaire and provided at least one stool sample

Table 3.4 Sensitivity analysis according to outcome variables

Method of sampling	Any parasite[1]		pChi[2] exact	Any pathogenic parasite[2]		pChi[2] exact	More than one parasite[3]		pChi[2] exact
	N	%		N	%		N	%	
Sistematic	87	44,8	0,14	4	2,1	0,72	19	9,8	0,85
Convenience	50	36,5		4	2,9		12	8,8	

[1] "Any parasite" means that in the sample analyzed, at least one parasite has been identified, regardless of pathogenicity

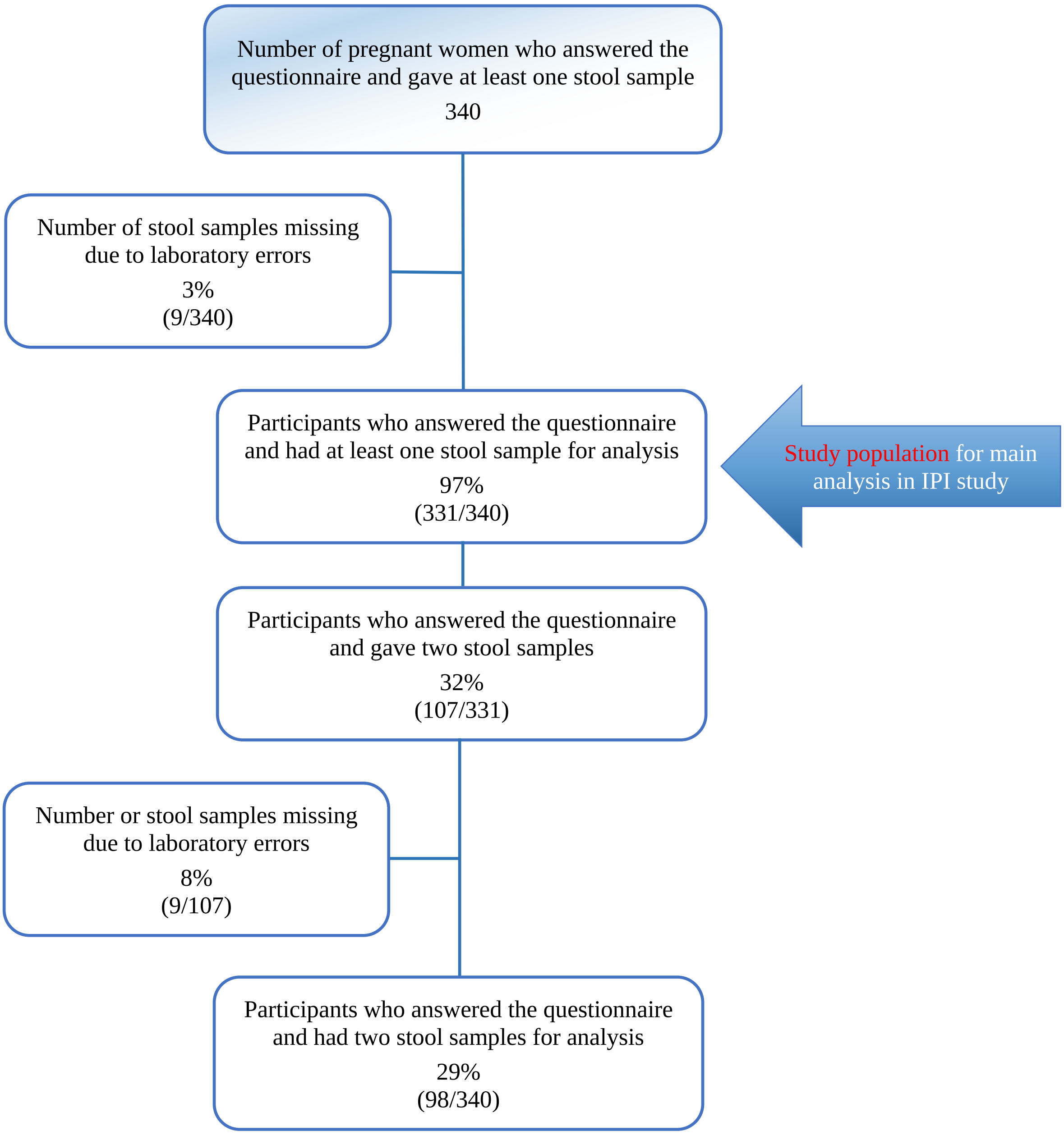
[2] "Any parasite" means that in the sample analyzed, at least one pathogenic parasite has been identified

[3] "More than one parasite" means that in the sample analyzed, multiple parasites have been identified, regardless of pathogenicity

3.1.2. Prevalence of intestinal parasitic infections in pregnant women

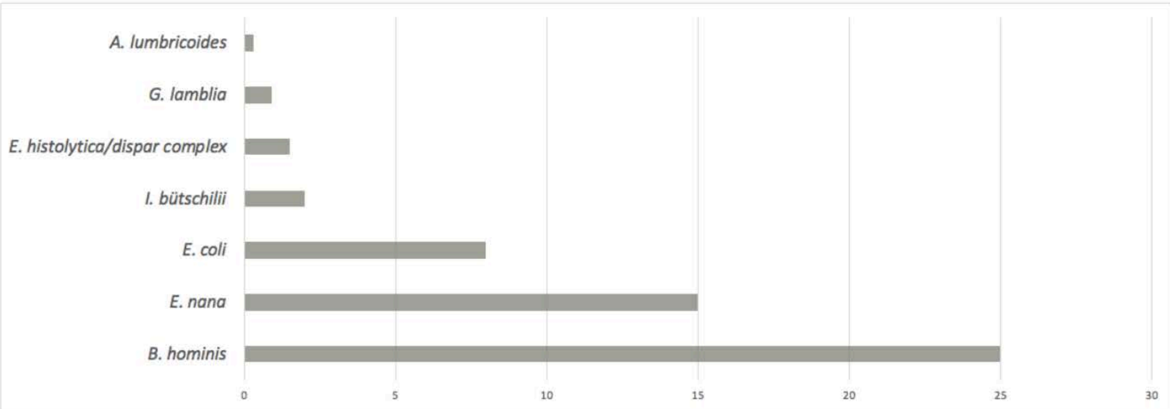
Of the 340 participants who answered the questionnaire and provided at least one stool sample, processing laboratory errors occurred in 3% of samples. From the remaining 331 participants, 32% provided a second stool sample. Of these, 8% missed due to processing laboratory errors. Thus, for this study, analysis of one stool sample was performed in 97% (331/340) of participants and, of two samples, in 29% (98/340) of participants (Figure 3.2). Then we recruited for IPI section the 1.1% of target population of this study.

Figure 3.2 Number of participants with one and two stool samples for analysis by combined microscopy technique



With the 331 participants who provided one stool sample, in 41% (CI 95%: 35.7–46.3) a minimum of one pathogenic or non-pathogenic intestinal parasite s were detected, and in 9% (CI 95%: 5.9-12.0) more than one intestinal parasite was detected (polyparasitism). The overall prevalence of any pathogenic parasite was 1.2% (CI 95%: 0.0–2.4) and included two parasite species: *G. lamblia*, diagnosed in 0.9% and *A. lumbricoides* in 0.3% of participants. The prevalence of *E. histolytica/dispar* complex was 1.5%. Since this complex was only detected with microscopy-based techniques, differentiation between the pathogenic *E. hystolytica* and the non-pathogenic *E. dispar* was not possible in this study (Figure 3.3). The overall prevalence of non-pathogenic parasites was 40.5% (134/331) and included four parasite species: *B. hominis* with a 25% (83/331) prevalence, *E. nana* 15% (50/331), *E. coli* 8% (26/331) and *I. butschilii* 2% (6/331) (Figure 3.3)

Figure 3.3 Prevalence of each intestinal parasite from the study population detected by combined microscopy technique (N=331)

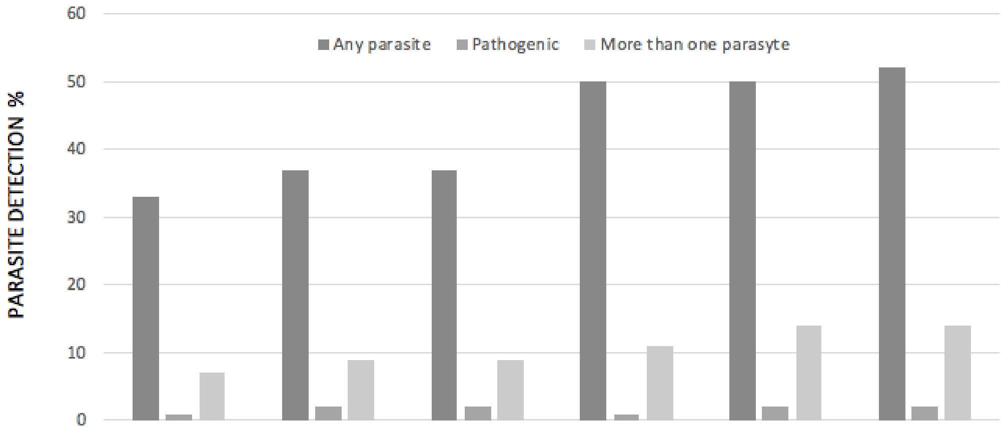


	B. hominis	*E. nana*	*E. coli*	*I. bütschilii*	*E. histolytica/ dispar complex*	*G. lamblia*	*A. lumbricoides*
Prevalence	25	15	8	2	1.5	0.9	0.3

Source: Espinosa *et al*. (257)

A second stool sample was analyzed for 98 women by combined microscopy techniques. With this double sample, the prevalence was of 52% for any parasite and 14% for more than one parasite. Overall detection was increased between examining one and two stool samples, with prevalence for any parasite of 37% and 52%, respectively. Similarly, polyparasitism was detected in 9% with one sample and in 14% with two stool samples. Prevalence for pathogenic parasites remained at 2% (Figure 3.4). When comparing the prevalence between the first and second stool samples, the estimated prevalence with a second stool sample for any parasite was 32%, in contrast with 34% for the first sample, with no statistically significant difference between both samples (p Chi2 exact test=0.26). For this outcome, positive and negative agreements were 42% (CI 32-52) and 70% (61-79), respectively. For any pathogenic parasite, prevalence with the second stool sample was 4.1%, and 3.1% with the first sample, a statistically significant difference between both samples (pchi2 exact test <0.01). Positive and negative agreements were 50% and 99%, respectively. For more than one parasite, prevalence with the second stool sample was 8.2%, and 9.2% with the first sample, a statistically significant difference between both samples (pchi2 exact test=0.02). Positive and negative agreements were 38% and 93%, respectively (Table 3.5).

Figure 3.4 Prevalence of intestinal parasitic infections in the study population



	Direct by one stool sample	Concentration by one stool sample	Combined by one stool sample	Direct by two stool samples	Concentration by two stool samples	Combined by two stool samples
Any parasite	33	37	37	50	50	52
Pathogenic	1	2	2	1	2	2
More than one parasyte	7	9	9	11	14	14

Parasite detection by three methods with one and two samples (n=98). Detection of any parasite and polyparasitism is increased with a combined microscopy technique and with two samples. From Espinosa *et al.* (257)

Table 3.5 Positive and negative agreement between first and second stool samples in 98 participants

Parasite	Prevalence by first stool sample	Prevalence by second stool sample	Prevalence by two stool samples	Positive agreement %	Negative agreement %
				Second vs. First	Second vs. First
	% (n)	% (n)	% (n)	95% CI	95% CI
B. hominis	22.4 (22)	21.4 (21)	35.7 (35)	38.1 (28.5-47.7)	81.8 (74.2-89.4)
E. nana	13.3 (13)	11.2 (11)	22.4 (22)	18.2 (10.6-25.8)	87.4 (80.8-94)
E. coli	4.1 (4)	6.1 (6)	9.2 (9)	16.7 (9.3-24.1)	96.7 (93.2-100.2)
I. bütschilii	3.1 (3)	1.0 (1)	3.1 (3)	100 (100-100)	97.9 (95.1-100.7)
E.hystolitica/ dispar complex	2.0 (2)	2.0 (2)	3.1 (3)	50 (40.1-59.9)	99 (97-101)
G. lamblia	2.0 (2)	2.0 (2)	3.1 (3)	50 (40.1-59.9)	99 (97-101)
A. lumbricoides	0.0 (0)	0.0 (0)	0.0 (0)	100 (100-100)	100 (100-100)
Any parasite[1]	33.7 (33)	31.6 (31)	52.0 (51)	41.9 (32.1-51.7)	70.1 (61-79.2)
Any pathogenic parasite[2]	3.1 (3)	4.1 (4)	5.1 (5)	50 (40.1-59.9)	98.9 (96.8-101)
More than one parasite[3]	9.2 (9)	8.2 (8)	14.3 (14)	37.5 (27.9-47.1)	93.3 (88.3-98.3)

[1] "Any parasite" means that in the sample analyzed, at least one parasite has been identified, regardless of pathogenicity

[2] "Any parasite" means that in the sample analyzed, at least one pathogenic parasite has been identified

[3] "More than one parasite" means that in the sample analyzed, multiple parasites have been identified, regardless of pathogenicity

3.1.2.1. Comparison of qPCR with the combined microscopy technique

Test results for a subset of 48 samples were compared between qPCR results for eight selected parasites, as outlined in the methods section, and the combined microscopy-based techniques. Two of these 50 samples could not be conclusively processed in the combined microscopy technique and therefore had to be excluded from this sub-analysis (Figure 3.5). For the eight investigated parasites, qPCR identified only two types of parasites, *B. hominis* in 54% (26/48) and *G. lamblia* in 4% (2/48). The combined microscopy technique identified *B. hominis* in 27% (13/48) and 0% (0/48) for *G. lamblia*. When comparing both techniques to identify the presence of any parasite in the samples, the prevalence estimated by qPCR was 54% (26/48) in contrast to 31% (15/48) with the combined microscopy technique (p Chi^2 exact <0.01). The positive and negative agreements to diagnose any parasite were 50% (13/26) and 91% (20/22), respectively, while positive and negative agreements to diagnose *B. hominis* were 48% (12/25) and 96% (22/23), respectively. With *G. lamblia*, there was a positive agreement of 0% and a negative agreement of 96% (Table 3.6).

Figure 3.5 Comparison of qPCR with the combined microscopy technique

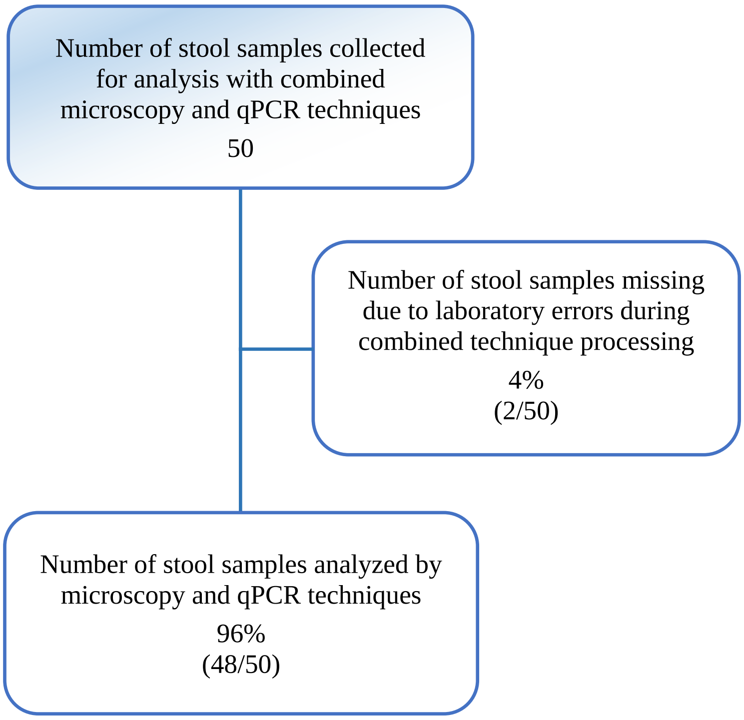


Table 3.6 Comparison between qPCR test and a combined microscopy technique in a subset of 48 participants

	Prevalence by combined microscopy technique % (n)	Prevalence by qPCR technique % (n)	Positive agreement percentage[1] 95% CI	Negative agreement percentage[2] 95% CI
B. hominis	27.1 (13)	52.1 (25)	48.0 30.0–66.5	95.7 79.0–99.2
G. lamblia	0.0 (0)	4.2 (2)	0.0 0.0–0.0	95.8 90.2–100
Any parasite[1]	31.0 (15)	54.2 (26)	50.0 32.1–67.9	90.9 72.2–97.5

n = number of positive study participants diagnosed by each individual test

CI = confidence interval

[1] Positive agreement percentage corresponds to the number of parasites detected by combined microscopy technique and confirmed by qPCR, over the total number of parasites detected by qPCR

[2] Negative agreement percentage corresponds to the number of stool samples reported as negative for parasites by combined microscopy technique and confirmed by qPCR, over the total negative cases detected by qPCR

[3] "Any parasite" means that in the sample analyzed, at least one parasite has been identified, regardless of pathogenicity

3.1.3. Factors associated with infection by any parasite and intestinal polyparasitism

We evaluated associations between infection by any parasite and infection by intestinal polyparasitism with sociodemographic characteristics, living conditions and hygiene behaviors. We found a statistically significant association between infection by any parasite and last deworming. The group with higher prevalence included those who had dewormed "more than 1 year ago" with 52%, followed by the group who "never had dewormed" with 36% prevalence. The group with lowest prevalence included those who had dewormed "less than 1 year ago" with 34% (p=0.02). We also found a higher but non-significant association for civil status and age. Regarding civil status, we found a higher prevalence of 45% for women who were married or cohabiting, while being single had a lower prevalence of 34% (p=0.07). (Tables 3.7-3.8). For age, the participants with any parasite were younger (median age 21, range 14-43 years), while participants without any parasite were slightly older (median age 23, range 14-40 years) (p=0.16).

For polyparasitism, there was a non-significant higher prevalence in women belonging to minority groups in comparison with women belonging to majority groups (21% vs 9%) (p=0.06), and in women residing in a house without water sink in comparison with those possessing a water sink (14 vs 7%) (p=0.07) (Tables 3.7-3.8). Regarding age, there was a non-significant difference between women with polyparasitism (median age 22 years, range 17–37 years) and women without polyparasitism (median age 22 years, range 14-43 years) (p=0.9).

Table 3.7 Prevalence of IPI by sociodemographic characteristics of 331 participants who provided at least one stool sample

		Any parasite			Polyparasitism		
Characteristic	**N**	**n**	**%**	**pChi² exact**	**N**	**%**	**pChi² exact**
City district of Bogotá							
Ciudad Bolívar	194	87	44.8		19	9.8	
Kennedy	115	45	39.1	0.11	11	9.6	0.77
Usaquén	22	5	22.7		1	4.5	
Stratum[1]							
One	168	74	44.0	0.37	17	10.1	0.70
Two	163	63	38.7		14	8.6	
Ethnicity							
Majority group	306	124	40.5	0.39	26	8.5	0.06
Minority group[2]	24	12	50.0		5	20.8	
Occupation							
Homemaker	259	105	40.5		27	10.4	
Student	33	13	39.4	0.38	1	3.0	0.50
Sales and services	21	8	38.1		1	4.8	
Other	18	11	61.1		2	11.1	
Level of education							
Elementary school	38	20	52.6		3	8.0	
Secondary school	234	92	39.3	0.30	22	9.4	0.99
Higher education	59	25	42.4		6	10.2	
Civil status							
Single	101	34	33.7	0.07	10	9.9	0.84
Married or cohabiting	230	103	44.8		21	9.1	
Health insurance coverage							
Yes	291	120	41.2	1.00	25	8.6	0.24
No	40	17	42.5		6	15.0	
Forced displacement							
No	267	107	40.1	0.32	23	8.6	0.34
Yes	64	30	46.9		8	12.5	
Monthly income[3]							
>1 Minimum wage	73	29	39.7	1.00	6	8.2	0.82
≤1 Minimum wage	241	96	39.8		22	9.1	
Parity							
Nulliparous	181	76	42.0	0.82	13	7.2	0.14
Parous	149	60	40.3		18	12.1	
Trimester of pregnancy							
First	61	21	34.4		7	11.5	
Second	149	64	43.0	0.47	16	10.7	0.51
Third	115	50	43.5		8	7.0	

[1]Socioeconomic classification in Colombia
[2]Afrocolombian, native ethnic people
[3]One minimum monthly Colombian income (for the 2016 year) = USD 233
The following variables had missing data: ethnicity (1 missing), monthly income (17 missing), parity (1 missing), and trimester (6 missing)

Table 3.8 Prevalence of IPI by living conditions and hygiene habits of 331 participants who provided at least one stool sample

Characteristic		N	Any parasite n	Any parasite %	Any parasite pChi² exact	Polyparasitism N	Polyparasitism %	Polyparasitism pChi² exact
Water supply								
	Yes	314	129	41.1	0 .80	29	9.2	1.00
	No	17	8	47.1		2	11.8	
Sewage								
	Yes	315	129	41.0	0. 60	29	9.2	0.65
	No	16	8	50.0		2	12.5	
Garbage collection frequency								
	>2 times per week	277	112	40.4	0.44	26	9.4	1.00
	≤2 times per week	52	24	46.2		5	9.6	
Presence of pests								
	No	135	55	40.7	0. 91	11	8.1	0. 57
	Yes	196	82	41.8		20	10.2	
Last deworming of participant								
	Less than 1 year ago	59	20	33.9		5	8.5	
	More than 1 year ago	106	55	51.9	0.02	13	12.3	0.33
	Never	135	48	35.6		9	6.7	
Boiling water before drinking								
	Yes	122	51	41.8	0.90	12	9.8	0.85
	No	207	85	41.1		19	9.2	
Washing fruits and vegetables								
	Yes	317	131	41.3	1.00	30	9.5	1.00
	No	14	6	42.9		1	7.1	
Place for washing hands at home								
	Sink	230	91	39.6	0.33	17	7.4	0.07
	Other[1]	100	46	46.0		14	14.0	
Water availability for washing hands at home								
	From tap water	274	114	41.6	1.00	26	9.5	1.00
	From water tank	56	23	41.1		5	8.9	
Washing hands before eating								
	Yes	211	92	43.6	0.30	21	10.0	0.70
	No	120	45	37.5		10	8.3	
Washing hands after going to the toilet								
	Yes	280	112	40.0	0.28	27	9.6	0.80
	No	51	25	49.0		4	7.8	
Walking barefoot at home								
	No	177	73	41.2	1.00	14	7.9	0.35
	Yes	154	64	41.6		17	11.0	

[1] Kitchen sink or scullery

The following variables had missing data: garbage collection (2 missing), last deworming of participants (31 missing), boiling water before drinking (2 missing), place for washing hands at home (1 missing), and water availability for washing hands at home (1 missing)

In the logistic regression model, women who had dewormed over a year ago showed increased significant odds for any parasite, when compared with women who had dewormed less than a year ago or had never dewormed (cOR 2.1; crude 95% Confidence Interval 1.8-4.06). This statistical difference stayed with the adjusted model (aOR 2.11; adjusted 95% Confidence Interval 1.09-4.09). For civil status, neither the crude nor the adjusted models showed statistical significance (Table 3.9).

Table 3.9 Crude and adjusted results of the logistic regression model relating sociodemographic and pregnancy characteristics to the Any parasite prevalence among 331 pregnant women who provided at least one stool sample

	Any parasite (n=137)			
	cOR1	**c95 % CI2**	**aOR3**	**a 95% CI4**
Last deworming of participant [Ref. Less than 1 year]				
More than 1 year ago	2.1	1.08-4.06	2.1	1.09-4.09
Never	1.08	0.56-2.04	1.1	0.57-2.10
Civil status [Ref. Single]				
Married or cohabiting	1.6	0.98-2.60	1.58	0.95-2.64

In the logistic regression model, being an ethnic minority and washing hands in a place different than a sink, did not show, in the crude and adjusted models, significant odds increase for polyparasitism. Being younger than age 23 showed non-significant decreased odds for polyparasitism, in both crude and adjusted models (Table 3.10).

Table 3.10 Crude and adjusted results of the logistic regression model relating sociodemographic and housing characteristics to the Polyparasitism prevalence among 331 pregnant women who provided at least one stool sample

	Polyparasitism (n=31)			
	cOR[1]	**c95% CI[2]**	**aOR[3]**	**a95% CI[4]**
Ethnicity [Ref. Majority group]				
Minority group	2.83	0.98-8.21	2.7	0.93-7.93
Place for washing hands at home [Ref. Sink]				
Other	2.04	0.96-4.32	1.98	0.93-4.22
Age [Ref. Age 23 or more years]				
Minor than 23 yrs.	0.91	0.43-1.93	0.95	0.44-2.02

3.2. Respiratory Symptoms Results

3.2.1. Descriptive characteristics of the study population, their housing, their environmental condition and their respiratory outcomes

Of the 399 pregnant women in this district who accepted our invitation to participate in the study, 79% provided sufficient residential information required to geocode their homes. For RS study we covered 1% of the target population. Participating women were young, with 40% of the population being younger than 20 years and only 13% older than age 30 yrs. Among all participants, 29% were single mothers. For 46% the participants, the current pregnancy was the first one. Of all participants, 42% were in their third trimester. Almost 19% of women lived in the district due to forced displacement. NDVI values were around zero, indicating the lack of green spaces in most parts of the neighborhood. About three-quarters of the population had a street within 21 meters of their house, while three-quarters of the population lived 3.37 km away from the waste disposal site (Table 3.11). Availability of public services was common with over 97% having access to water services, sewage, electricity and garbage collection. However, housing conditions were precarious with 22% of the women not having a sink and 16% of women sharing their bathroom with other families. Likewise, housing materials were basic with, for instance, only 34% of the houses having concrete floor (Table 3.12).

The overall prevalence of allergic rhinitis was 21%, while the 12-month prevalence of wheezing without a cold was 5.2%, and the prevalence of physician-diagnosed asthma was 4.5%. Concerning sociodemographic characteristics, single mothers had higher prevalence of reported rhinitis, wheezing and asthma than mothers with a partner. Those in the 1st trimester reported higher prevalence of rhinitis and wheezing than those in the 2nd and 3rd trimester. Women older than 30 had a higher prevalence of rhinitis compared with women younger than 30. Women with forced displacement had higher prevalence of rhinitis and asthma than those not forcefully displaced (Table 3.13).

Regarding greenness, the highest proportion of participants with rhinitis was in Q1 (less greenness), with wheezing in Q4 (most greenness) and with asthma in Q3. Participants with asthma lived 15 m away from a main street, while those without asthma lived 13 m away. Regarding access to public services, participants living in housing with poor access (quartile 4) showed lower rhinitis prevalence but higher wheezing and asthma prevalence. For housing conditions, participants living in worse conditions (quartile 4) showed higher rhinitis prevalence but lower wheezing and asthma prevalence. Participants living in housing with a lower quality of materials (quartile 4), showed a higher prevalence of all RS (Tables 3.14-3.16).

Table 3.11 General characteristics, environmental factors and housing factors among 310 pregnant women residing in a low-income neighborhood of Bogotá, Colombia

General characteristics		%	n
Age (years)	≤20	40.0	124
	21-30	47.1	146
	31+	12.9	40
Single mother	Yes	29.4	91
Trimester of pregnancy[1]	1st	20.0	60
	2nd	38.7	116
	3rd	41.3	124
Number of pregnancies	1	45.5	141
	2+	54.5	169
Forced displacement	Yes	18.7	58
Housing factors[3]			
Access to public services	Exposed [4]	32.6	101
Housing conditions	Exposed [4]	66.1	205
Housing materials	Exposed [4]	27.3	86
Environmental factors		Median	IQR
NDVI[2] (radius 100m)		-0.007	(-0.01; 0.00)
Distance to the closest street (m)		13.19	(7.21; 20.89)
Distance to the waste disposal site (km)		2.50	(2.07; 3.37)

[1] N=10 missing data

[2] NDVI: Normalized Difference Vegetation Index

[3] After imputation

[4] Corresponding to the exposed fraction of each dichotomized housing index. Each index was obtained and converted into a scale between 0 (better conditions) and 100 (worst conditions). After the index was obtained, it was divided into quartiles, with the dichotomization cutoff set at the 4th quartile (worst conditions). The confidence interval for the 4th quartile of “access to public services” index was 99.33-100, for the 4th quartile of “housing conditions” index was 94.88-100 and for the 4th quartile of “construction materials” was 84.50-100

Table 3.12 Distribution of variables used to create the housing indices among 310 pregnant women residing in a poor neighborhood in Bogotá, Colombia

Indices and Variables	%	N
Index 1: Access to public services		
No water supply[1]	2.7	8
No access to sewage system[1]	2.7	8
No electricity[1]	2.7	8
No natural gas supply[1]	8.6	25
No garbage collection[1]	0.3	1
Garbage collection frequency 1-2 a week[2]	10.7	31
No land phone[1]	59.9	175
No cellphone[1]	6.8	20
No Internet connection[1]	63.4	185
Index 2: Housing conditions		
One toilet[1]	16.4	48
No bathroom[1]	2.1	6
Bathroom shared with other families[3]	15.7	45
No sink[1]	21.6	63
Sink shared with other families[4]	14.0	32
No separate kitchen[5]	9.8	25
Index 3: Housing materials		
Ceiling materials[6]		
Concrete[7]	50.0	70
Zinc roof tile	30.0	42
Other[8]	20.0	28
Walls materials [6]		
Brick[9]	90.7	127
Non-brick[10]	9.3	13
Floor materials[6]		
Tile[11]	26.4	37
Concrete[11]	33.6	47
Ceramic tablet[11]	32.9	46
Other[12]	26.4	10

[1] N=18 data missing
[2] Only one participant reported no garbage collection
[3] N=24 data missing
[4] N=81 data missing
[5] N=55 data missing
[6] N=170 data missing
[7] Concrete was considered better material for ceiling
[8] Wood, clay roof tile, paperboard or fiber cement (Eternit)
[9] Brick was considered better material for walls
[10] Prefabricated material, wood, clay, paperboard or tin
[11] Tile, concrete and ceramic tablet were considered better materials for floor
[12] Soil, wood or carpet.

3.2.2. Associations between housing conditions, urban green space, environmental exposures and respiratory outcomes

Women in their first trimester of pregnancy had increased odds for allergic rhinitis, although not reaching statistical significance in the adjusted model (aOR 2.09; adjusted 95% Confidence Interval 0.94-4.62). No other general characteristic was associated with the outcomes under study. The crude and adjusted logistic regression models identified non-linear inverse associations between NDVI quartiles and allergic rhinitis reaching statistical significance for the fourth quartile (aOR 0.41; adjusted 95% Confidence Interval 0.17-0.98). Living further away from a street was borderline associated with increased odds for allergic rhinitis and asthma (aOR 0.98; adjusted 95% Confidence Interval 0.93-1.03). None of the housing characteristics were associated with the outcomes (Tables 3.17-3.19).

Table 3.13 Stratified prevalence of respiratory symptoms by sociodemographic covariates among 310 pregnant women residing in a poor neighborhood in Bogotá, Colombia

		Rhinitis %(N)	Wheezing %(N)	Asthma %(N)
		21.0 (65)	**5.2 (16)**	**4.5 (14)**
Sociodemographic variable		**% (n)**	**% (n)**	**% (n)**
Single mother	Yes	26.4 (24)	5.5 (5)	5.5 (5)
	No	18.7 (41)	5.0 (11)	4.1 (9)
Trimester of pregnancy[1]	1st	28.3 (17)	8.3 (5)	5.0 (3)
	2nd	24.1 (28)	5.2 (6)	5.2 (6)
	3st	14.5 (18)	4.0 (5)	4.0 (5)
Number of pregnancies	2+	21.3 (36)	3.5 (5)	2.8 (4)
	1	20.6 (29)	7.9 (11)	7.1 (10)
Age (years)	≤ 20	21.0 (26)	5.6 (7)	4.8 (6)
	21-30	18.5 (27)	4.8 (7)	4.8 (7)
	31+	30.0 (12)	5.0 (2)	2.5 (1)
Forced displacement	Yes	25.9 (15)	5.2 (3)	5.2 (3)
	No	19.8 (50)	5.2 (13)	4.4 (11)

[1] N=10 data missing

Table 3.14 Stratified prevalence of respiratory symptoms by NDVI covariate among 310 pregnant women residing in a poor neighborhood in Bogotá, Colombia

		Rhinitis %(N)	Wheezing %(N)	Asthma %(N)
		21.0 (65)	**5.2 (16)**	**4.5 (14)**
	Q	**% (n)**	**% (n)**	**% (n)**
NDVI 100m	Q1	28.2 (22)	6.4 (5)	3.8 (3)
	Q2	16.9 (13)	2.6 (2)	2.6 (2)
	Q3	26.0 (20)	3.9 (3)	6.5 (5)
	Q4	12.8 (10)	7.7 (6)	5.1 (4)

Table 3.15 Stratified prevalence of respiratory symptoms by air pollution covariates among 310 pregnant women residing in a poor neighborhood in Bogotá, Colombia

	Rhinitis		Wheezing		Asthma	
	Yes	No	Yes	No	Yes	No
Variables	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Distance to the closest street (m)	12.78 (6.76;21.57)	13.39 (7.21;20.68)	10.07 (7.65;15.88)	13.54 (6.86;21.46)	14.79 (11.74;17.30)	12.94 (6.50;21.73)
Distance to waste disposal site (km)	2.53 (2.04;3.34)	2.49 (2.07;3.38)	2.51 (1.99;3.30)	2.49 (2.07;3.37)	2.67 (2.10;3.23)	2.49 (2.07;3.38)

Table 3.16 Stratified prevalence of respiratory symptoms by housing covariates among 310 pregnant women residing in a poor neighborhood in Bogota, Colombia

		Rhinitis % (N)	Wheezing % (N)	Asthma % (N)
		21.0 (65)	**5.2 (16)**	**4.5 (14)**
Housing indices[1] (higher quartiles indicating worse conditions)		**% (n)**	**% (n)**	**% (n)**
Access to public services[2]	Quartile 1-3	23.8 (24)	5.0 (5)	3.0 (3)
	Quartile 4	19.6 (41)	5.3 (11)	5.3 (11)
Housing conditions[3]	Quartile 1-3	20.5 (42)	5.9 (12)	4.9 (10)
	Quartile 4	21.9 (23)	3.8 (4)	3.8 (4)
House materials[4]	Quartile 1-3	18.6 (16)	2.3 (2)	3.5 (3)
	Quartile 4	21.8 (49)	6.3 (14)	4.9 (11)

[1] After multiple imputations of missing data

[2] Water supply, sewage, electricity, natural gas, land phone, cellphone, internet connection, garbage collection, and garbage collection frequency

[3] Availability of basic hygiene devices: one toilet, no bathroom, bathroom shared with other families, no sink, sink shared with other families and no separate kitchen

[4] Construction materials of the ceiling, walls, and floor

Table 3.17 Crude and adjusted results of the logistic regression models relating sociodemographic characteristics, environmental factors and housing characteristics to the prevalence of rhinitis among 310 pregnant women residing in a poor neighborhood of Bogotá

		Rhinitis (n=65)			
		cOR[1]	c95% CI[2]	aOR[3]	a95% CI[4]
General characteristics					
Age (years) [Ref. ≤ 20 year]	21-30	0.86	0.47; 1.56		
	31+	1.62	0.72; 3.60		
Single mother [Ref. No]	Yes	1.56	0.87; 2.77	1.70	0.92; 3.15
Trimester of pregnancy[5] [Ref. 3rd]	1st	2.33	1.10; 4.94	2.09	0.94; 4.62
	2nd	1.87	0.97; 3.61	1.87	0.95; 3.70
Number of pregnancies [Ref. 1st]	2+	1.05	0.60; 1.81		
Forced displacement [Ref. No]	Yes	1.41	0.73; 2.74		
Environmental variables					
NDVI Quartile (100 m radius)	2	0.52	0.24; 1.12	0.59	0.26; 1.33
[Ref. Q1 = lowest greenness]	3	0.89	0.44; 1.81	0.92	0.42; 1.99
	4	0.37	0.16; 0.86	0.41	0.17; 0.98
Distance to closest street (m)		1.01	1.00; 1.03	1.02	1.00; 1.04
Distance to waste disposal site (km)		0.95	0.77; 1.17	0.95	0.75; 1.19
Housing indices [6] (higher quartiles indicating worse conditions) [Ref. Quartiles 1-3]					
Access to public services[7]	Quartile 4	1.28	0.72	2.26	1.13
Housing conditions[8]	Quartile 4	0.92	0.52; 1.63	0.79	0.42; 1.48
House materials[9]	Quartile 4	0.82	0.44; 1.53	0.81	0.42; 1.58

[1] crude Odds Ratio
[2] crude 95% Confidence Interval
[3] adjusted Odds Ratio
[4] adjusted 95% Confidence Interval
[5] N=10 missing data
[6] Missing data imputed
[7] Water supply, sewage, electricity, natural gas, land phone, cellphone, internet connection, garbage collection, and garbage collection frequency
[8] Availability of basic hygiene devices: one toilet, no bathroom, bathroom shared with other families, no sink, sink shared with other families and no separate kitchen
[9] Construction materials of the ceiling, walls, and floor

Table 3.18 Crude and adjusted results of the logistic regression models relating sociodemographic characteristics, environmental factors and housing characteristics to the 12-month prevalence of wheezing among 310 participants residing in Bogotá

		Wheezing (n=16)			
		cOR[1]	**c95% CI[2]**	**aOR[3]**	**a95% CI[4]**
General characteristics					
Age (yrs) [Ref. ≤ 20 year]	21-30	0.84	0.29; 2.47		
	31+	0.88	0.18; 4.42		
Single mother [Ref. No]	Yes	1.10	0.37; 3.26		
Trimester of pregnancy[5] [Ref. 3rd]	1st	2.16	0.60; 7.78		
	2nd	1.30	0.39; 4.37		
Number of pregnancies [Ref. 1st]	2+	1.54	0.48; 4.96		
Forced displacement [Ref. No]	Yes	1.00	0.28; 3.64		
Environmental variables					
NDVI Quartile (100 m radius)	2	0.39	0.07; 2.19	0.41	0.08; 2.19
[Ref. Q1 = lowest greenness]	3	0.59	0.14; 2.88	0.65	0.14; 2.88
	4	1.22	0.36; 4.11	1.17	0.33; 4.11
Distance to the closest street (m)		0.97	0.92; 1.02	0.98	0.93; 1.03
Distance to waste disposal site (km)		0.98	0.67; 1.43	1.00	0.68; 1.47
Housing indices[6] (higher quartiles indicating worse conditions) (Ref. Quartiles 1-3)					
Access to public services[7]	Quartile 4	0.94	0.32; 2.77	0.90	0.29; 2.79
Housing conditions[8]	Quartile 4	1.57	0.49; 4.99	1.41	0.42; 4.74
House materials[9]	Quartile 4	0.36	0.08; 1.61	0.42	0.09; 1.93

[1] crude Odds Ratio
[2] crude 95% Confidence Interval
[3] adjusted Odds Ratio
[4] adjusted 95% Confidence Interval
[5] N=10 missing data
[6] Missing data imputed
[7] Water supply, sewage, electricity, natural gas, land phone, cellphone, internet connection, garbage collection, and garbage collection frequency
[8] Availability of basic hygiene devices: one toilet, no bathroom, bathroom shared with other families, no sink, sink shared with other families and no separate kitchen
[9] Construction materials of the ceiling, walls, and floor

Table 3.19 Crude and adjusted results of the logistic regression models relating sociodemographic characteristics, environmental factors and housing characteristics to the 12-month prevalence of asthma among 310 participants residing in Bogotá

		Asthma (n=14)			
		cOR[1]	c95% CI[2]	aOR[3]	a95% CI[4]
General characteristics					
Age (yrs) [Ref. ≤ 20 year]	21-30	0.99	0.32; 3.03		
	31+	0.50	0.06; 4.32		
Single mother [Ref. No]	Yes	1.36	0.44; 4.16		
Trimester of pregnancy[5] [Ref. 3rd]	1st	1.25	0.29; 5.42		
	2nd	1.30	0.38; 4.37		
Number of pregnancies [Ref. 1st]	2+	1.05	0.60; 1.81		
Forced displacement [Ref. No]	Yes	1.20	0.32; 4.43		
Environmental variables					
NDVI Quartile (100 m radius)	2	0.67	0.11; 4.10	0.59	0.09; 3.76
[Ref. Q1 = lowest greenness]	3	1.74	0.40; 7.53	1.63	0.36; 7.46
	4	1.35	0.29; 6.25	1.12	0.23; 5.40
Distance to closest street (m)		1.02	1.00; 1.05	1.02	1.00; 1.05
Distance to waste disposal site (km)		1.09	0.75; 1.60	1.04	0.71; 1.51
Housing indices[6] (higher quartiles indicating worse conditions) [Ref. Quartiles 1-3]					
Access to public services[7]	Quartile 4	0.55	0.15; 2.02	0.48	0.12; 1.85
Housing conditions[8]	Quartile 4	1.29	0.40; 4.23	1.46	0.41; 5.17
House materials[9]	Quartile 4	0.70	0.19; 2.53	0.71	0.19; 2.71

[1] crude Odds Ratio
[2] crude 95% Confidence Interval
[3] adjusted Odds Ratio
[4] adjusted 95% Confidence Interval
[5] N=10 missing data
[6] Missing data imputed
[7] Water supply, sewage, electricity, natural gas, land phone, cellphone, internet connection, garbage collection, and garbage collection frequency
[8] Availability of basic hygiene devices: one toilet, no bathroom, bathroom shared with other families, no sink, sink shared with other families and no separate kitchen
[9] Construction materials of the ceiling, walls, and floor

4. DISCUSSION

4.1. Summary of Main Findings

We performed a study that included 550 pregnant women living in strata 1 and 2 neighborhoods in three districts of Bogotá. We assessed two health outcomes: IPI and RS. Fieldwork started initially in the districts of Usaquén and Kennedy to assess IPI and then focused on Ciudad Bolívar where both, IPI and RS, were studied. For IPI, analysis of stool samples by combined microscopy techniques found in our participants a 41% prevalence of any intestinal pathogenic and non-pathogenic parasites, and a 9% prevalence of polyparasitism. Women who had dewormed over a year ago had a statistically significantly higher prevalence of any parasite, while women who were married or lived with a partner showed a higher but not statistically significant prevalence of any parasite. Women reporting to belong to minority ethnic groups and those not having handwashing facilities had a higher not statistically significant prevalence of polyparasitism.

Regarding RS, based on questions from the ECHRS questionnaire, we found in our participants a 4.5% prevalence of physician-diagnosed asthma, a 5.2% prevalence of asthma based on symptoms and 21% prevalence of rhinitis. Prevalence of rhinitis was higher in areas with low access to greenness. Finally, in contrast to our own expectations, odds for rhinitis and asthma increased when participants lived further away from main streets.

4.2. Methodological Strengths and Limitations

4.2.1. Strengths of this study

The main strength of this study is that it is the first, in Colombia, to assess IPI, a neglected disease, and RS, in association with sociodemographic and environmental risk factors in pregnant women living in marginalized urban areas of a megacity and in vulnerable socioeconomic conditions. This study included a number of participants living in vulnerable urban settings despite important recruitment and access challenges.

4.2.2. Limitations of this study

4.2.2.1. Limitations of response and field work

In the IPI study, restrictions for recruitment of participants, as well as difficulties collecting at least one stool sample, were main limitations, further magnified by challenging safety conditions and limited access to participants' residences by the research team. In addition, obtaining one or two stool samples was limited by physiologic constipation and specimen collection discomfort often reported by participating pregnant women.

We had different challenges for the recruitment of participants. First, we were not able to obtain the information to build a sample size frame since, as under Colombian data protection laws, we were not allowed to use the contact data that pregnant women gave to the UPA. Consequently, we could not make phone calls to invite pregnant women to participate in our study. Additionally, the schedules for prenatal control in the UPA were interspersed with other medical centre appointments. As a solution to these limitations, the UPA staff suggested that we could invite and recruit pregnant women who came to antenatal courses.

Second, four months after fieldwork had started, during preliminary analysis, we realized that women attending antenatal courses were mostly in their first gestation and were housewives. Added to this, safety problems in Usaquén and selective sampling in Kennedy neighborhoods led us to decide to suspend fieldwork in these districts. To continue the research study, we then decided to focus fieldwork on the district of Ciudad Bolívar. This decision was deemed appropriate as, in this district, most of its inhabitants live in housing classified in strata 1 and 2. Besides, this district has two UPAs that attend 80% of pregnant women in Ciudad Bolívar. Based on these conditions, we did systematic recruitment, following statements outlined by Rothman *et al.* (258).

Third, in Ciudad Bolívar, we again found unsafe conditions for doing fieldwork, and although our research assistants made their best effort, with help by local community leaders, we had the ethical responsibility to guarantee the assistants' safety. Given the low prevalence of pathogenic parasites being found, we decided to stop fieldwork with 550 participants. Our dropout quote was 26%, which was close to our expectation based on empirical estimations of 20% dropout quotes for community-based studies done in Latin America. Also, we were not able to visit homes and observe indoor living conditions in 31% (170/550) of participants, who provided incorrect residence addresses or did not attend agreed home visit appointments. Families living in strata 1 and 2 often move to other locations, as their limited income determines the quality of their rented housing and the time of stay in one home (259). This could explain the difficulty to visit homes by the research team, as a participant could incorrectly provide a past address. Unsafe conditions for research assistants also hindered some home visits.

In our sensitivity analysis comparing convenience and systematic sampling, the only difference found was higher participation of pregnant women in their second trimester, and recruited by convenience sampling. This can be explained as women in the second trimester are more likely to attend antenatal courses, once the uncomfortable first trimester symptoms have passed and pregnancy has stabilized. This observation supported our decision to suspend the convenience recruitment that, in this way, was introducing a selection bias.

Women living in stratum 1 provided fewer stool samples than those who lived in stratum 2. This may be explained by increased difficulty visiting their homes located in areas that were difficult to access, through street stairs and/or located close to the less safe summit. Women living in these conditions can also be more vulnerable as, in this study, they were young and had poor healthcare insurance coverage. However, regarding income, participants earning less than one minimum wage provided more stool samples than those with the highest household income. This could be because women having a job outside the home and thus earning more, were not often there, making it impossible to meet them at home. Nevertheless, this finding requires further exploration in future studies. These differences further emphasize a selection bias, that could hide the reality of pregnant women living in more vulnerable conditions. This is one of the reasons to consider that our observations were only applicable to our study participants.

Regarding RS, access restrictions to participants' residences limited the determination of indoor hygiene indicators through direct observation by research team members. In Ciudad Bolívar, once pregnant women were contacted at the community health centre, a follow-up visit to their homes was scheduled to observe housing conditions related to hygiene. However, there were challenges reaching their homes or obtaining their permission to enter. At times, participants provided an incorrect address, broke the appointment or warned the team about unsafe access, in which case they preferred to answer the questionnaire at the health centre. Altogether, these challenges limited systematic collection of information in some participants, requiring data imputation. The resulting information bias related to georeferencing and hygiene indicators, was then specifically inferred only to the participants who provided the information. Reasons for incorrect provision of an address were not further explored in this study, but may occur due to lack of knowledge of the address, having recently moved in or unwillingness to welcome visits. It would also be possible, in future studies, to evaluate if frequent home address changes, common in Bogotá and Ciudad Bolívar, could indicate economic vulnerability, unsafe living conditions and/or social violence. If this is the case, it is then possible that information bias in this study limited identification of hygiene variables and georeferencing in economically vulnerable pregnant women living in unsafe neighborhoods.

Despite these limitations, our research team made their best individual and collaborative efforts to adapt to the existing conditions. For future similar research, the active participation of local health, security and community leaders is highly recommended to facilitate safe access to locations that are difficult to reach. Although this research was assisted by local health professionals and community leaders, their support was limited. On the one hand, even though health authorities allowed access to pregnant women attending the health centres and provided information about their appointment systems and population outreach programs, they did not facilitate a plan to access women living in the most vulnerable areas in the community. While they had community access experience and information, during our research fieldwork they were undergoing restructuring of the local health system, including centralization of attention at the health centre with less mobilization into the community. On the other hand, the support obtained from community leaders resulted from efforts by local research team members who had built trust through previous work with them and facilitated access to local areas unreachable on their own. Community leaders, however, would often respond informally, with limited commitment and with timing incongruent with the project chronogram. This is reflective of their working priorities that do not include local research activities. Consequently, the support required by local health professionals, community leaders and security authorities, must result from their commitment with the research project, and be reflected by logistics support motivated by a conviction that the research findings may positively impact the community. Although our research team discussed the project and its potential impact with health organizations and community leaders, and invited them to participate, we would have required more advanced development and community-based research projection in these locations to assure their stronger participation (260, 261).

4.2.2.2. Limitations of sample size

The calculated sample size corresponded to 3.5% of the target population, with the 550 participating pregnant women representing 1.8%, the 331 women assessed in the IPI study representing 1.1% and the 310 women assessed in the RS study representing 1% of the target population. Thus, achieving 51% of the estimated sample size in the IPI study reduced the power from 80% to 57%, limiting the possibility of inference from the study. Namely, the probability that the differences found in the study population are real is below 80% of the statistical power, the minimum allowed in biomedical research (262). Thus, in the group of 331 pregnant women who provided at least one stool sample, the association found between "any parasite" and "last deworming" showed a 38% power (231), when comparing last deworming over 1 year ago *versus* never dewormed, with highest prevalence of "any parasite" in women dewormed over 1 year ago. For the same association, a 28% power was found when comparing last deworming over 1 year ago *versus* less than 1 year ago, with highest prevalence of "any parasite" in women dewormed over 1 year ago. The highest prevalence of "any parasite" in married or cohabiting women, compared with single women, showed a 20% statistical power.

In the same group of 331 participants, the highest not significant prevalence of polyparasitism in women of an ethnic minority, compared to those belonging to an ethnic majority, showed a 48% statistical power. Similarly, the highest non-significant prevalence of polyparasitism in women with *versus* without access to handwashing facilities, showed a 10% statistical power. Although having stool analysis sub-groups (one sample *versus* two samples *versus* qPCR), with different sample sizes, consistently showed low prevalence of pathogenic parasites, it limited the power of our findings. Addition of the differences in sensitivity for each type of analysis, further limits inference of the real IPI prevalence. Diagnostic sensitivity of one single stool sample is 76%, 92% for two stool samples and 100% for qPCR.

Similar to the IPI study, in the RS study the power of the findings was 30% (231), affected by imputation of over half of the hygiene data, which negatively impacted the validity of the findings related to this variable. Thus, it is not possible to draw inferences due to the high *beta* error, a consequence of the low power. Increased odds for rhinitis in the first trimester, compared with the second and third trimesters, showed a 10% and 17% power, respectively. The nonlinear association identified between NDVI (Q1 vs Q4) and allergic rhinitis showed a 15% power.

In conclusion, limitations achieving the sample size affected the power of inference of our results. Therefore, our findings described only the characteristics of a specific study population in one specific time.

4.2.2.3. Limitations of study design

A cross-sectional design study simultaneously evaluated exposure and outcomes to establish associations, but not causal inference (263). Added to that, in the IPI study, making association inferences of the findings was limited by missing questionnaire information evaluating exposure data specifically related to monthly income, trimester of pregnancy, last deworming, as well as missing stool samples, the latter evaluating the outcome variable. In the RS study, more than 50% of exposure variables related to indoor housing facilities and construction materials were missing, which limited the possibility of evaluating the real associations with respiratory symptoms. This imputation may be hiding the real situation regarding these variables in populations living in conditions with highest vulnerability.

4.2.2.4. Limitations of questionnaire used in the study

Questionnaire limitations were related to sections that, to be answered, required access to the home of the study participant by a research team member. When access did not occur, these information gaps hindered exposure data related to housing conditions relevant to both the IPI and RS studies. The USAID Demographic and Health Surveys Program (232), when using questionnaires as basis of a study, logistically deploys teams of trained interviewers composed of both men and women who together visit the home, and are supported by fieldwork leaders and field editors who, *in situ*, review data quality. The present study was performed with limited resources that did not permit a similar field strategy.

Regarding RS, outcome variables were collected through self-reporting which can inherently generate recall bias. However, the questions used in our survey were selected from internationally validated questionnaires. Our main limitation was that the exposure variables for housing factors and air pollution were proxy variables. Although Bogotá has 14 environmental air monitors widely spread across the city (264), they are not sufficient to identify environmental pollution for each neighborhood and district. The housing indices used in this study included proxy indicators, some of which were socioeconomic factors perhaps not fully representative of housing conditions.

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4.2.2.5. Limitations of IPI laboratory methods

Study limitations related to the laboratory methods were, on one hand related to the diagnostic performance of the combined technique which improves with serial stool samples (265), and, on the other hand, related to the number of stool samples studied with PCR. Obtaining double stool sampling in 20% of the study population limited our diagnostic capacity of intestinal parasites. The increased IPI prevalence we found with a second stool sample supports the use of serial sampling to achieve better diagnostic capacity. This suggests that IPI prevalence in the study population may be higher than estimated. Molecular diagnosis using PCR techniques, with 100% specificity and close to 100% sensitivity (266, 267), was only possible in 9% of the study population, and revealed higher prevalence of two parasites than with the combined technique. Similar to our double stool sampling results, this observation implies that, had we been able to use PCR in all participants, we would have most likely detected a higher proportion of intestinal parasites. Financial constraints, however, did not permit comprehensive PCR use in all samples.

4.2.2.6. Limitations of statistical methods

The statistical methods used in this study were those originally proposed. In the RS study, however, 55% of housing construction variables and 7-26% of indoor home facilities variables were imputed. Since lack of access to home visits predominated in participants who lived in more vulnerable conditions, these missing data could have revealed more deficient residential infrastructure.

4.3. Study Findings in Comparison with Other National and International Studies

We investigated two health disorders in which the prevalence in pregnant women living specifically in marginalized districts of Bogotá and Colombia, in general, was previously unknown. On the one hand, the study of IPI can provide an approximate overview of environmental factors associated with sanitary conditions and transmission routes. On the other hand, studying RS as chronic non-transmissible diseases can deliver a landscape of environmental factors associated with environmental pollution and living conditions.

Regarding IPI, we found a low prevalence of pathogenic parasites which may reflect the positive effects of public anti-helminthic therapy prevention programs, the good quality of potable water in the city, as well as the presence of running water and sewage systems that decrease the likelihood of pathogen transmission. Although this was expected when studying this population in the capital city of an upper middle-income country, our research also revealed a prevalence of up to 25% of commensal intestinal protozoa, some of which are of disputed pathogenicity, a finding that may point to the persistence of fecal-oral contamination routes in our participating pregnant women. This outcome could be explained through chains of transmission that may still be present in overcrowded family homes built with inadequate infrastructure. This result is also supported by the presence of intestinal polyparasitism, which was also higher in pregnant women belonging to ethnic minorities and in participants who did not have sinks for handwashing in their homes, an indication of lower economic conditions often seen in self-built or poor infrastructure housing. These are all characteristics expected in a country with high inequality.

Regarding RS, the prevalence of asthma and rhinitis in this study was within the range previously reported in the general population in Bogotá. Access to green spaces was inversely correlated with prevalence of rhinitis and living away from the main streets was a risk factor for rhinitis and asthma. These findings are consistent with the physical and socioeconomic environment described, in which study participants living at a distance from green spaces and the main streets are precisely those living in lower quality housing and unsafe conditions. We hypothesize that these RS are additionally determined by the stressful context of living in such conditions.

The environmental factors that we found associated with pregnant women in our study are determined by socioeconomic conditions worth exploring in the future. Although the challenging access to the participants prevented us from achieving a better sampling power, we perhaps are seeing only the tip of the iceberg. To further understand and correct the vulnerable nature of marginalized urban pregnant women, future studies require the participatory support of local health organizations, community leaders and the police to better access vulnerable pregnant women, but also to fund an advanced longitudinal community-centered research through constructive and sustainable fieldwork in Colombia.

Our study provides the first evidence that, in pregnancy, access to green space may be inversely associated with allergic rhinitis in a vulnerable urban neighborhood of an upper middle-income country. At the same time, vulnerability, as indicated by living distance to the main street, might outweigh the effects of housing conditions on respiratory health. The social conditions in Ciudad Bolívar, evident on economic limitations, high insecurity, and neighborhoods that are difficult to access (268), provide a unique context to explain our findings regarding greenness and air pollution. Future studies are needed to dissect and control for these variables to more clearly assess the effects of environmental exposures on respiratory disorders in this population. Because of security and housing conditions in our study population, we consider that the RS identified can be mediated by the vulnerability, environmental and socioeconomic conditions. Although these could all point to the non-atopic nature of the RS, future studies must typify them to confirm this hypothesis in our population.

4.3.1. General study population characteristics

The distribution by socioeconomic strata in our study population is similar to that of Ciudad Bolívar District. Specifically, 62% of the study participants lived in stratum 1, similar to the 59% proportion of Ciudad Bolívar. Moreover, our 39% of study participants living in stratum 2 was comparable with the 35% in Bogotá. Overall then, regarding socioeconomic strata, our study population more closely resembled the district of Ciudad Bolívar. Regarding affiliation to the social security system, in our study, 85% of participants were affiliated, much lower than the affiliation coverage in Bogotá and Colombia, ranging from 95% nationwide to 99.8% in Usaquén. Regarding levels of education, 71% of study participants had secondary education, a higher proportion than the three districts individually, Bogotá and Colombia. Participants also proportionally had higher post-secondary education than inhabitants of Ciudad Bolívar, but lower than those living in other districts, Bogotá and Colombia. For occupation, data to compare our findings regarding stay-at-home women and women who study, were not available. Participant distribution by occupation including 55% working in sales and services, and 45% in other occupations, was similar to that reported for the districts of Usaquén and Kennedy, as well as for Bogotá and Colombia. In contrast, data from Ciudad Bolívar showed a much higher 79% proportion of women working in sales and services. The proportion of single women in our study was similar to all women and all pregnant women in Bogotá and Colombia. It is noticeable that our study included a high proportion of displaced women, similar to the 20% reported in Ciudad Bolívar but higher than the nationwide Colombian 15% average. In this study, 7% of participants self-identified as belonging to an ethnic group, higher than those separately reported in the three districts, similar to Bogotá and lower than Colombia. In our study the 73% of participating women with income equal or lower than one monthly minimum wage was much higher than that of women living in the comparing districts, Bogotá and Colombia, where proportions were between 13% in Kennedy District and 43% in Colombia. This research included 31% of pregnant women under age 20, a higher proportion than those reported in Bogotá and Colombia, ranging between 15% in

Bogotá and up to 25% in Ciudad Bolívar. In conclusion, sociodemographic characteristics of participants in this study showed particular differences, not comparable with the districts, Bogotá and Colombia. Specifically, our study participants included a high proportion of women living in socioeconomic stratum 1, with secondary education, first pregnancy under age 20, displaced and with income lower than one minimum wage (Table 4.1).

Table 4.1 Comparison of participants' general characteristics with women in Ciudad Bolívar, Usaquén and Kennedy Districts, Bogotá and Colombia

Variable	Current Study		Ciudad Bolívar District		Usaquén District		Kennedy District		Bogotá D.C		Colombia	
	n	%	n	%	n	%	n	%	N	%	n	%
Stratum[1]												
One	340	61.8	360,009[4]	58.4	21,374[5]	4.6	16,961[6]	1.7	1,284,836[7]	15.9	2,798[8]	21.2
Two	210	38.2	232,403	37.7	52,506	11.3	555,715	55.7	2,820,176	34.9	5,504	41.7
Health insurance coverage[1]												
Yes	468	85.0	729,456[9]	99.4	473,237[10]	99.8	1,201,726[11]	99.4	7,612,051[12]	94.2	48,067,320[13]	95
Level of education[2]												
Elementary school	73	13.3	108,236[14]	37.1	30,005[15]	12	108,114[16]	21.8	863,213[17]	23.4	6,001[18]	15.5
Secondary school	390	70.9	135,369	46.4	80,013	32	216,725	43.7	1,479,266	40.1	18,972	49
Higher education	87	15.8	32,675	11.2	133,521	53.4	154,237	31.1	1,217,351	33	12,970	33.5
Pregnant women <20 yrs	171	31.1	7,847[19]	25.1	3,916[20]	18.7	6,421[21]	14.7	51,697[22]	15.3	1,149[23]	17.4
Occupation[3]												
Sales and services	41	54.7	100,256[24]	79.4	51,424[25]	49.2	116,588[26]	54.2	906,913[27]	55.4	15,473[28]	59.1
Other	34	45.3	26,137	20.7	52,992	50.7	98,519	45.8	730,114	44.6	10,708	40.9
Civil status[2]												
Single	170	30.9	NA	NA	NA	NA	NA	NA	767,216[29]	35.9	13,779[30]	35.6
Married or cohabiting	380	69.1	NA	NA	NA	NA	NA	NA	1,038,626	48.6	19,242	49.7
Forced displacement [1]												
Yes	107	19.5	89394[31]	15.65[32]	13310[33]	2.33	77056[34]	13.49	571207[35]	7.78	7338916[36]	15[37]
Ethnicity[1]												
Minority group	38	6,9	6,560[38]	1.2	5,258[39]	1.2	11,061[40]	1.2	NA	6.6[41]	NA	14.4[42]
Monthly income[1]												
≤1 Minimum wage	353	72.9	62,732[43]	37	31,048[44]	20	36,036[45]	12.5	448,104[46]	20.5	18,400,535[47]	43.0[48]

NA: Information not available

[1] Estimations of these variables included women and men, as available data were not segregated by gender

[2] Estimations of these variables included only women

[3] Information of the number of homemakers and the number of women only studying, according to the age range of our study population, is not available for comparison within districts and Colombia

[4-6] (138), [7,9] (269), [8] (270), [10] (271), [11] (272), [12] (273), [13] (274), [14-22] (50), [24-27,29] (50), [23,28] (14), [30] (14), [31-36] (275), [37] (276), [38-40] (277), [41,42] (14), [43-46] (278), [47-48] (279). Data in this table was built by the main researcher, taking available information from different sources. Best available data were obtained from Colombian resources with data that are frequently changing, not and/or unified, not and/or missing, in which case it was calculated, built or estimated

4.3.2. Prevalence of intestinal parasitic infections

Prevalence with one stool sample per participant for any parasite was 41% and less than 2% for any pathogenic parasite. The detection of parasite infections was increased with two stool samples, as previously reported by Cartwright (237). Despite this increased sensitivity, we verified the low prevalence of pathogenic intestinal parasites in our participants. Physiologic constipation during pregnancy, unsafe conditions during fieldwork and geographical limitations for access, were all factors that constrained the collection of second samples in more participants. Double stool sampling in the study, if increased, would have likely shown a more accurate IPI prevalence. Based on the agreement analyses between the first and second stool samples, first, there was a low agreement when both samples were independently analyzed, and second, there were statistically significant differences in the detection of pathogenic parasites and polyparasitism between both samples. These findings may be explained by the non-continuous parasite excretion in stools (280), and by the stronger diagnostic performance achieved with serial, rather than independent, sampling, demonstrated by a higher parasite detection when the sum of both samples is considered (281). Overall, the diagnostic capacity of this study was negatively affected by the lack of serial sampling in all participants.

A low prevalence of pathogenic parasites was confirmed by qPCR amplification, although, when compared with the combined microscopy techniques, this molecular analysis identified a higher prevalence of *B. hominis* and *G. lamblia*. As expected, there was a low relative positive agreement between both techniques, since qPCR has a sensitivity in stool samples of up to 100% with a primer-determined specificity of 100% (266, 267). This optimal sensitivity is superior to the detection reported when combining three techniques (direct, concentration and Kato-Katz) of 47% for *T. trichiura*, 75% for hookworms and 78% for *A. lumbricoides* (236). Of these three parasites, our study using direct, concentration and qPCR techniques only detected *A. lumbricoides* in 0.3% of stool samples. If in our study we could have used qPCR to analyze all stool samples, it would have been possible to achieve a more precise prevalence of intestinal parasites. Thus, prevalence findings in this study are likely underestimating the real IPI prevalence in participants.

This research is the first study establishing the prevalence of intestinal parasitism during pregnancy in Colombia and identifying associated environmental factors. Until now, such studies have mainly focused on pediatric populations and reported intestinal parasitism prevalence ranging between 11% and 50%. Two large scale studies have confirmed these findings, first one PAHO database from country-specific point prevalence studies (74) and second by a 2012-2014 cross sectional national study to identify IPI prevalence in school children (282). In the general population, a 1985-1986 cross-sectional study with 205 people aged 0-64 years living in marginal neighborhoods in Bogotá, found a 31% prevalence of both, *A. lumbricoides* and *E. coli*, 15% *T. trichiura*, 13% *E. histolytica*, 11% *E. nana*, 8% *G. lamblia* and *I. Bütschlii*, 3% *H. nana* and 1% *S. stercoralis*. The group age with a higher prevalence of parasitism was 5-14 years, except for *E. histolytica*, most prevalent at age 25-44 (227). In contrast, our results showed a decreased prevalence of pathogenic parasites which could indicate that environmental, socioeconomic and hygienic conditions were better in our population, and our prevalence of non-pathogenic parasites (*E. coli* 8% and *E. nana* 15%) were closely similar to those reported by Agudelo *et al.* (227) (Table 4.2).

A 2012-2013 study in Bogotá (82) with children 0-5 years old and living in low socioeconomic conditions, reported a high prevalence of intestinal parasitism, mainly pathogenic protozoa (*G. lamblia* 19% and *E. histolytica/dispar complex* 8%) and protozoa of debated pathogenicity (mainly *B. hominis* 10%). It also found a low prevalence of helminths including *H. nana* 1%, *T. trichiura* 1% and *A. lumbricoides* 1%. Although this study was performed in Usaquén, one of the districts included in our study, the higher prevalence of pathogenic protozoa reported when compared with our findings, may be due to studying children who have a developing immune system and depend on others to practice behaviors that prevent parasitic transmission (283). Moreover, in children found to have intestinal parasites, 50% lived in areas without access to piped water or sewage systems, compared with our study population, in which less than 1% of participants lacked these services (Table 4.2).

The Colombian national survey of parasitism (282) evaluated IPI prevalence in approximately 7,800 children nationwide, using the combined microscopy and Kato-Katz techniques. The most common parasite was *B. hominis* with 52% prevalence, two times the reported in our study. The most common pathogenic parasite was *T. trichiura* with 18% prevalence, not identified in our study. Associated factors included living in a rural zone, belonging to an ethnic group, affiliation to subsidized health coverage, low household income and walking barefoot. The survey also reported low IPI prevalence in children not recently dewormed with anti-parasitic drugs. Although it focused on children, the survey did not assess children living in Bogotá. Although it is not comparable with our study, it identified factors associated with IPI (Table 4.2).

A 2011 cross-sectional study of 90 school children living in poor socioeconomic conditions in urban Medellin (236), analyzed single stool samples collected from each participant, with three different diagnostic methods, namely, direct examination, Ritchie's concentration and Kato-Katz techniques. This study did not, however, assess sociodemographic and environmental characteristics of the participating schoolchildren. Prevalence reported for soil-transmitted helminths included 64% for *T. trichiura*, 44% for *A. lumbricoides* and 9% for hookworms. The diagnostic sensitivity and ability to determine degree of infection were similar when comparing Kato-Katz *versus* combined direct/Ritchie techniques for *A. lumbricoides* and hookworms, and slightly lower for *T. trichiura* with Kato-Katz alone. These findings showed higher geohelminth prevalence than in our study, as it was done with schoolchildren living in a city with environmental characteristics more favorable to helminth life cycles. The comparable sensitivity between Kato-Katz, the method recommended by the World Health Organization, and the combined microscopy technique used in our study, further supports the validity of the IPI prevalence found in our study population (Table 4.2).

A 2005 cross-sectional study in Tunja, Colombia, a city with similar weather and altitude to Bogotá, where 507 school children and adolescents, aged 5-18 years, showed a 90% overall IPI prevalence, with *B. hominis* showing the highest prevalence of 67%, followed in descending order by *E. nana* 47%, *E. coli* 32%, *E. histolytica/dispar complex* 9%, *G. lamblia* 8%, *I. bütschlii* 4% and *T. trichiura* 1% (133). Chronic malnutrition was present in 34% of girls and 22% of boys. Similar to our findings, this study showed higher protozoal, rather than helminthic, IPI prevalence, an observation that may be partially explained by the similar climatic conditions of Tunja and Bogotá, both unfavorable to helminthic life cycles. Finally, the protozoal prevalence described in Tunja is higher than in our study, consistent with the much lower age bracket of the study population (Table 4.2).

A 2004 cross-sectional study in a Colombian general community, included 382 individuals aged 15-44 living in a rural area without sanitary infrastructure in a tropical northern coast of Colombia. It found that 92% of participants had at least one intestinal parasite with 60% *E. coli*, 56% *A. lumbricoides*, 54% *E. histolytica/dispar complex*, 53% *T. trichiura*, 36% *E. nana*, 29% *B. hominis*, 21% *I. butschilii*, 17% *G. lamblia*, 6% uncinaria, 4% *H. nana* and 3% *S. stercoralis* (87). Compared with our study, it showed higher prevalence for all parasites, explained by the sea level community location favoring parasitic life cycles, and the rural community setting with poor sanitary infrastructure, open defecation, water delivery by tank trucks, 12% illiteracy and 39%

incomplete primary school. In contrast, in our study, basic sanitary conditions corresponded with the urban sanitary infrastructure of the capital city, with less favorable climatic conditions for parasite life cycles and a community with a higher educational level (Table 4.2).

Overall, these studies show that both, pathogenic and non-pathogenic parasites are prevalent in urban and rural Colombian communities, and that socioeconomic and sanitary characteristics such as belonging to an ethnic group in vulnerable conditions, subsidized health insurance, low income, wearing no shoes at home and dirt floors (227, 282), may be important conditions to favor the develop of IPI prevalence. Furthermore, differences in prevalence for each parasite within the same community, although sharing similar risk factors, suggest that there are particular environmental conditions and host characteristics, such as nutritional and immunological status and age, that favor higher prevalence for specific parasites (282).

Table 4.2 Comparison of findings in our IPI study with other similar IPI Colombian studies

Study information [title, year of study, location, altitude (meters over sea level) and participants]	Study design & data collection	Main Findings		
		Socio-demographics characteristics	Prevalence	Risk factors
• Prevalence and risk factors for intestinal parasitic infections in pregnant women residing in three districts of Bogotá, Colombia (257) • 2015-2016 • Bogotá, Colombia • 2640m • Pregnant women: 331	• Cross-sectional, community-based • Questionnaire • Stool samples: - 331 stool samples analyzed by combined microscopy technique - 48 stool samples analyzed by qPCR	• 51% stratum 1 • 59% living in Ciudad Bolívar district • 78% housemakers • 88% secondary school or higher education • 69% married or cohabiting • 88% health insured • 73% monthly income ≤253 USD	• IPI 41% (1 sample) • IPI 52% (2 samples) • Polyparasitism 9% (1 sample) and 14% (2 samples) • *B. hominis* 25% • *E. nana* 15% • *E. coli* 8% • *I. bütschlii* 2% • *E. histolytica/dispar* 2% • *G. lamblia* 1% • *A. lumbricoides* <1%	• High prevalence of any parasite - Pregnant women who had never dewormed - Married or cohabiting • High prevalence of polyparasitism - Pregnant women who belong to minority ethnic groups - No sink for washing hands
• Access to drinking water, environmental protection and intestinal parasites in pediatric patients from the neighborhood El Codito in Bogotá, Colombia (82) • 2012-2013 • Bogotá, Colombia • 2640 m • Children:144	• Cross sectional study • Questionnaire • 144 stool samples analyzed by direct and Ritchie methods	• Age 4-70 months • Forcefully displaced people • Low socioeconomic conditions • No infrastructure for public services (water supply, sewage, garbage collection)	• IPI 39% • *G. duodenalis* 19% • *B. Hominis* 10% • *E. histolytica/dispar* 8% • *E. coli* 6% • *E. nana* 6% • *A. lumbricoides* 1% • *I. bütschlii* 1% • *H. nana* 1% • *T. trichiura* 1%	• High IPI prevalence: - Children without access to water and sewage - Girls - Low socioeconomic conditions - Children living in households with many family members - Children with subsidized health coverage - Children living in tenement houses - Children living with animals • Lower IPI prevalence in children with mothers working in technical and professional jobs

Study information [title, year of study, location, altitude (meters over sea level) and participants]	Study design & data collection	Main Findings		
		Socio-demographics characteristics	**Prevalence**	**Risk factors**
• National Survey of Intestinal Parasitism in the Colombian School Population (282) • 2012-2014 • Colombia • Different Altitudes • Schoolchildren: 7.860	• Cross-sectional • Observational, population survey • Stool sample (direct, concentration, Kato-Katz)	• Age 7-10 years • 24% stratum 2 and 48% stratum 1 • 12% belong to any minority ethnic group • 96% health insured	• Any STH 30% • *B. Hominis* 52% • *E. coli* 28% • *I. bütschlii* 26% • *E. nana* 25% • *T. trichiura* 18% • *E. histolytica/dispar* 17% • *G. lamblia* 15% • *A. lumbricoides* 11% • *E. hartmanni* 11% • Hookworms 6% • *C. mesnili* 2% • *S. stercoralis* 1% • *E. vermicularis* 1% • *H. nana* 1% • *Cryptosporidium sp* 1%	• For helminths: - Rural residential zone (RP: 1,35, IC95%: 1,24-1,46) - Belonging to a minority ethnic group (RP: 1,71, IC95%: 1,55) - Health coverage different to contributive regime (RP: 2,80, IC95%: 2,37-3,31) - Household's income lower than 2012 minimum wage (OR: 2,13, IC95%: 1,10-4,13) - Lower geohelminth prevalence in children who had not received antiparasitic drugs in the last 3 months (RP: 0,73, IC95%: 0,66–0,80) - Never or almost never wearing shoes (RP: 1,28, 95%IC: 1,18 – 1,38)
• Evaluation of three coproparasitoscopic techniques for the diagnosis of intestinal geohelminths (236) • 2011 approx. • Medellín, Colombia • 1538 m • Schoolchildren: 90	• Cross- sectional • One stool sample analyzed by three methods: direct, Ritchie, Kato-Katz	• Not studied	• *T. trichiura* 64% • *A. lumbricoides* 44% • Hookworms 9%	• Not studied

Study information [title, year of study, location, altitude (meters over sea level) and participants]	Study design & data collection	Main Findings		
		Socio-demographics characteristics	**Prevalence**	**Risk factors**
• Prevalence of intestinal parasitism and nutritional status in school children and adolescents in Tunja (133) • 2005 • Tunja, Colombia • 2810 m • Schoolchildren: 507	• Cross-sectional • One stool sample (direct, Ritchie) • Hemoglobin • Nutritional status	• Age 5-18 years • 80% from public schools • 72% secondary education	• Any parasite 90% • Polyparasitism 54% • *B. hominis* 68% • *E. nana* 47% • *E. coli* 32% • *E. histolytica/dispar* 9% • *G. intestinalis* 8% • *I. bütschlii* 4% • *C. mesnili* 1% • *T. trichiura* 1%	• Not studied
• Prevalence of intestinal parasitosis and associated factors in a township of the Colombian Atlantic coast (134) • 2004 • Loma Arena, Bolívar, Colombia • 0 m • General population:382	• Cross-sectional • Household survey • Two stool samples (direct, Ritchie)	• 15-44 years old • 67% females • 29 dedicated to household activities • 12% illiteracy • 39% had incomplete primary education	• Any parasite 92% • Any pathogenic parasite 92% • Polyparasitism 89% • *E. coli* 60% • *A. lumbricoides* 56% • *E. histolytica/dispar* 54% • *T. trichiura* 53% • *E. nana* 36% • *B. hominis* 29% • *G. duodenalis* 17% • Hookworms 6% • *H. nana* 4% • *S. stercoralis* 3% • *Ciclospora sp* 1% • *E. vermicularis* 1% • *T. hominis* 1%, *Taenia sp* 1%	• No significant associations between parasitism, educational level and sanitary habits

Study information [title, year of study, location, altitude (meters over sea level) and participants]	Study design & data collection	Main Findings		
		Socio-demographics characteristics	**Prevalence**	**Risk factors**
• Intestinal parasitism in marginalized communities of Bogotá (228) • 1988 • Bogotá-Colombia • 2600 • General population: 207	• Cross-sectional • Stool samples (Ritchie-Frick)	• Age 0-64 years • Marginalized poor	• *A. lumbricoides* 31% • *E. coli* 31% • *T. trichiura* 15% • *E. histolytica* 13% • *E. nana* 11% • *G. lamblia* 8% • *I. bütschlii* 8% • *H. nana* 3% • *S. Stercoralis* 1%	• Housing with dirty floors • Poor environmental & hygienic conditions

Regarding IPI in pregnancy, we compared the findings of this study with 13 similar investigations (Table 4.3) evaluating IPI in pregnant women in Latin America, Africa and Oceania. These were all done with populations living at altitudes ranging between 80 and 2,800 meters above sea level, while our study was carried out at the high altitude of 2,630 meters. Most studies (11 of 13) shared similar cross-sectional study designs, with two exceptions being a clinical trial (284) and a retrospective study (285). All studies were performed between 1994 (Uberlandia, Brazil) and 2016 (Mecha District, Ethiopia) and included between 153 (Kitale, Kenya) and 2,390 (Quininde, Esmeralda Province, Ecuador) participants. Information on factors associated with IPI was mostly collected using questionnaires. Stool parasite detection techniques included triple serial fecal sampling in only one Mexican study that used Faust's concentration (148). The only studies that used three techniques, included one with Ecuadorian women in which stools were analyzed with a combination of direct, formol-ether concentration and Kato-Katz (286), and the other with Ethiopian participants in which stools were analyzed using direct, formol-ether concentration and modified Ziehl-Neelsen (29). Aside from these, as in the present study, the most common parasite stool detection involved a combination of direct and Ritchie's concentration in four studies (284, 287-289). Finally, just one study used only direct parasite detection methods (290). Overall, regarding parasite detection techniques, our findings are comparable only with the four studies that used the same combined microscopy techniques in different Ethiopian and Tanzanian study populations (Table 4.3).

Latin American studies of IPI in pregnant women revealed contrasting findings with our research. The first study was done in Uberlandia, Brasil, where polyparasitism in pregnant women and pathogenic parasite were reported to be higher than in our study (285). A Mexican study with pregnant women in Minatitlan, Veracruz, assessed associations between IPI and low birth weight, and reported higher prevalence of pathogenic parasites when compared with our study, including 66% *G. lamblia*, differences probably understood in the context of an education level lower than high school in their participants, and a geographical location with warmer low-altitude weather (148). A large multicentric study involving nine Venezuelan states that evaluated IPI and anemia in pregnancy, found higher prevalence in all intestinal parasites, except *E. nana* and *E. coli*, without providing a sociodemographic context sufficient to compare with our study (291). In a study in Quininde, Ecuador, a rural low-altitude location, Cooper *et al.* (286) evaluated helminthic IPIs in pregnant women in a follow-up cohort, using three detection techniques, including Kato-Katz, a high sensitivity technique. This study found a higher STH prevalence than in our study, likely due to its tropical setting favoring the development of parasitic cycles (292) and the use of more accurate laboratory techniques.

Studies of IPI in pregnant women in Ethiopia, Kenya and Tanzania reported higher prevalence of soil-transmitted helminths and pathogenic protozoa, when compared to our research, in which just 1% of participants had *A. lumbricoides* and *G. lamblia*. A study in the Ethiopian northwestern city of Bahir Dar, at 1,800 meters above sea level, reported, compared with our findings, lower IPI prevalence (32%) but higher prevalence of *G. lamblia* (13%) and STHs, findings interpreted by the authors as being consistent with their use of three parasite detection techniques and local environmental water pollution favoring fecal-oral transmission (29). At a similar high altitude of 1,780-2,566 meters above sea level in Ethiopian East Wollega, Mengist *et al.*(289) reported a 15% prevalence of hookworms, parasites not found in our study, a contrasting finding that could be understood in the context of their 63% rural population with 34% illiteracy and lack of basic sanitary facilities. The Mecha district Ethiopian study, another high-altitude region at 1,720-2,800 meters above sea level, reported a much higher overall 71% IPI prevalence, with 33% *A. lumbricoides*, 17% *S. mansoni* (not found in our participants) and 14% hookworms (113), findings that may be higher due to the rural setting, overall lower education level, lack of latrines and handwashing facilities in the community. Three studies carried out in predominantly rural Ethiopian and Kenyan communities (287, 288, 293), all found higher IPI prevalence for pathogenic geohelminths than this study, differences likely explained by more limited rural basic sanitary infrastructure, warmer lower 1,357-1,600 m altitude and higher illiteracy when compared with our study population. Similarly, a study in the agricultural town of Kitale, Kenya, with an altitude of 1,890 m above sea level, found higher intestinal helminth infections, particularly in individuals with low educational levels (294). A study in Dar es Salaam, Tanzania, a large port city, reported, in HIV-infected pregnant women, higher helminth and similar protozoal prevalence than in our study, likely reflecting the sea level urban conditions of their participants (284). Only one study from Oceania, examined IPI in pregnant women in Goroka, a small town in the highlands of Papua New Guinea (290), and reported much higher helminth and protozoa IPI than our study, differences likely explained by the lack of residential toilet facilities and piped drinking water in the majority of participants, compared with 5% in our participants (Table 4.3).

Given that many IPI share common routes of transmission, polyparasitism is a common occurrence in populations with associated risk factors. In our study, the prevalence of polyparasitism was 9%, within the range found in two studies which reported prevalence as low as 7% in Ethiopian pregnant women (159) and up to 33% in a Brazilian cohort (285). This variability may be explained by geographic differences, age variations, diversity of health conditions and cultural practices in different study areas (29). Polyparasitism in pregnant women was reported as low as 1% (4/372) of women with two or more intestinal helminths (289), 1% (2/153) of women with two parasites (294), 3% (13/384) with two different parasites (29), 5% (10/207) with two parasites and 1% (3/207) with three parasites (148), 7% (60/908) with double infection and 1% (6/908) with triple infection (159), 11% (53/503) having two parasites and 3% (17/503) with several parasites (285), and as high as 35% (360/1038) with two simultaneous intestinal parasites and 8% (84/1038) with three and 0.2% (2/1038) with more than 3 parasites (291).

Using various IPI detection techniques, we found a low prevalence of pathogenic intestinal parasites in pregnant women, including *G. lamblia* and *A. lumbricoides*. These results contrast with similar studies reporting higher prevalence. For *G. lamblia*, the 1% prevalence reported here was the same found in 927 Tanzanian pregnant women infected with HIV (284) but lower than the reported 2% in a Brazilian cohort (285), 3% in southeastern Ethiopia (295), 13% in northwestern Ethiopia (29), 14% in a Venezuelan study (291), 19% in southern Ethiopia (288), 39% in New Guinea (290) and 66% in coastal Mexico (148). For *A. lumbricoides*, the only helminth found in our study, the prevalence of 0.3% reported here contrasted with similar studies reporting, in ascending order, 3% in northwestern Ethiopia (29), 3% in Brazil (285), 7% in western Ethiopia Ethiopia (289) and in western Kenya (294), 9% in Butajira, central region from Ethiopia (159), 14% in coastal Mexico (148) and New Guinea (290), 19% in southeastern Ethiopia (295), 23% in Ecuador (286), 29% in southern Ethiopia (288), 33% in western Ethiopia (113), 52% in western Kenya (293), and 57% in Venezuela (291). For *E. histolytica/dispar* complex, the 2% prevalence reported here was lower than the 12% reported in a large multi-state study from Venezuela (291) and 8% in a smaller study in northwestern Ethiopia (29). In the combined microscopy technique we used for stool samples, it was not possible to distinguish between *E. histolytica* and the non-pathogenic strain *Entamoeba dispar*, as their morphologies are identical (296). Nevertheless, using these microscopy techniques, the prevalence of *E. histolytica/dispar* complex in this study was 1.5%. To confirm this low prevalence, multi-parallel real-time qPCR was performed in a subgroup of stool samples using, among others, a primer targeting an 18S rRNA target region of *E. histolytica*, with 100% specificity for this parasite (241). Using this complementary technique, this study found no (zero out of 48) *E. histolytica*-positive stool samples, thus confirming our microscopy findings.

In this study, most positive findings were of non-pathogenic intestinal parasites. *B. hominis* appeared in 25% of stool samples with the combined microscopy technique, increasing to 36% with two stool samples and 54% using PCR amplification. This protozoon is ubiquitous worldwide and is frequently identified in stool samples (84), with a prevalence as high as 100% reported in Senegalese children in whom *B. hominis* was detected with PCR (297). In contrast, prevalence as low as 4% has been reported in children living in San Luis Potosi, a mid-size city in north-central Mexico (77). In Colombia, using PCR amplification in stool samples, Ramirez *et al*. (298) detected *B. hominis* in 45% (125/277) of participants from six different regions of the country. In the 125 *Blastocystis*-positive individuals, the protozoal subtypes found included subtype 1 (ST1) in 70 asymptomatic individuals, ST2 in 40 individuals with diarrhea (most of them with polyparasitism) and ST3 in 15 individuals with inflammatory bowel disease. Colombian studies in schoolchildren identified this parasite as common with over 50% prevalence (282). In a study in children attending public daycare, Londoño-Franco *et al.* (299) reported a 58% prevalence in 275 children under 5 years of age, all living in strata 1 and 2. In this study, *B. hominis* was also found in domestic animals, boiling water pots, and the nails of the children and their siblings, among others. In pregnant women, Acurero *et al.* (27) reported a 48% prevalence of *B. hominis* in 120 participants living in Maracaibo, Venezuela. Despite its debated pathogenicity, *B. hominis* has been reported to cause or be associated with abdominal pain and diarrhea (300), hematological abnormalities (301), pregnancy-related anemia (97), and immunosuppression (302). In 125 *Blastocystis*-positive individuals, Ramirez *et al.* (298) found that 56% were asymptomatic and 12% had symptoms compatible with inflammatory bowel disease. More recently, Ramirez *et al.* (303) reported that 72% of children positive for *B. hominis* were asymptomatic, with just 11% showing abdominal pain and 2% diarrhea. In contrast, a study of outpatients with digestive disorders in Spain reported a 7% prevalence of *B. hominis* infestation (304). The major routes of transmission include drinking water, food, direct human-to-human contact, and zoonotic infections (300).

Aside from *B. hominis*, other prevalent non-pathogenic parasites included *E. nana* and *E. coli*. Regarding *E. nana*, in this study, the prevalence of 15% in pregnant women contrasts with 2% in the Brazilian study done in pregnant women (285) and the 25% in a Venezuelan study (27). For *E. coli*, the prevalence of 5% in this study is lower than the reported range between 13% (27) and 19% (285) in similar cohorts and the 9% reported in HIV-infected Tanzanian women (284).

The presence and intensity of fecal-oral routes of transmission, particularly in study areas where fecal contamination of water and food may occur, may be evidenced by analyzing the overall prevalence of non-pathogenic and pathogenic intestinal parasite species (282). In our study, the high prevalence of non-pathogenic and low prevalence of pathogenic parasites may be interpreted in relation to host, environment and parasitic factors. Intestinal parasitism in pregnant women is different from that of children and older adults, as in the latter groups, poor hygiene habits and possible consumption of contaminated water may increase IPI prevalence (305, 306). Environmental factors unique to our study that may explain the low prevalence of intestinal pathogenic parasites include the good quality of potable water in Bogotá (307) and the widespread availability of antiparasitic drugs made available through public health programs or at the UPA (306). In addition, as is the case with Bogotá, higher education and availability of sanitary facilities play an essential role in IPI prevention (294). Geographically, this is the first study on IPI in pregnancy in an urban community living over 2,600 meters above sea level, where an average temperature of 14 centigrade does not favor most helminthic life cycles but could be permissive to less demanding environmental conditions by commensal protozoa (282).

Table 4.3 Comparison of findings in our study with other similar IPI pregnancy studies

<table>
<tr><th rowspan="2">Study information
[title, year, location, altitude (meters over sea level), participants]</th><th rowspan="2">Study design & data collection</th><th colspan="3">Main Findings</th></tr>
<tr><th>Socio-demographics characteristics</th><th>Prevalence</th><th>Risk factors</th></tr>
<tr><td>• Prevalence and risk factors for intestinal parasitic infections in pregnant women residing in three districts of Bogotá, Colombia (257)
• 2015-2016
• Bogotá, Colombia
• 2640m
• Pregnant women: 331</td><td>• Cross-sectional, community-based
• Questionnaire
• Stool samples:
- 331 stool samples analyzed by combined microscopy technique
- 48 stool samples analyzed by qPCR</td><td>• 51% stratum 1
• 59% living in Ciudad Bolívar district
• 78% housemakers
• 88% secondary school or higher education
• 69% married or cohabiting
• 88% health insured
• 73% monthly income ≤253 USD</td><td>• IPI 41% (1 sample)
• IPI 52% (2 samples)
• Polyparasitism 9% (1 sample) and 14% (2 samples)
• B. hominis 25%
• E. nana 15%
• E. coli 8%
• I. bütschlii 2%
• E. histolytica/dispar 2%
• G. lamblia 1%
• A. lumbricoides <1%</td><td>• High prevalence of any parasite
- Pregnant women who had never dewormed
- Married or cohabiting
• High prevalence of polyparasitism
- Pregnant women who belong to minority ethnic groups
- No sink for washing hands</td></tr>
<tr><td>• Prevalence of helminthic infections and determinant factors among pregnant women in Mecha district, Northwest Ethiopia (113)
• 2015-2016
• Mecha district, Ethiopia
• 1720-2800 m
• Pregnant women:783</td><td>• Cross-sectional
• Questionnaire
• Stool sample analyzed by concentration technique</td><td>• Average age 20 years
• 88% Amhara ethnicity
• 77% rural area
• 59% elementary school education</td><td>• IPI 71%
• Polyparasitism 5%
• A. lumbricoides 33%
• S. mansoni 17%
• Hookworms 14%
• S. stercoralis 6%</td><td>• High IPI prevalence associated with:
- Absence of latrines
- No regular hand washing habit
- Not wearing shoes
- Illiteracy
- Ingesting raw vegetables
- Age ≤21 years</td></tr>
</table>

Study information [title, year, location, altitude (meters over sea level), participants]	Study design & data collection	Main Findings		
		Socio-demographics characteristics	Prevalence	Risk factors
• Prevalence of intestinal parasitic infections and associated risk factors among pregnant women attending antenatal care center at Felege Hiwot Referral Hospital, northwest Ethiopia (29) • 2013-2014 • Bahir Dar, Ethiopia • 1800m • Pregnant women:384	• Cross-sectional • Questionnaire • Stool sample (direct, formol-ether concentration, modified Ziehl-Neelsen)	• 54% >28 weeks of pregnancy • 44% first pregnancy • Average age 27 years (18-44) • 93% married • 62% secondary school or higher education • 11% illiteracy • 89% urban area • 42% homemakers	• IPI 32%, of which: - Polyparasitism 11% - *G. lamblia* 13% - *E. histolytica/dispar* 8% - Hookworms 6% - *A. lumbricoides* 3% - *S. mansoni* 3% - *S. stercoralis* 2% - *Taenia sp* 1% - *H. nana* <1%	• No significant associations with sociodemographic, pregnancy, hygiene and environmental factors
• Cohort profile: the Ecuador life (ECUAVIDA) study in Esmeraldas Province, Ecuador (286) • 2006-2009 • Quininde, Esmeralda Province, Ecuador • 80-300 m • Pregnant women: 2.390	• Cross-sectional • Questionnaire • Stool sample (direct, Kato-Katz, formol-ether acetate concentration)	• Median age 24 years • Ethnicity - 25.6% Afro-Ecuadorian - 74% mestizo - 0.4% indigenous	• STH IPI 46% • *T. trichiura* 29% • *A. lumbricoides* 28% • Hookworms 6% • *S. stercoralis* 4% • *H. nana* <1%	• No significant associations with sociodemographic, pregnancy, hygiene and environmental factors
• Anemia and associated factors among pregnant women attending antenatal care clinic in Wolayita Sodo Town, Southern Ethiopia (288) • 2014 • Wolayita Sodo, Ethiopia. • 1600 m	• Cross-sectional • Questionnaire • Stool sample (direct, formol-ether concentration) • Hematology analysis	• Average age 29 years (25-35) • Average family size 5 (1-8) • 7% illiteracy • Average household monthly income USD 29 (11-109)	• IPI 19% • *A. lumbricoides* 29% • *T. trichiura* 20% • *G. lamblia* 19% • Hookworms 16% • *E. histolytica* 9% • *E. vermicularis* 4% • *S. mansoni* 3%	• No significant associations with sociodemographic, pregnancy, hygiene and environmental factors

Study information [title, year, location, altitude (meters over sea level), participants]	Study design & data collection	Main Findings		
		Socio-demographics characteristics	Prevalence	Risk factors
• Pregnant women: 363				
• Anemia among pregnant women in Southeast Ethiopia: prevalence, severity and associated risk factors (287) • 2013 • Babile Woreda, Ethiopia • 1357 m • Pregnant women: 284	• Cross-sectional • Questionnaire • Body mass index • Stool sample (direct, formol-ether concentration) • Hematology analysis	• 52% pregnant women • 13-28 weeks of pregnancy • 80% multigravida • Average age 27 years (18-37) • 87% married • 62% homemakers • 61% rural area • 61% illiteracy	• IPI 37% • *A. lumbricoides* 19% • Hookworms 6% • *T. trichiura* 5% • *G. duodenalis* 3% • *S. mansoni* 2% • *E. vermicularis* 1%	• No significant associations with sociodemographic, pregnancy, hygiene and environmental factors
• Intestinal helminth infections in pregnant women attending antenatal clinic at Kitale District Hospital, Kenya (294) • Kitale, Kenya • 1890 m • Pregnant women: 153	• Cross-sectional, hospital-based • Survey stool sample (Kato-Katz)	• Pregnant women, age 18-45 years • 38% primary school level	• IPI 14%, of which: - Polyparasitism 10% - *A. lumbricoides* 48% - *N. americanus* 29% - *T. trichiura* 10% - *E. vermicularis* 5%	• Higher IPI associated with absence of pit latrines for waste disposal, primary education level, less age than 29 yrs. • Low IPI associated with hand washing and permanent housing
• Risk factors for preterm birth among HIV-infected Tanzanian women: a prospective study (284) • 1995-1997 • Dar es Salaam, Tanzania. • 55 m • Pregnant women: 767	• Vitamin supplement trial • Body measurements • Stool sample (direct, formol-ether concentration) • Hematology analysis	• HIV-infected pregnant women • Mean gestational age 21 weeks • 11% single • 8% illiterate	• Hookworms 12% • *E. coli* 9% • *A. lumbricoides* 6% • *C. parvum* 4% • *E. histolytica* 2% • *S. stercoralis* 2% • *T. trichiura* 1% • *G. lamblia* 1%	• No significant associations with sociodemographic, pregnancy, hygiene and environmental factors

Study information [title, year, location, altitude (meters over sea level), participants]	Study design & data collection	Main Findings		
		Socio-demographics characteristics	Prevalence	Risk factors
• Intestinal parasitic infections and anaemia among pregnant women in the highlands of Papua New Guinea (290) • 2008-2009 • Goroka, Papua New Guinea • 1500 m • Pregnant women 201	• Cross-sectional • Questionnaire • Stool sample (direct) • Hemoglobin	• 76% third trimester • 62% multigravida • 56% <25 years old • 52% > primary school education • 89% without access to toilet • 54% without access to piped drinking water	• IPI: 81% • Protozoan IPI 65% • Helminthic IPI 31% • *E. histolytica* 43% • *G. lamblia* 39% • *N. americanus* 18% • *A. lumbricoides* 14% • *P. hominis* 14% • *S. stercoralis* 3% • *T. trichiura* 2%	• High protozoan IPI during first pregnancy • High helminthic IPI in women with elementary school or lower education
• Geohelminth infections among pregnant women in rural western Kenya: a cross-sectional study (293) • 2003 • Gem, Nyanza Province, Kenya • Without data about altitude • Pregnant women: 390	• Cross-sectional • Questionnaire • Stool sample (modified formol-ether concentration, Kato-Katz) • Hemoglobin • Body measurements	• Pregnant women, 89% multigravida • Median age 25 (21-31) • 87% married • 72% low/medium socioeconomic status • 64% <8 years of education • 59% use of unprotected water source • 63% drinking untreated water	• Geohelminth IPI 76% • Polyparasitism 35% • *A. lumbricoides* 52% • Hookworms 40% • *T. trichiura* 29% • *S. mansoni* <1%	• High gravidity associated with increased *A. lumbricoides* and decreased hookworms • IPI associated with use of unprotected water source and lack of household treatment of drinking water • Age <30 associated with increased hookworms and decreased *A. lumbricoides* • Being married associated with decreased hookworms

Study information [title, year, location, altitude (meters over sea level), participants]	Study design & data collection	Main Findings		
		Socio-demographics characteristics	Prevalence	Risk factors
• Intestinal parasitic infections among pregnant women in Venezuela (291) • 2003-2004 • Venezuela, 9 states (Aragua, Caracas, Miranda, Portuguesa, Sucre, Tachira, Trujillo, Valencia, Zulia) • Different altitudes • Pregnant women: 1,038	• Cross-sectional, • Questionnaire • Stool sample (direct, formol-ether concentration) • Hematology analysis	• Pregnant women, mean age 26 years • Mean gestational age 29 weeks	• IPI 74%, of which: - Polyparasitism 47% - *A. lumbricoides* 57% - *T. trichiura* 36% - *G. lamblia* 14% - *E. histolytica/dispar* 12% - *N. americanus* 8% - *E. vermicularis* 6% - *E. coli* 6% - *E. nana* 4% - *S. stercoralis* 3% - *Cryptosporidium sp* <1%	• No significant associations with sociodemographic, pregnancy, hygiene and environmental factors
• Enteric parasites and commensals in pregnant women seen at the university hospital, Federal University of Uberlandia, State of Minas Gerais, Brazil (285) • 1994 • Uberlandia, Minas Gerais, Brazil • 863 m • Pregnant women: 503	• Retrospective • Stool sample (Merthiolate Iodine Formaldehyde Concentration)	• Pregnant women, age 13-42 years, 2-41 weeks gestational age	• IPI 32%, of which: - Polyparasitism 43% - *E. coli* 19% - *E. histolytica* 10% - Hookworms 6% - *E. hartmanni* 3% - *A.lumbricoides* 3% - *G. lamblia* 2% - *S. stercoralis* 2% - *E. nana* 2% - *T. trichiura* 2% - *H. nana* 1% - *S. mansoni* 1% - *Taenia sp* <1%	• No significant associations with sociodemographic, pregnancy, hygiene and environmental factors

Study information [title, year, location, altitude (meters over sea level), participants]	Study design & data collection	Main Findings		
		Socio-demographics characteristics	**Prevalence**	**Risk factors**
• Prevalencia y factores de riesgo asociados a parasitosis intestinal en mujeres embarazadas y su relación con el peso del niño al nacer (148) • 1997 • Minatitlan, Veracruz, Mexico. • 20 m • Pregnant women: 207	• Cross-sectional • Questionnaire • 3 stool samples (Faust concentration)	• Pregnant women, third trimester • 48% primigravida	• IPI 38% • Polyparasitism 17% • G. *lamblia* 66% • *A. lumbricoides* 14% • *T. trichiura* 9% • *N. americanus* 9% • *E. histolytica* 6% • *H. nana* 5%	• Participants with IPI were younger, had education lower than secondary school and reported having more domestic pets, than participants without IPI • Having a dirt floor in their house and a positive contact with domestic animals.

4.3.3. Sociodemographic, environmental and living risk factors for intestinal parasitic infections

4.3.3.1. Any parasite

For pregnant women infected with any intestinal parasite, two probable factors were identified, namely the time since the last deworming procedure and civil status. Pregnant women who had dewormed more than year ago showed a statistically significant higher prevalence of infection by any intestinal parasite (p=0.01). However, although prophylactic deworming programs in children and women of reproductive age have been recommended (119, 308), their effectiveness in health outcomes have not shown constant benefits (120, 121). Colombia has parasite therapy prevention programs focused on sizeable primary school populations (122) and pregnant women living in endemic zones for hookworms [(123) where 25ºC average temperature and 60-70% relative humidity conditions favor larvae development, characteristics not present in Bogotá (282). There is also over the counter availability of antiparasitic drugs in pharmacies, to the point that, culturally, it is common practice to take antiparasitic drugs as a healthy habit. Thus, our findings may indicate that deworming treatments and programs could help decrease the prevalence of intestinal parasites. Of the 13 studies we identified addressing intestinal parasitism in pregnant women, none included last deworming treatment as a variable, as they focused on the assessment of environmental conditions and hygiene habits, more than preventive pharmacological therapies. Although, the World Health Organization recommends preventive interventions in high risk populations (309), the use of anti-parasitic drugs during pregnancy can generate fear of fetal secondary effects.

Women who were married or living with a partner showed a not significant trend towards a higher prevalence of intestinal parasitism, while Derso *et al.* (29) did not find a difference in IPI in pregnant women when considering marital status. In contrast, van Eijk *et al.* (293) found that married women had a lower prevalence of hookworm infections. An explanation for this trend, that contrasts with the other studies in northwest Ethiopia and rural western Kenya, will require further exploration in future research studies.

4.3.3.2. Polyparasitism

The prevalence of polyparasitism was higher in women that belonging to minority groups. These groups, which nationwide include 4% indigenous people, 30% African Colombians, and less than 1% Raizals (from the Colombian Caribbean islands) (310), likely immigrated into Bogotá from other regions with a high risk of endemic polyparasitism (282) and may have arrived with undiagnosed infestations. This study recruited 20% of pregnant women who self-identified as forcefully displaced from other regions in Colombia. This is not surprising since Ciudad Bolívar accounted for 16% of those forcefully displaced into Bogotá, Kennedy 14% and Usaquén 2% (275). Migration into Bogotá has been dominated by internal forced displacement due to armed conflict and human rights abuses. Internal displacement started to increase in the 1980s, peaked in 1999-2002 and progressively decreased ever since, from regions with the highest individual and mass forced expulsion such as Antioquia, Choco, Cordoba, Magdalena, Nariño, Norte de Santander and Valle (311). Among these, only Magdalena is a well-established endemic area for geohelminths and protozoa in children (282). Given the lack of geographic and temporal congruence between internal displacement and IPI endemicity, it is unlikely that the incoming migrant populations, despite their socioeconomic vulnerability and unequal access to reproductive and health care services (312), brought and maintained parasitic life cycles in urban Bogotá.

Prevalence of polyparasitism was also higher in pregnant women living without a water sink. Having a water sink facilitates the hygienic habit of washing hands before and after going to the bathroom and after changing diapers. This variable was assessed in Kenyan children living in urban slums (313), in which 14% of homes lacked adequate sanitary services and 3% practiced open defecation. The authors found an increased STH infection prevalence in children living in homes where the water sink was located near to the toilet facility. Although their study population is different than our participants, both studies support an association between access to handwashing facilities and IPI prevalence. Altogether, these findings warrant future research to further analyze this association in pregnant women.

Although illiteracy (113, 159, 289) and low educational level (148, 290, 294) have been reported as risk factors for intestinal parasitism, our study and Derso *et al.* (29), did not find associations of these variables with infection by any parasite or polyparasitism. Our finding could be explained by the level education in our participants, with only 13% of them reporting primary level education, while 71% had secondary school and 16% university studies. The education level of our participants was similar to that reported in the districts of Ciudad Bolívar and Kennedy, Bogotá and Colombia, but not the district of Usaquén, where the professional level is most prevalent (Table 5.1). Thus, the participants in this study had a higher level of education when compared with the populations in other studies that analyzed this variable in pregnant women.

Previous studies have reported a lack of handwashing, not cleaning fruits prior to consumption, use of latrines and walking without shoes, as risk factors for intestinal parasitism (113, 159, 289, 294). However, we did not find differences in the prevalence with these variables. Derso *et al.* (29) also did not report associations between handwashing, lack of household bathrooms and IPI prevalence. Our findings may be explained by the low (15%) proportion of our participants reporting not handwashing after using the toilet, 4% not washing the fruits and 4% lacking household bathroom. For these, underreporting can be a consequence of social desirability bias, which hinders assessment of the real situation, as participants are more likely to provide socially acceptable answers (314, 315). Thus, it is possible that lack of these hygienic behaviors could be higher than reported. To control this bias, future studies would require a more probabilistic sample selection, optimization of the questions regarding hygiene practices and the way interviewers ask them, as well as a multivariate analysis. Finally, even though 47% of our participants reported walking without shoes indoors, we did not find an association between this behavior and IPI prevalence.

Young age in pregnant women was associated with a higher prevalence of intestinal parasitism in previous studies (113, 148, 159, 294). However, in our study, as well as in Acurero *et al.* (27), no associations with this variable were found. This may be explained by local deworming programs in school-aged children which increase the likelihood that our young participants could have received anti-parasitic prevention drugs, a hypothesis worth exploring in future studies.

Congruent with Derso *et al.* (29), our study did not find associations of IPI with parity. This result contrasts with Phuanukoonnon *et al.* (290) who reported a higher risk of intestinal protozoal infections in women in their first pregnancy. Future studies could best assess this variable with sufficient sample size to perform an explicative multivariate model.

4.3.4. Prevalence of respiratory symptoms

Prior to this study, six Colombian studies had assessed respiratory symptoms, including wheezing, asthma and rhinitis (Table 4.4). One was part of a Latin American ISAAC Phase III analysis of 3,830 children living in Bogotá (173). As for the general population, the earliest study reported their prevalence in 4,000 participants of all ages in Cartagena (174), while the most recent comprised study populations in six Colombian cities (Bogotá, Medellin, Barranquilla, Cali, San Andres, Bucaramanga), with over 5,000 participants of all ages (316). This large multi-city study also included participants aged 1-59, with over 2,000 from Bogotá (176, 317). A more recent and similar multi-city cross-sectional study focused on asthma prevalence in adults older than 40 years (177). Our study is the first in Colombia to focus on pregnant women living in vulnerable conditions, with a comparatively lower number of participants. Indeed, the sociodemographic characteristics of our study population were unique, as participants included pregnant women living in conditions of socioeconomic vulnerability, while the other studies included a broader population spectrum with respect to age, gender and socioeconomic strata.

As with our research, all previous studies had cross-sectional designs, with one nested case-control (316) and two multicentric studies (173, 174). Although asthma was defined differently in some studies, our study applied the most frequently used criteria, namely, physician-diagnosed asthma (174, 176, 177, 317) and wheezing during the last 12 months (173, 176, 317). In contrast, rhinitis was not consistently defined in the studies that included it as an outcome.

All studies identified higher wheezing and asthma prevalence than in our study, with the exception of the 3.5% physician-diagnosed asthma reported by Dennis *et al.* (317). The higher prevalence reported in other Colombian studies may be explained by more inclusive study populations of children, adults, males and females, as well as the use of random selection of participants from larger sample sizes. As for rhinitis, the prevalence reported by this study was higher than that reported by Caraballo *et al.* (174) and similar to the six-city study by Dennis *et al.* (317). It was, however, lower than the 2009-2010 updated six-city rhinitis prevalence (176), which may suggest that rhinitis in Colombia is increasing with time.

Table 4.4 Comparison of RS on 310 pregnant women living in Ciudad Bolívar with other RS Colombian studies

Study information [title, study population, place- year of the study, study design]	Respiratory Symptoms Definition	Main Findings		
		Socio-demographics Characteristics	**Prevalence (%)**	**Risk Factors**
• Environmental Risk Factors Associated with Intestinal Parasitic Infections and Respiratory Symptoms in Pregnant Women Residing in Low Income Neighborhoods in Bogotá, Colombia • 310 pregnant women • Bogotá-2016 • Cross sectional community study	Answered "yes" to the questions: • Current wheezing: - Did you have wheezing without a cold in the past 12 months? OR - Did you have wheezing or whistling in your chest sometime in the last 12 months? • Cumulative asthma - Has your physician ever told you that you have asthma? • Rhinitis - Do you have nasal allergies, including rhinitis?	• 20% younger than 20 years • 30% single mother • 46% first pregnancy • 19% forced displacement	• Wheezing: 5.2% • Asthma diagnosed by physician: 4.5% • Rhinitis: 21%	• First trimester of pregnancy had not statistical significance on increased odds for rhinitis • Less greenness was associated with higher prevalence of rhinitis • Living further away from a street was borderline associated with an increased odd for allergic rhinitis and asthma
• Factors associated with Allergic Rhinitis in Colombian subpopulations aged 1 to 17 and 18 to 59 (316) • 5,008 people from 1 to 59 years. • 6 Colombian cities, 2009-2010 • Observational cross-sectional survey and a nested case-control study	• No reported for asthma • Rhinitis: answer "yes" to the following question: - In the past 12 months, have you (or your child) had a problem with sneezing or a running or blocked nose, when you (or your child) did not have a cold or the flu?	• 69% adults, of them: - 65% women - 49% strata 1 and 2 - 8% not health insured	• No reported	• Risk factors for allergic rhinitis in adults - Female - Asthma in parents or brothers - Allergic rhinitis in parents or brothers - Atopic eczema in parents or brothers - Caesarean delivery - Acetaminophen consumption at least once per month or per week • Protection factor for allergic rhinitis in adults - Eggs consumption at least once per week during last 12 months

Study information [title, study population, place- year of the study, study design]	Respiratory Symptoms Definition	Main Findings		
		Socio-demographics Characteristics	**Prevalence (%)**	**Risk Factors**
• Prevalence, risk factors and underdiagnosis of asthma and wheezing in adults 40 years and older: A population-based study (177) • 5,539 people older than 40 years (1,106 from Bogotá) • Six Colombian cities, 2003-2004 • Cross sectional population based observational study	• Wheezing: answered "yes" to the question: - Have you ever had two or more attacks of ''wheezes'' causing you to feel short of breath? • Asthma: - Wheezing definition AND - Post-bronchodilator Forced Expiratory Volume 1/ Forced Vital Capacity Ratio higher than 70% • Physician diagnosed asthma • No rhinitis definition	• 36% 40-49 years old • 67% women • 20% obese • 20% respiratory disease before 16 years old • 23% first-degree relative with asthma • 25% no education • 18% current smokers • 26% passive smokers • 61% indoor wood smoke exposure (cooking) • 25% occupational gases or fumes exposure • 33% occupational dust particles exposure	• Asthma prevalence - General 9.0% - Bogotá 11.9% • Physician diagnosed asthma - General 6.5% • Wheezing - General 11.9% - Bogotá 14.9% • Not reported for rhinitis	• Risk factor associated with asthma - Living in Bogotá - Female - Obesity - No education - Respiratory disease before 16 - First-degree relative with asthma - Occupational gases or fumes exposure - Occupational dust particles exposure • Risk factor associated with wheezing - Living in Bogotá - Female - Obesity - No education - Respiratory disease before 16 - First-degree relative with asthma - Indoor wood smoke exposure (cooking) - Occupational gases or fumes exposure

<table>
<tr><th rowspan="2">Study information [title, study population, place- year of the study, study design]</th><th rowspan="2">Respiratory Symptoms Definition</th><th colspan="3">Main Findings</th></tr>
<tr><th>Socio-demographics Characteristics</th><th>Prevalence (%)</th><th>Risk Factors</th></tr>
<tr><td>• Prevalence of asthma and other allergic conditions in Colombia 2009–2010: a cross-sectional study (176)
• General population: 5,978 (2,392 From Bogotá).
• Six Colombian cities, 2009-2010
• Cross-sectional, population-based study</td><td>• Asthma: answered “yes” to either questions:
- Have you had wheezing (whistling) in the chest during the past year?
OR
- Has your physician ever told you that you have asthma?
• Rhinitis: allergic rhinitis symptoms in the last year and answered “yes” to the question:
- In the past 12 months, have you had a problem with sneezing or a running or blocked nose, when you DID NOT have a cold or the flu?”</td><td>• 52% women
• 68% 18-59 years old
• 56% elementary school
• 29% secondary school
• 59% living in Bogotá</td><td>• Prevalence of asthma symptoms in the past 12 months:
- General 10.5%
- Bogotá 9.4%
• Physician diagnosed (asthma ever):
- General 7.0%
- Bogotá 6.3%
• Cumulative prevalence of asthma symptoms (wheeze ever):
- General 21.1%
- Bogotá 19.0%
• Rhinitis symptoms in the past 12 months:
- General 32.6% ()
- Bogotá 31.7% ()
• Cumulative prevalence Rhinitis: 38%
• Overall prevalence of physician- diagnosed rhinitis: 14%</td><td>• Subjects with asthma had statistically significant higher levels of:
- Total Immunoglobulin E (IgE)and Specific IgE Against Blomia tropicalis and Dermatophagoides pteronyssinus</td></tr>
<tr><td>• Regional variation in asthma symptom prevalence in Latin American children (173)
• 165,917 schoolchildren (363 from Bogotá)
• 17 Latin American countries. Bogotá, 2001-2003
• Randomized, cross-sectional and multicentric study</td><td>• Current wheezing: one or more wheezing episode in the last 12 months
• Cumulative asthma: asthma ever, as reported diagnostic label
• No rhinitis definition</td><td>• No specific data for Bogotá or Colombia</td><td>• Current wheezing:
- Latin America 15.9%
- Bogotá 8.5%
• Asthma:
- Latin America 13.6%
- Bogotá 9.5%
• No reported for rhinitis</td><td>• No specific data for Bogotá or Colombia</td></tr>
</table>

Study information [title, study population, place- year of the study, study design]	Respiratory Symptoms Definition	Main Findings		
		Socio-demographics Characteristics	Prevalence (%)	Risk Factors
• Asthma and other allergic conditions in Colombia: a study in 6 cities (317) • 6,507 people between 1-59 years (2065 from Bogotá). • Six Colombian cities, 1998-2000 • Cross-sectional, population-based study	• Asthma: answered "yes" to either questions: - Have you had wheezing (whistling) in the chest during the past year? OR - Has your physician ever told you that you have asthma? • Rhinitis: answered "yes" to either questions: - How you had persisting nasal symptoms, such as sneeze-watery discharge, obstruction, or itching, during the past year? OR - Has your physician ever told you that you have rhinitis?	• 32% from Bogotá • 11% 1-4 years old • 55% 19-59 years old • 59% secondary education	• Prevalence of asthma symptoms in the past 12 months: - General 10.4% - Bogotá 9.4% • Physician diagnosed (asthma ever): - General 6.2% - Bogotá 3.5% • Cumulative prevalence of asthma symptoms (wheeze ever): - General 22.7% - Bogotá 22.5% • Rhinitis symptoms in the past 12 months: - General 22.6% - Bogotá 21.6% • Cumulative prevalence Rhinitis: 31.3% • Overall prevalence of physician- diagnosed rhinitis: 7.0%	• Higher statistical significance for asthma: - 1-4 years old
• Prevalence of asthma in a Tropical city of Colombia (174) • General population: 4,000 • Cartagena,1989-1990 • Cross-sectional study	• Asthma: if participant had consulted their physicians for shortness of breath AND wheezing during the last year AND had received asthma medication • Rhinitis: if participant have persistent nasal symptoms, and have any of symptoms when removing dust	• 55% women • 55% 20-98 years old • Mean average 21 years	• Point prevalence: 8.8% • Cumulative prevalence: 12.8% • Rhinitis:16.4%	• Risk factors for asthma - Had at least one first degree relative having symptoms of asthma - Passive exposure to cigarette smoke

Regarding Latin American RS studies, we compare this study with five others reporting asthma prevalence and associated factors in Latin America, all published between 2010 and 2018, and including two systematic reviews, two cross-sectional studies and one report. Two studies focused on childhood asthma, and one on adults, with the other two including both. Asthma prevalence ranged between 3% and 33% in children, who were diagnosed by reporting wheezing in the last year or taking asthma medications. Prevalence in adults with physician-diagnosed asthma ranged between 3% and 12%. In our study, 4.5% prevalence of physician-diagnosed asthma was within this range. Our 5.2% prevalence of asthma diagnosed by having had wheezing in the last year, was lower than the 12% to 23% range reported in the other studies (Table 4.5).

Based on the Global Asthma Report (318), adult asthma prevalence was reported as 2.7% in Chile, 6.5% in Argentinian adults aged 20-44 and 12% physician-diagnosed asthma for Brazilians aged 18-54 (170). In another study carried out in metropolitan Mexico City, 5% of 1,063 participants older than 40 years reported physician-diagnosed asthma (319). Thus, the 4.5% asthma prevalence reported in our study was similar to that found in Mexican and Chilean adults, and lower than the prevalence reported in Argentina and Brazil. Since associated factors with reported asthma prevalence were not identified in these studies, it was not possible to compare them with our findings. However, as it is well established that asthma is a syndrome with various phenotypes and risk factors (198), and considering the environmental and social diversity in Latin America, to contrast study findings it would be necessary to use comparable diagnostic criteria and age groups with similar lifestyles and environmental conditions (Table 4.5).

Table 4.5 Comparison of RS on 310 pregnant women living in Ciudad Bolívar with other RS Latin American studies

Study information (title, study population, place- year of the study, study design)	Respiratory Symptoms Definition	Main Findings		
		Socio-demographics Characteristics	Prevalence	Risk Factors
• Environmental Risk Factors Associated with Intestinal Parasitic Infections and Respiratory Symptoms in Pregnant Women Residing in Low Income Neighborhoods in Bogotá, Colombia • 310 pregnant women • Bogotá-2016 • Cross sectional community study	Answered "yes" to the questions: • Current wheezing: - Did you have wheezing without a cold in the past 12 months? OR - Did you have wheezing or whistling in your chest sometime in the last 12 months? • Cumulative asthma - Has your physician ever told you that you have asthma? • Rhinitis - Do you have nasal allergies, including rhinitis?	• 20% younger than 20 years • 30% single mother • 46% first pregnancy • 19% forced displacement	• Wheezing: 5.2% • Asthma diagnosed by physician: 4.5% • Rhinitis: 21%	• First trimester of pregnancy had not statistical significance on increased odds for rhinitis • Less greenness was associated with higher prevalence of rhinitis • Living further away from a street was borderline associated with an increased odd for allergic rhinitis and asthma
• Global Asthma Network (2018). The Global Asthma Report 2018 (318) • Children 6-7 years old from 61 countries Adolescents 13-14 years old from 97 countries.17 countries from Latin America. - 93,774 children 6-7 years old[1] - 165,900 children 13-14 years old * • 2000-2003 • Report about burden of asthma	• Asthma in children - ISAAC Phase 3, questionnaires - Experienced wheezing in the preceding 12 months • Asthma in adults: - Diagnosed by physician - Wheezing in the last 12 months • No rhinitis definition	• Children between 6-7 years and 13-14 years • Adults	• Children - Prevalence of current symptoms of asthma, age 6-7: 17.3% (Latin America) - Prevalence of current symptoms of asthma, age 13-14: 15.9% • Adults - Diagnosed by physician: 6.5-12% (Argentina-Brazil) - Wheezing in the last 12 months: 23% (Brazil)	• No reported

Study information (title, study population, place- year of the study, study design)	Respiratory Symptoms Definition	Main Findings		
		Socio-demographics Characteristics	Prevalence	Risk Factors
• Prevalence of asthma in Latin America. Critical look at ISAAC Phase 2 and 3 vs. Other Latin American studies that evaluated children: Perú, Ecuador, Brazil, Mexico, Colombia (320) • Children • Colombia-Not reported • Systematic review	• Asthma: - ISAAC: Wheezing or whistling in the past 12 months? VS - Perú: The Peru Urban v. Rural Asthma (PURA) questionnaire: wheezing or asthma medication use in the previous year + Pulmonary function + others - Ecuador: wheezing in the previous year - Brazil: wheezing in the last 12 months - Mexico: wheezing in the last 12 months - Colombia: wheezing in the last 12 months and asthma diagnosed by physician • No rhinitis definition	• ISAAC: no reported • PURA: 48% girls • Ecuador: ecological characteristics of different communities • Brazil: 50.4% girls • Mexico: 52% girls • Colombia: 52% girls	• ISAAC (Lima 19.6%) vs PURA: (Urban Lima 12%) - (Rural Tumbes 3%) • ISAAC (Guayaquil no reported but the study said that is higher than reported by Ecuador study 10.1%) • ISAAC (no reported) vs Brazil (13.5%) • ISAAC (5-14%) vs. Mexico (6.8% and 9.9%) • ISAAC and Colombia studies showed similar prevalence: 17-19%	• ISAAC: no reported • PURA: high asthma prevalence in urban area • Ecuador: better socioeconomic conditions, urban lifestyles are associated with higher asthma prevalence • Brazil: high prevalence in families with low income, short breastfeeding time and acute respiratory failure • Mexico: not reported • Colombia: subjects with asthma had statistically significant higher levels of: - Total Immunoglobulin E (IgE) and Specific IgE Against *Blomia tropicalis* and *Dermatophagoides pteronyssinus*
• Regional variation in asthma symptom prevalence in Latin American children (173) • 165,917 children 13-14 years old (363 from Bogotá) • 17 Latin American countries • Bogotá, 2001-2003 • Randomized, cross-sectional and multicentric study	• Current wheezing: one or more wheezing episode in the last 12 months • Cumulative asthma: Asthma ever, as reported diagnostic label • No rhinitis definition	• No reported	• Current wheezing: - Latin America: 15.9% - Bogotá: 8.5% - Range: 3.9-30.8 • Asthma: - Latin America: 13.6% - Bogotá: 9.5%	• Not associations between - Altitude, latitude or tropical settings - Gross national income • Low socioeconomical conditions

Study information (title, study population, place- year of the study, study design)	Respiratory Symptoms Definition	Main Findings		
		Socio-demographics Characteristics	Prevalence	Risk Factors
• Asthma in Latin America (198) • Children & adults • Latin America, 2009-2014 • Systematic review	• Asthma: - Wheezing in the last 12 months - Physician-diagnosed asthma - Ever asthma • No rhinitis definition	• Children in most studies • Two studies reported data from adults	• Children - Asthma ever prevalence 18.0% - Current wheeze: o Mexico 8.7% o El Salvador 30.8% - Ever asthma: o Mexico 6.9% o Colombia 14.2%- o Perú 33.1% • Adults - Physician diagnosed asthma: o Colombia 6.3% o Mexico 5.0%	• High prevalence of asthma in: - Urban residence - Population living violence or stress situations - Vitamin D deficiency - Obesity - Environments with allergens and pollutants • Low prevalence of asthma in: - Breastfeeding more than 3 months
• Adult asthma in Mexico City: a population-based study (321) • 1063 adults over 40 years • Mexico City-2003 • Cross sectional survey	• Asthma: - Has a physician told you that you had or have asthma? - Spirometry • No rhinitis definition	• 57.7% women • 55.9 mean age (11.9 SD) • 7.1 mean years of educational level • 28.8 mean Body Mass Index (5.1 SD) • 19% smoking	• Prevalence of physician-diagnosed asthma: - Women 6.2% - Men 3.3%	• High prevalence of asthma in: - Smoking - Reduced pulmonary function

[1] Data from Latin America were taken from ISAAC Phase three

Since Latin American studies evaluating the prevalence of asthma during pregnancy were not identified, this study was contrasted with six studies that assessed respiratory symptoms in pregnant women from Africa (2), Sweden (2), Australia (1) and United States (1) (Table 4.6).

Regarding sociodemographic characteristics, in our study, 30% of participants were single mothers, a high proportion when compared to the 11% reported by Adeyemi *et al.* (190), 18% by Hansen *et al.* (322), 6% by Rejno *et al.* (323) and 3% by Sawicki *et al.* (188). This can be explained by our 20% of participants being aged under 20, as, in Bogotá, less than 5% of young women are married and less that 9% cohabit with their partner. In our RS study, 55% of participants had two or more children, higher than the 42% reported by Rejno *et al.* (323), a difference that could be understood in the context of the higher global fertility rate of 2.3 in Ciudad Bolívar (50), compared with 1.8(324) for Colombia. Also, 20% of pregnant women of our study were in their first gestational trimester, lower than the 43% reported by Sunyer *et al.* (325), and 19% were forcefully displaced into the city from other regions of the country, the latter a unique characteristic of our study when compared with other published studies in pregnant women with RS.

Comparing our results to the two cross-sectional African studies from low- and middle-income countries in pregnant women, notwithstanding differences in asthma diagnosis between studies, our 4.5% prevalence was similar to the 3.5% current asthma found in a study done in 658 pregnant women in the district hospital of Ifakara, a semi-rural area in the southeast of Tanzania (325). Our prevalence was also higher than the 1.7% physician-diagnosed asthma reported in 347 pregnant women from Ogbomoso, one of the largest urban centers in southwestern Nigeria (190). Although the Nigerian study was done in an urban center, as in our study, our prevalence was more comparable with the rural study from Tanzania. By asking participants if they had wheezing during the last 12 months, our study found a prevalence of 5%, lower than the 8% reported in the Nigerian cohort, using the same question (190). In the Tanzanian study, when asking a broader question of having ever had a wheezing chest, the prevalence reported was of 11% (325). Thus, it is possible that asthma and wheezing in our participants, similar to the Tanzanian study, where an association between serum IgE with maternal asthma was not observed, are non-atopic in nature, and that environmental and socioeconomic conditions are likely underlying determinant factors.

Registry-based studies in high-income countries reported higher asthma prevalence. In United States, using a sizeable multi-state database of medication during pregnancy, Hansen *et al.* (322) reported that 6.7% (38,495 of 575,632) pregnant women had a diagnosis of asthma, and this condition was more prevalent in women under 24 years of age. Similarly, Rejno *et al.* (323) using four Swedish national registries, found a 9.4% (26,586 of 284,214) asthma prevalence in pregnant women, 13% of whom were under age 25, 58% primiparous and 6% single mothers. In Australia, Sawicki *et al.* (188), in a questionnaire-based survey, found that 13% (104 of 819) of pregnant women self-reported asthma during pregnancy, with a mean age of 30 years (range 18-41) and only 3% being single mothers. Comparing our study done in an upper middle-income country with these studies done in high-income countries, our asthma prevalence is lower, with similarities in that most of our participants were also younger than 30 years and with a high number of single mothers, as with the Swedish participants. Although the prevalence of asthma in the general population is variable across countries, it tended to be higher in communities living in high-income countries and is currently showing increasing prevalence in low- and middle-income countries (326).

For rhinitis, our 21% prevalence coincided with the reported 20% of allergies during pregnancy in the United States, mainly including rhinitis and asthma (327), and the 22% identified in a Swedish study (186). It was, however, higher than the 6% reported in Nigeria, in which the question inquired about self-reported rhinitis ever in the past (190). Thus, the prevalence of rhinitis in our study is consistent with previous United States and Swedish studies, and may indicate that although our country is classified as an upper middle-income country, we may share some common environmental risk factors with these high-income countries, such as “western” lifestyles and frequent exposures to urban pollution, potential commonalities worth exploring in future research.

Inner cities, defined as urban areas with high unemployment, low income, common single parenting, poor quality housing, race disparities, poor socioeconomic status, low health literacy and poor environmental conditions, face unique personal and public health challenges (328). Most of these inner-city characteristics are similar to our study population, namely pregnant women living in the district of Ciudad Bolívar, one of the largest Latin American conglomerates of people living in vulnerable conditions and high community violence. Individuals living in inner cities are presumed to have high asthma prevalence as they are more exposed to environmental pollutants and stress (329). Regarding the asthma prevalence we report in Ciudad Bolívar, similar studies in inner cities showed much higher prevalence, likely because they compared associated risk factors in individuals with and without asthma. For instance, Wright *et al.* (330) found that in prenatal assessments, mothers living in urban inner cities with high cumulative stress were more likely to have asthma and altered immune responses. However, in a similar study population of young mothers living in poor socioeconomic conditions in St. Louis, Baltimore, Boston and New York, Gruenberg *et al.* (331) reported a 46% prevalence of asthma without finding a positive association between external stressors, asthma and allergy. Similarly, a study with 509 inner-city pregnant women from Madison, Wisconsin, USA, reported 36% current asthma diagnosis (329). Finally, a more recent study with inner-city pregnant women living in Philadelphia, USA, found that those presenting with severe prenatal asthma exacerbations, when compared to controls without exacerbations, were characterized by higher maternal history of mechanical ventilation, maternal use of asthma medications, absence of flu vaccination and allergic rhinitis (332). A study comparing Afro-Caribbean with Puerto Rican children living in The Bronx, New York, a borough with inner city communities, reported higher prevalence of asthma morbidity in Puerto Rican children, underscoring the importance of examining sociocultural factors that may mediate this difference (333).

The variety of factors determining the clinical presentations of asthma and rhinitis, including biological, genetic, environmental, psychological and lifestyle habits, challenges the development of unifying definitions and diagnostic gold standards (198, 320). Studies based on the ISAAC questionnaire include broad queries, such as having wheezing in the past year, which can generate over estimation, particularly when including children, as other human diseases can show similar clinical symptoms (198, 320). However, this methodology has shown reproducible results that support its validity (320). In addition, the diagnostic amplitude for rhinitis, when based on the patient's perception, favors diagnostic imprecision. Latin American studies on asthma and rhinitis focus on subgroups with specific characteristics, the diversity of which highlights the need for population studies that include biomarkers (198). Furthermore, these studies require logistic support to access unique communities living in vulnerable conditions and using questionnaires and diagnostic tests that will allow diagnostic precision.

Table 4.6 Comparison of RS on 310 pregnant women living in Ciudad Bolívar with other RS in pregnant women studies

Study information (title, study population, place- year of the study, study Design)	Respiratory Symptoms Definition	Main Findings		
		Socio-demographics Characteristics	Prevalence (%)	Risk Factors
• Environmental Risk Factors Associated with Intestinal Parasitic Infections and Respiratory Symptoms in Pregnant Women Residing in Low Income Neighborhoods in Bogotá, Colombia • 310 pregnant women • Bogotá-2016 • Cross sectional community study	Answered "yes" to the questions: • Current wheezing: - Did you have wheezing without a cold in the past 12 months? OR - Did you have wheezing or whistling in your chest sometime in the last 12 months? • Cumulative asthma - Has your physician ever told you that you have asthma? • Rhinitis - Do you have nasal allergies, including rhinitis?	• 20% younger than 20 years • 30% single mother • 46% first pregnancy • 19% forced displacement	• Wheezing: 5.2% • Asthma diagnosed by physician: 4.5% • Rhinitis: 21%	• First trimester of pregnancy had not statistical significance on increased odds for rhinitis • Less greenness was associated with higher prevalence of rhinitis • Living further away from a street was borderline associated with an increased odd for allergic rhinitis and asthma
• The prevalence, risk factors and changes in symptoms of self-reported asthma, rhinitis and eczema among pregnant women in Ogbomoso, Nigeria (190) • 347 pregnant women and 85 no pregnant women • Ogbomoso, Nigeria, 2012-2013. • Cross sectional analyzed as a case-control study.	• Current wheezing: - Wheezing in the last 12 months • Asthma: - Have experienced an asthmatic attack during the last 12 months OR - Participant is currently using asthma medications • Rhinitis: - Rhinitis ever in the past - Problem with sneezing, runny or blocked nose were present when there was no cold or flu in the last 12 months	• Pregnant women: - 11% single - 87% secondary or higher education - 52% trading occupation, - 97% city dwellers - 89% first & second trimester - 99% never smoked - 83% monthly income <300 USD	• Current wheezing - Pregnant women vs non-pregnant women: 7.5% vs 7.1% • Asthma diagnosed by physician: - Pregnant women vs. non-pregnant women: 1.7% vs 5.9% • Rhinitis ever in the past - Pregnant women vs non-pregnant women: 8.4% vs 25.9% • Rhinitis last 12 months	• Risk of asthma was increased with family history • Risk of allergic rhinitis was increased with family history of rhinitis and low family income

Study information (title, study population, place- year of the study, study Design)	Respiratory Symptoms Definition	Main Findings		
		Socio-demographics Characteristics	Prevalence (%)	Risk Factors
			- Pregnant women vs non-pregnant women: 5.8% vs 15.3%	
• Asthma during pregnancy in a population-based study – Pregnancy complications and adverse perinatal outcomes (323) • 284,214 pregnancies • Sweden, 2006-2009 • Population-based cohort study. Data were taken from health registries	• Asthma: - Self-reported asthma ever - Recorded diagnosis of asthma 12 months before and during pregnancy - Dispensed asthma medication • No rhinitis definition	• 1.7% younger than 19 years • 13% 20-24 years old • 58% first pregnancy • 5.5 single mother • 35.78% high level education	• Asthma recorded in 9.4% of all pregnancies - 31% of these women had asthma medication recorded • No reported for rhinitis	• Asthma during pregnancy was associated with all pregnancy complications
• Medication exposure in pregnancy risk evaluation program: The prevalence of asthma medication use during pregnancy (322) • 575,632 Pregnant women, age 15-45 • United States, 2001-2007 • A prevalence and associated factors based on a cohort. Multi data were taken from health registries	• Asthma: - Asthma diagnosis by physician - Asthma medication • No rhinitis definition	• 26% younger than 24 years • 53% 25-34 years old • 18% single mothers • 27.3% high education level • 6.8% smoking	• Had asthma diagnosis: 6.7% - 63% of them filled an asthma medication during pregnancy • No reported for rhinitis	• Asthma was more prevalent among - <24 years old women - less educated - Native American - Smoking mothers
• Management of asthma by pregnant women attending an Australian maternity hospital (188) • 819 pregnant women • Melbourne, Australia, 2009 • Population-based survey	• Asthma: - Self-reported asthma • No rhinitis definition	• Pregnant women with asthma: - Mean age 30 years Range 18-41 - 3% single mothers - 44% with smoking history - 8% smokers	• Pregnant women self-reported asthma: 12.7% • No reported for rhinitis	• No reported for the asthma prevalence

Study information (title, study population, place- year of the study, study Design)	Respiratory Symptoms Definition	Main Findings		
		Socio-demographics Characteristics	Prevalence (%)	Risk Factors
		- 56% university education - 28% annual income >100,000 AUD		
• The incidence of pregnancy rhinitis (186) • 599 pregnant women • Bohuslandstinget, Sweden, 1995-1996 • Longitudinal study	• Rhinitis - Longstanding nasal congestion during pregnancy - Present subjective nasal congestion - Use of nasal decongestants • No asthma definition	• No reported	• Prevalence of rhinitis during pregnancy: 22% • No reported for asthma	• Higher in smokers
• The association between atopy and asthma in a semirural area of Tanzania (East Africa) (325) • 658 pregnant women • Ifakara, Southeast Tanzania, 1985-1986 • Cross sectional	• Wheezing: answer “yes” to the following question: - Have you ever had a wheezing chest? • Current asthma: answer “yes” to at least one of the following three questions: - `Have you been woken by an attack of shortness of breath at any time in the last 12 months?' - Have you had an attack of asthma in the last 12 months? - Are you currently taking any medicine (including inhalers, aerosols, or tablets) for asthma? • No rhinitis definition	• Mean age: 26 years Range: 15-44	• Wheezing: 10.7% • Current asthma: 3.5% • No reported for rhinitis	• Not associations were found with specific and total Immunoglobulin E (IgE) with asthma

4.3.5. Pregnancy, environmental and living risk factors for respiratory symptoms

4.3.5.1. Trimester

In this study, the participants who were in their first trimester of pregnancy had increased but not statistically significant odds of reporting allergic rhinitis, which could be consistent with physiological changes in the upper airways during pregnancy (334). In the study by Ellergard *et al.* (186), it is reported that rhinitis appeared predominantly in the first trimester, although it could also present in latter pregnancy stages. Demoly *et al*. (334) reported that persistent allergic rhinitis could appear during the third trimester disappearing after birth. On the other hand, a Nigerian study did not find significant differences in prevalence of allergic conditions between gestational trimesters (190). Our findings, although not statistically significant, show a first trimester predominance of rhinitis, and its progressive decrease during the second and third trimesters. These findings may be due to higher susceptibility to rhinitis during early pregnancy in our participants, who live in inadequate baseline socioeconomic conditions that could enhance their physiologic immunosuppression.

4.3.5.2. Access to green space

As in other studies (199-201, 335), NDVI was used in our study to establish residential proximity to greenness by participants. Our population mostly lived in areas characterized by concrete infrastructure (median NDVI -0.007, IQR -0.01;0.00). When compared with the other studies that used NDVI (199-201, 335), Ciudad Bolívar had the NDVI value closest to zero, corresponding to very low or no vegetation. This reflects poor residential environmental conditions, fitting with an area that was originally a sand quarry and then became inhabited through unplanned urbanization (268). This sharply contrasts with well-developed areas in the Netherlands, Spain, Sweden and Germany, where the lowest NDVI value was 0.038 in Sabadell, Spain (201) and the highest was 0.43 in rural Germany (200). Regarding housing location, in our study, we identified that participants with more access to green spaces showed a significantly lower prevalence of rhinitis. To our knowledge, this is the first study that reports this association in a population of pregnant women. The association found is congruent with the German birth cohort GINI/LISA North study done in 2,497 children where the authors found a protective effect by mean greenness of 0.43 in a 500m buffer zone around their home address during their first 10 years of life, for allergic rhinitis, eyes and nose symptoms and aeroallergen sensitization (200). Our results are also congruent with the Dutch birth cohort PIAMA done in 3,339 children, where the authors found a protective effect of mean greenness of 0.37 in a 500m buffer zone around their home address for allergic rhinitis at 6-8 years and 10-12 years (199). In contrast, in the birth cohort GINI/LISA South with 3,306 children during the first 10 years, mean greenness of 0.35 in a similar buffer zone was reported as a risk factor for eyes, and nose symptoms, without any association with rhinitis and aeroallergen sensitization (200). Similar risk associations were found in the Swedish BAMSE birth cohort with 3,304 at 6-8 and 10-12 years for allergic rhinitis (199). In 3,178 Spanish schoolchildren, 9 to 12 years of age living in Sabadell, a city on the northeast of Spain, surrounding residential greenness was not associated with current asthma and rhinoconjunctivitis, and living close to a park or forest was associated with a higher prevalence of asthma and rhinitis (201). Based on the hypothesis that more neighborhood trees reduce air pollution, a birth cohort of 727 African American and Dominican children living in New York City, showed that tree canopy coverage was directly associated with asthma and allergic sensitization at 7 years of age, while rhinitis showed no such association (336) (Table 4.7).

Finally, in a UK cross-sectional study done in adults that assessed asthma hospitalization rates (based on 660,505 registries), urban greenness (based on percentage of green space, percentage of gardens and density of mature trees) and air pollution (based on NO_2, $PM_{2.5}$ and SO_2 levels), the authors found protective associations between green space and gardens with asthma prevalence only in areas with low levels of air pollution, while the density of mature trees was reported as a protective factor where air pollution levels were high. In this study, rhinitis was not included as an outcome (205) (Table 4.7).

The incidence of rhinitis is increasing (337, 338) and this have a negative effect over quality of life (339). Although it is presumed that increased exposure to outdoor mold and pollen may increase the incidence of allergic rhinitis, a plausible link of a protective effect of allergic rhinitis by greenness suggests that living close to green spaces decreases air pollution, which in turn may reduce exposures to allergens and pollutants thus decreasing the risk of environmentally-induced rhinitis. However, the findings about associations between green spaces, air pollution, and RS are not conclusive (203).

Considering the variability in our findings regarding associations between greenness and rhinitis, Fuertes *et al.* (199) suggest interpreting the results based on the specific conditions of the study settings. Accordingly, our findings may be influenced by variables of population density, that in

Ciudad Bolívar shows disparities with some district areas concentrating more inhabitants living in low income and inadequate housing. In these areas, urban growth is disorganized and unplanned, generating neighborhoods that are difficult to access, unsafe, stressful and devoid of green spaces. In Ciudad Bolívar, these are mainly located close to the mountaintop and away from main streets. In contrast, other district areas show housing with slightly better socioeconomic conditions, with better-planned neighborhoods, better access to green spaces and proximity to main streets. Congruent with our observed disparity within Ciudad Bolívar, population density has elsewhere been identified as an important co-variable that potentiates associations between greenness and RS, in particular for allergic rhinitis (200). Considering the unsafe conditions of Ciudad Bolívar district, we could formulate a hypothesis that the association between lack of greenness and higher prevalence of rhinitis could also be mediated by the stress caused for worst neighborhood conditions, including high levels of community exposure violence. Although the evidence linking greenness and violence is ambiguous, there is a trend demonstrating that green spaces favor a decrease in violence and crime (340). In turn, violent neighborhoods have been associated with increased odds of allergies and asthma in adolescents and adults, including in a Colombian study population (341-343).

Table 4.7 Comparison of RS of 310 pregnant women living in Ciudad Bolívar with studies addressing associations between respiratory symptoms and greenness

Title	Place Year of Study	Study Population	Study Design Data Collection	Main Findings
Environmental Risk Factors Associated with Intestinal Parasitic Infections and Respiratory Symptoms in Pregnant Women Residing in Low Income Neighborhoods in Bogotá, Colombia.	• Bogotá-Colombia • 2016	• 310 Pregnant women	• Cross-sectional community-based study • Questionnaire • NDVI[1] at 100 m buffer • Home addresses distance: nearest street and waste disposal	• Prevalence of rhinitis was higher in areas with low access to greenness • Odds for rhinitis and asthma increased when participants lived further away from main streets
Land cover and air pollution are associated with asthma hospitalizations: A cross-sectional study (205)	• England-urban areas • 1997-2012	• 26,455 urban residential areas	• Cross-sectional ecological study • Asthma hospitalization standardized rates, percentage of green space, percentage of gardens, density of mature trees • Air pollution • English indices of deprivation	• Green space and gardens associated with reduced asthma hospitalizations when air pollutant exposures were low • Tree density associated with reduced asthma hospitalizations when air pollutant exposures were high
Residential greenness is differentially associated with childhood allergic rhinitis and aeroallergen sensitization in seven birth cohorts (199)	• Sweden, Australia, Netherlands, Canada and Germany	• 13,016 participants children age 6-8 years, adolescents 10- 12 years	• 7 longitudinal birth cohorts • Parent-completed questionnaires, skin prick test, allergen-specific Immunoglobulin E (IgE) levels • NDVI around home address at 500 & 1000m.	• Greenness at 500m was positively associated with allergic rhinitis in children 6-8 in Swedish NDVI mean 0.30 (0.1-0.55) and Munich Area NDVI mean 0.35 (0.13-0.5) cohorts • Greenness at 500m was inversely associated with allergic rhinitis in children 6-8 in predominantly Rural German Area NDVI 0.37 (0.15-0.58) and Dutch cohorts NDVI mean 0.37 (0.1-0.6)
Childhood intermittent and persistent rhinitis prevalence and climate and vegetation: a global ecologic analysis (335)	• Global, 87 countries • 2001-2003	• Children age 6-7 & 13-14	• Ecologic analysis • ISAAC Phase 3 • parent- or child-completed questionnaire, • NDVI monthly averages (2005)	• Risk estimates for NDVI 0.4 (0.3-0.5) were elevated but not significant for intermittent and persistent rhinitis • Positive within-country association between maximum monthly vegetation and persistent rhinitis prevalence in 6-7 years old children

Title	Place Year of Study	Study Population	Study Design Data Collection	Main Findings
Risks and benefits of green spaces for children: a cross-sectional study of associations with sedentary behavior, obesity, asthma, and allergy (201)	• Sabadell, Spain • 2006-2007	• 3,178 participants Schoolchildren, age 9-12 years	• Parent-completed questionnaires • Body Mass Index[2], NDVI around home address 100, 250, 500 & 1000 m • Residential proximity within 300m from a park or forest	• NDVI - 100 m buffer: median 0.038 IQR 0.076 - 250 m median 0.061 IQR 0.105 - 500 m median 0.095 IQR 0.120 - 1000 m 0.125 IQR 0.097 • Not association between increase of residential surrounding greenness an current asthma • Residential proximity to parks was positively associated with childhood asthma
Greenness and allergies: evidence of differential associations in two areas in Germany (200)	• Ruhr area (GINI/LISA[3] North)-1997-1999 • Munich area (GINI/LISA South)-1995-1998	• 5,803 children, 3-10 years old	• Longitudinal cohort study • Parent-completed questionnaire, • NDVI around home address at 500, 800, 1000 & 3000 m (2003)	• GINI/LISA North - NDVI: Mean 0.43 (0.18-0.65) 500 m buffer - Greenness Ruhr (500 m buffer) associated with less eyes & nose symptoms, allergic rhinitis and aeroallergen sensitization • GINI/LISA South - NDVI: Mean 0.35 (0.08-0.65) 500 m buffer - Greenness Munich (500 m buffer): associated with more eyes & nose symptoms
Urban tree canopy and asthma, wheeze, rhinitis, and allergic sensitization to tree pollen in a New York city birth cohort (336)	• New York, NY, USA • 1998-2006	• 427 Children age 5-7 years, African American or Dominican, living in economically disadvantaged urban areas	• Longitudinal birth cohort study • Children, parent-completed questionnaire • Serum IgE • Urban tree canopy coverage 250m from prenatal home address (2001-2010)	• Tree canopy coverage near prenatal home address was risk factor for: - Reported asthma diagnosis at age 7 years - Any specific allergic sensitization - Allergic sensitization to tree pollen

[1] NDVI: Normalized Difference Vegetation Index

[2] BMI: Body Mass Index

[3] German Infant Nutritional Intervention Study (GINI study)/Life-style, Immune System and Allergies (LISA)

Exposure to air pollution was estimated by determining the distance between the house address and the nearest street. We found increased odds of rhinitis and asthma prevalence in participants living further away from the main streets. These findings contrast with evidence reporting a higher prevalence of rhinitis and asthma in inhabitants of housing located closer to streets and thus with increased exposure to vehicular air pollutants as risk factors. Shirinde *et al.* (225) performed a study in two cities in the Highveld region, an area with high air pollution in South Africa, in which they evaluated 3,764 children aged 13-14, to study associations between RS and exposure to vehicular truck traffic. These authors found associations between ever having rhinitis and almost all-day frequency of exposure to truck traffic, reporting that 56% (679/1212) of exposed children had rhinitis (aOR 1.46, CI 1.16-1.84, p=0.001). An association was also found between current rhinitis and frequency of truck traffic, with 43% (521/1212) of exposed children having rhinitis (aOR 1.60, CI 1.24-2.02, $p<0.001$) (225). In a systematic review of 41 studies addressing the contribution of traffic-related air pollution to asthma development in children, the overall random-effects risk estimates (95% CI) showed associations between asthma and black carbon 1.08 (1.03, 1.14), nitrogen dioxide 1.05 (1.02, 1.07), and particulate matter $PM_{2.5}$ 1.03 (1.01, 1.05) and PM_{10} 1.05 (1.02, 1.08) (221).

A review of asthma in Latin America, summarized studies on air pollution as a risk factor for asthma, including a Mexican report evaluating diesel vehicle exposure as a risk factor for wheezing, cough and decreased pulmonary function, a Brazilian report in which lung function in children was negatively affected by PM_{10} and NO_2, and an Argentinian report in which higher asthma, exacerbations and lower pulmonary function were found in children living close to the main oil refinery in the country (198).

Our findings may be explained by the unique geographical and sociodemographic characteristics of Ciudad Bolívar that generate unequal access to main streets, with neighborhood clusters in poor infrastructure and housing conditions that can likely present differential exposure to environmental pollution. This district is located on mountain slopes with incomplete urbanization and unequal access to adequate paved streets and vehicular traffic (344, 345). Along the mountain, from its base to the summit, there is housing only accessible via steep staircases, of lower commercial value and inhabited by families with lower income. Particularly at the summit, it is common to inhabit houses with lower hygiene conditions, higher overcrowding, lower safety and higher exposure to ozone and ascending airborne PM_{10} and $PM_{2.5}$ contaminants (345).

4.3.5.3. Hygiene

In our study, hygiene conditions were not associated with RS. This may be due to rhinitis, wheezing and asthma in our participants, being mediated by mechanisms such as underlying stress related to low socioeconomic conditions, high levels of violence and social disadvantages, all risk factors which have been associated with childhood asthma and rhinitis (219, 346-348). This could be further analyzed particularly in a population such as Ciudad Bolívar, with low socioeconomic conditions and high levels of violence (349), as stress caused by these lower housing conditions and safety can affect the prevalence of asthma and rhinitis.

4.4. Conclusions

The study population was characterized because the majority of pregnant women were young. Their sociodemographic conditions were unique with the majority of them living in the capital district of Ciudad Bolívar in households with adequate basic sanitation. Participants were mostly homemakers, having achieved secondary education, but reporting a low monthly income. In addition, 30% of them were single mothers and 20% reported having been forcefully displaced from other Colombian regions.

Regarding the IPI study, the majority of participants who answered the questionnaire and provided at least one stool sample, were women in the second trimester of pregnancy, and living in Usaquén and Kennedy, capital districts where sample selection was non-probabilistic. Study participants mostly lived in socioeconomic stratum 2, with health insurance coverage and low monthly income. In this study, the prevalence of pathogenic intestinal parasites was lower than expected, a finding limited by the stool sample quote response, the diagnostic techniques used and difficult access to participants living in marginalized unsafe locations. Even so, climate conditions in Bogotá and urban access to piped water could also be contributing to this low prevalence. The only factor statistically associated with higher prevalence of any intestinal parasite was having received deworming drugs over a year ago, a finding that could be indicating a positive effect of preventive therapy. However, given the limited sample size and selection bias in this study, future research could explore other factors uncovered by this study, including trends for higher IPI prevalence in married or cohabiting women, participants who self-identified as belonging to an ethnic minority and women without access to handwashing facilities at home. These future studies should use probabilistic selection of all participants, with a sufficient sample size to allow accurate interpretation of the findings.

Regarding RS, the participants were pregnant women living in Ciudad Bolívar, who reported asthma and wheezing prevalence lower than the adult population of Colombia, and rhinitis prevalence similar to other Colombian studies. The high percentage of women who did not participate limits the statistical power to do inference based on our findings. The findings of higher prevalence of rhinitis in areas with low access to greenness, and increased odds for rhinitis and asthma when participants lived away from main streets, may be mediated by individual socioeconomic variables (203), including low employment and monthly income, high inbound and outbound migration in the population with short permanence in one house, and the unique environmental quality of each neighborhood. These social and environmental conditions of vulnerability may override the effects of hygiene on respiratory health. Future studies should focus on the effects of these variables when evaluating greenness in this population. Other additional studies are needed to assess the types of greenness and vegetation, as NDVI is a general assessment that does not fully capture the characteristics of green spaces that could affect allergic disorders (199).

Overall, considering the challenges inherent to accessing urban populations living in vulnerable conditions, it is necessary to design and support community-based research studies with active and committed participation by local community leaders and organizations, and using mixed methodology that will include qualitative and quantitative approaches.

4.5. The implications of the study

Considering the limitations of sample size and participant selection bias, this study can only provide hypothesis for future research on health outcomes in pregnant women who live in vulnerable conditions and in housing that is difficult to access. It argues for studies with larger population samples, to continue the assessment of the impact of IPI and RS in pregnant women, as well as the potential health impacts for their offspring. Collaborative initiatives with community leaders and governmental agencies could facilitate overcoming research barriers regarding safe and continuous access to participants. Considering our IPI findings, future studies could assess all stool samples using PCR strategies with 100% sensitivity, which would require more funded research considering the increased costs of molecular diagnosis. Regarding our finding of higher rhinitis in pregnant women living away from main streets in marginalized areas, future research and health actions should focus on these populations. Thus, to perform community-based research that will discriminate health, socioeconomic and environmental variables with higher resolution, the support by local health, government and community leadership and agencies is of paramount importance.

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6. ANNEX

STATEMENT ON PRE-RELEASE AND CONTRIBUTION

Research on IPI was published as Espinosa *et al*., “Prevalence and risk factors for intestinal parasitic infections in pregnant women residing in three districts of Bogotá, Colombia”, in BMC Public Health 18(1):1701 on August 29, 2018.

Under the supervision, support and guidance of Prof. Dr. Katja Radon, Dr. Maria Delius and Dr. Angela Pinzon, I carried out the research project including the initial proposal, ethics approval, funding, field work, data collection, analysis of findings, and writing of the published article and thesis. The statistical analysis of RS section was performed by Dr. Ronald Herrera.

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To God, giver of life, my most valuable fortress.

APPENDIX 1

Information protocol to give maternal women once the questionnaire has been filled
Once the form has been filled, request the patient five more minutes to provide her the following information for antenatal care.
Signs of alarm

There are some symptoms you should pay attention to because may represent a risk to your baby or your own health.

1. High blood pressure: Get your blood pressure checked regularly.
2. Headache.
3. Blurred vision.
4. Hearing a buzzing sound in your ear.
5. Pain or burning sensation in stomach.
6. Face, hands, or feet swelling.
7. Stop feeling the baby's movement during pregnancy.
8. Uterine contractions.
9. Genital bleeding.
10. Pain while urinating.
11. Liquid loss or vaginal discharge.

General recommendations

1. Remember the units of immediate attention in case of emergency: the hospital in your district
2. Do not self medicate.
3. Avoid tobacco, alcohol and psychoactive drugs.

In case of identifying psychoactive drugs use inform the patient about risks of early labour and low birht weight in the baby. Encourage the mother to reduce drug use to minimum

APPENDIX 2

CODE OF THE SURVEY_________

QUESTIONNAIRE OF STUDY

Hello, my name is ____. I work in a research project carried out by Universidad del Rosario and in which you accepted to participate. If you agree, I will now start the survey mentioned in the informed consent and assent (if apply) form. I will ask you some questions about your health and your home, and if you authorize it, we will visit you at your home to observe the facilities. This survey will take approximately 15 minutes of your time. You are free to take part of this survey or not participate at all. In addition, you are free to not answer one or more questions, and to stop this interview at any time.

Can I start the interview? YES 1 NO 2

Questionnaire Date DD/MM/YY

Stratum 1 2

GENERAL INFORMATION OF THE PARTICIPANT

1. What is your date of birth?
   .... DD/MM/AA

2. Are you the head of the household?
   No.. 1
   Yes.. 2

3. Do you currently have a partner?
   No.. 1
   Yes.. 2

4. Are you currently studying?
   No.. 1
   Yes.. 2

5. Are you a victim of forced displacement?
   No.. 1
   Yes.. 2

6. Are you currently breastfeeding?[1]
   No.. 1
   Yes.. 2

7. According to your culture, do you consider yourself?[2] **Select one option only**

[1] This question was modified after pilot test of the questionnaire. Changed from Are you breastfeeding to are you currently breastfeeding?

[2] This question was modified after pilot test of the questionnaire. Changed from to ask to the participant: Which is your ethnicity group? to ask her if according to her culture she self-considered an of the presented options.

Afro-Colombian... 1
Indigenous 2
Rom Gypsy 3
Raizal 4
None 5

8. What is your civil status? **Select one option only**

Single 1
Married 2
Divorced/Separated 3
Free Union 4
Widow 5
NR 8

9. How many people form your family?

Children .... |__|__|
Adults .... |__|__|

10. How many people live under the same roof?[3] **Including those who are not part of your family but share common spaces at your home**

Children .... __|__|
Adults .... |__|__|

11. What is your educational level?

Elementary school 1
Secondary school 2
Technical education 3
University 4
Years at the highest educational level .... |__|__|

12. What is your health care system? **Select one option only**

Contributory regime 1
Name of the Health Promoting Entity ____
Subsidized regime 2
Name of the Subsidized Health Promoting Entity ____
Temporarily linked 3
Special regime 4
Which____
Not affiliated 5
Don't know / NR 88

13. Currently, what is your main occupation?

Homemaker 1
Student 2
Agricultural worker 3
Technician 4
Office worker 5

[3] This question was modified after pilot test of the questionnaire. Changed from to aske to the participant: How many people lived in this house to how many people lived under the same roof.

Sales and services worker 6
Professional 7
Manager 8
Skilled laborer 9
Unskilled laborer 10
NR 88

14. Currently are you mainly?

Employed in a formal job 1
Employed in an informal job 2
Self-employed 3
Out of work in the last 12 months 4
Out of work for more than one year 5
Retired, but still working 6
Retired 7
Have never worked 8

GENERAL CHARACTERISTICS OF PREGNANCY

15. Do you have any disability?
    - No 1
    - Yes 2

16. What is the date of your last menstrual period? .... DD/MM/AA
    - Don’t know / NR 88

17. What pregnancy week are you in? .... |__|__|
    - Don’t know / NR 88

18. Your pregnancy is
    - Simple 1
    - Twins 2
    - More than two 3
    - Don’t know 88

19. In the current pregnancy, have you attended prenatal control?
    - No 1
    - Yes 2

20. How many prenatal control visits have you attended? (insert number) .... |__|__|

21. In your previous pregnancies, have you had a newborn weighing:
    - Less than 2500 grams 1
    - More than 4000 grams 2
    - Normal weight 5
    - Has not occurred 7
    - Unknown 8

22. Please indicate the number of: (insert number)
    - Pregnancies .... |__|__|
    - Born alive .... |__|__|
    - Vaginal deliveries .... |__|__|
    - Cesarean deliveries .... |__|__|
    - Abortions .... |__|__|
    - Born still alive .... |__|__|
    - Stillborns (born dead) .... |__|__|
    - Ectopic pregnancies .... |__|__|
    - Multiple pregnancies .... |__|__|

23. Have you had any of the following diseases during pregnancy? (**Select with an X all applicable**)

	NO	YES
Low gestational weight	1	2
Malnutrition	1	2
Diabetes	1	2
Kidney disease	1	2
Hypertension	1	2
Vaginal Infections	1	2
Urinary tract infections	1	2

	NO	YES
Obesity	1	2
Placenta previa	1	2
Thyroid gland problems	1	2
Vaginal bleeding	1	2
Syphilis	1	2
HIV	1	2
Anemia	1	2
Treated anemia	1	2
Skin allergy (dermatitis)	1	2
None	1	2

24. Have you ingested alcohol during current pregnancy?
    - No 1
    - Yes 2

25. Have you taken psychoactive substances during current pregnancy?
    - No 1
    - Yes 2

26. Have you been hospitalized during your current pregnancy?
    - No 1
    - Yes 2

27. Why have you been hospitalized?
    - Infection 1
    - Bleeding 2
    - Hypertension 3
    - Respiratory problems 4
    - Threatened miscarriage 5
    - Rupture of membranes (amniorrhexis) 6
    - Domestic violence 7
    - Other, which?________________________________ 8

28. Fill in values and dates of hematocrit and hemoglobin (**use as source the history of the participant**)

	1st trimester		**2nd trimester**		**3rd trimester**	
	Date	**Value**	**Date**	**Value**	**Date**	**Value**
Hematocrit						
Hemoglobin						

29. When was your last deworming treatment?
    - Currently 1
    - One month ago 2
    - Two months ago 3
    - Three months ago 4
    - Six months ago 5
    - One year ago 6
    - More than one year ago 7
    - Never 8

Don't know.. 9

30. Please answer the following questions regarding your respiratory health:

30.1. Have you had wheezing or whistling in your chest sometime in the last 12 months? **(If the answer is NO, skip to question 30.2)**

No.. 1

Yes.. 2

30.1.1. Have you had shortness of breath when you had wheezing or whistling?

No.. 1

Yes.. 2

30.1.2. Have you had this wheezing or whistling in the absence of a cold?

No.. 1

Yes.. 2

30.2. Do you have or have you ever had asthma? **(If the answer is NO, skip to question 30.3)**

No.. 1

Yes.. 2

30.2.1. Has your physician ever told you that you have asthma?

No.. 1

Yes.. 2

30.2.2. How old were you when you had your first asthma attack? .... |__|__|

30.2.3. Have you had episodes of asthma during last 12 months?

No.. 1

Yes.. 2

30.2.4. Do you currently take any asthma medication? (including inhalers, aerosols or pills)

No.. 1

Yes.. 2

30.3. Do you have any nasal allergies, including rhinitis?

No.. 1

Yes.. 2

30.4. Do you smoke or have you smoked for more than one year? **(If the answer is NO, skip to question 31)**

No.. 1

Yes.. 2

30.4.1. Do you currently smoke (minimum within the last month)?

No.. 1

Yes.. 2

HOUSING CHARACTERISTICS

31. How much is your household's monthly income? **($689.454) Select only one option**

Less than one monthly minimum wage 1
One monthly minimum wage 2
More than one monthly minimum wage 3
More than two monthly minimum wages 4
Don't known / NR 8

32. What type of housing does the pregnant woman live in?

Owned house 1
Rented house 2
Owned apartment 3
Rented apartment 4
Rented room(s) in a tenement 5
Rented room(s) in any other type of structure 6
Indigenous housing 7
Other, which?______________________________ 8

33. What public services do you have in your home? **(Select the ones present; remember that water, sewage and waste collection are included in the same bill)**

Piped water supply .... ☐
Sewerage .... ☐
Electricity .... ☐
Natural gas .... ☐
Landline .... ☐
Cellphone .... ☐
Internet .... ☐
Garbage collection .... ☐
How many times per week does garbage collection occurred in your home? .... |__|__|

34. How is garbage mainly disposed of at home?

Picked up by cleaning services 1
Burned 2
Buried 3
Thrown into the river, drainage, pond, creek 4
Thrown into the yard, lot, ditch, wasteland 5
Picked up by informal service (cart, carriage) 6
Other, which?______________________________ 7
Don't know / NR 8

35. What type of sanitary facilities exist in your home? **Select only one option**

a. Toilet connected to sewage system 1
Exclusive use?
No 1
Yes 2

b. Toilet connected to septic well 2
Exclusive use?
No 1

Yes 2

c. Toilet without connection 3
Exclusive use?
No 1
Yes 2

d. Latrine 4
Exclusive use?
No 1
Yes 2

e. No sanitary facilities 5

f. Other, which?______________________________ 6

36. How many toilets are there in your home? .... |__|__|
Exclusive use?
No 1
Yes 2

37. Does your home have a shower service?
No 1
Yes 2
Exclusive use?
No 1
Yes 2

38. Does your home have a bathroom sink?
No 1
Yes 2
Exclusive use?
No 1
Yes 2

39. What is the <u>main</u> water source for you and your family at home? **(Select only one option)**
Tap water from house aqueduct 1
Tap water from another house aqueduct 2
Water from a water truck 3
Water from a building cistern 4
Water from a underground well 5
Rainwater 6
Bottled water 7
Other, which?______________________________ 8

40. How much time do you spend getting water? **(Only applicable for homes without piped water)**
Time in minutes .... |__|__|

41. What do you usually do to make the water potable? **(Register all options mentioned)**
Boil 1
Ozonize 2

Chlorinate 3
Add ashes 4
Strain through a cloth 5
Filter 6
Nothing.. 7
Don't know.. 8
Other, which?_______________________________ 9

42. Where do you usually prepare your food?
Kitchen in an independent space.. 1
Kitchen shared with other room(s).. 2
What room is it shared with? _____________________________________
Not possible to observe.. 3

43. Is the kitchen exclusively used by people living in the house?
No 1
Yes.. 2

Do you have a direct water source in the kitchen? **(piped water faucet, water storage)**
No 1
Yes.. 2

44. How many bedrooms in the house are occupied by your family? .... |__|__|
Don't know / NR__________________________________
How many people on average sleep in each bedroom? .... |__|__|
Don't know / NR__________________________________

45. How many people does the pregnant woman sleep with in the same bedroom? |__|__|

46. Now **select with an X** the main material the house roofs, walls and floors are made of (one option)

Roof	
Concrete	1
Wood	2
Zinc roof tile	3
Clay roof tile	4
Paperboard	5
Fiber cement (Eternit)	6
Other/Which? __________	7
Not possible to observe	8

Walls	
Brick	1
Prefabricated material	2
Wood	3
Clay	4
Paperboard	5
Tin	6
Other/Which? __________	7
Not possible to observe	8

Floors	
Soil	1
Concrete	2
Tile	3
Ceramic tablet	4
Rough wood	5
Polished wood	6
Carpet	7
Other/Which? __________	8
Not possible to observe	9

47. Include information regarding animals in your home

	Animals		**How many?**	**Do they sleep in rooms?**		**Dewormed in last 6 months?**	
	NO	YES		NO	YES	NO	YES
Cats	1	2		1	2	1	2
Dogs	1	2		1	2	1	2
Chicken	1	2		1	2	1	2

Others_______ Which? ____

HYGIENE HABITS

48. Is there any type of home pest? (**Register what the participant mentions and what you observe**)

	NO	YES
Flies	1	2
Mosquitoes	1	2
Houseflies	1	2
Fleas	1	2
Lice	1	2
Ticks	1	2
Cockroaches	1	2
Pigeons	1	2
Rats	1	2
None	1	2

Others______________________ Which____

49. Please show me the place where your family members most often wash their hands.
    - Bathroom sink.. 1
    - Kitchen sink.. 2
    - Laundry sink.. 3
    - No specific place.. 4
    - Not observed.. 5

50. Do you do anything to fruits and vegetables prior to consumption?
    - No.. 1
    - Yes.. 2

What do you do? (Do not induce the answer, wait until the participant mentions the options and then select with an X the one(s) mentioned by her)
- Nothing.. 1
- Washing with water.. 2
- Washing with water and soap.. 3
- Wasingh with water and disinfectant.. 4
- Don't know / NR.. 5
- Other, which?_______________________________ 6

51. Where do you get water to wash your hands? (**Based on what is reported and observed**)
    - No water available.. 1
    - From tap water.. 2
    - From a water tank.. 3
    - Other, which?_______________________________ 4

52. What kind of soap is available to wash your hands?
    - No soap available.. 1
    - Detergent soap.. 2
    - Bar soap.. 3
    - Powder soap.. 4
    - Liquid soap.. 5
    - Other, which?_______________________________ 6

53. When do you wash your hands? **(do not mention the moments, register what the participant reports)**

	NO	YES
Before eating	1	2
Before using the toilet	1	2
After using the toilet	1	2
Before preparing food	1	2
After preparing food	1	2
When arriving home	1	2
Before taking care of the baby	1	2

54. Do you walk barefoot at home?
   - Never 1
   - Sometimes 2
   - Always 3

55. Do you walk barefoot outside of your home? (observe and ask)
   - Never 1
   - Sometimes 2
   - Always 3

Ask if you can walk through <u>home spaces occupied by people living at home</u> to observe hygiene conditions of the different locations indicated below

56. Now register cleanliness of the following locations in the house

	Kitchen			Living room			Dining room			Other home spaces		
	Clean	Dirty	Not observed	Clean	Dirty	Not observed	Clean	Dirty	Not observed	Clean	Dirty	Not observed
Walls												
Ceiling												
Floor												
Surfaces												

57. Cleanliness of bedrooms used by the <u>family</u> **(indicate based on observations)**

	Bedroom 1 (where pregnant woman sleeps)			**Bedroom 2**			**Bedroom 3**			**Bedroom 4**		
	Clean	Dirty	Not observed	Clean	Dirty	Not observed	Clean	Dirty	Not observed	Clean	Dirty	Not observed
Walls												
Ceiling												
Floor												
Surfaces												

58. Cleanliness of bathrooms used by the <u>family</u>

	Bathroom 1			Bathroom 2			Bathroom 3			Bathroom 4		
	Clean	Dirty	Not observed	Clean	Dirty	Not observed	Clean	Dirty	Not observed	Clean	Dirty	Not observed
Walls												
Ceiling												
Floor												
Surfaces												

THANK YOU FOR YOUR ATTENTION AND COLLABORATION.

WE REQUEST YOU NOT TO MENTION THE CONTENT OF THESE QUESTIONS TO OTHER PREGNANT WOMEN IN THE NEIGHBOURHOOD SO THAT THE ANSWERS WILL ASSURE THE BEST RESULTS FROM THE SURVEY

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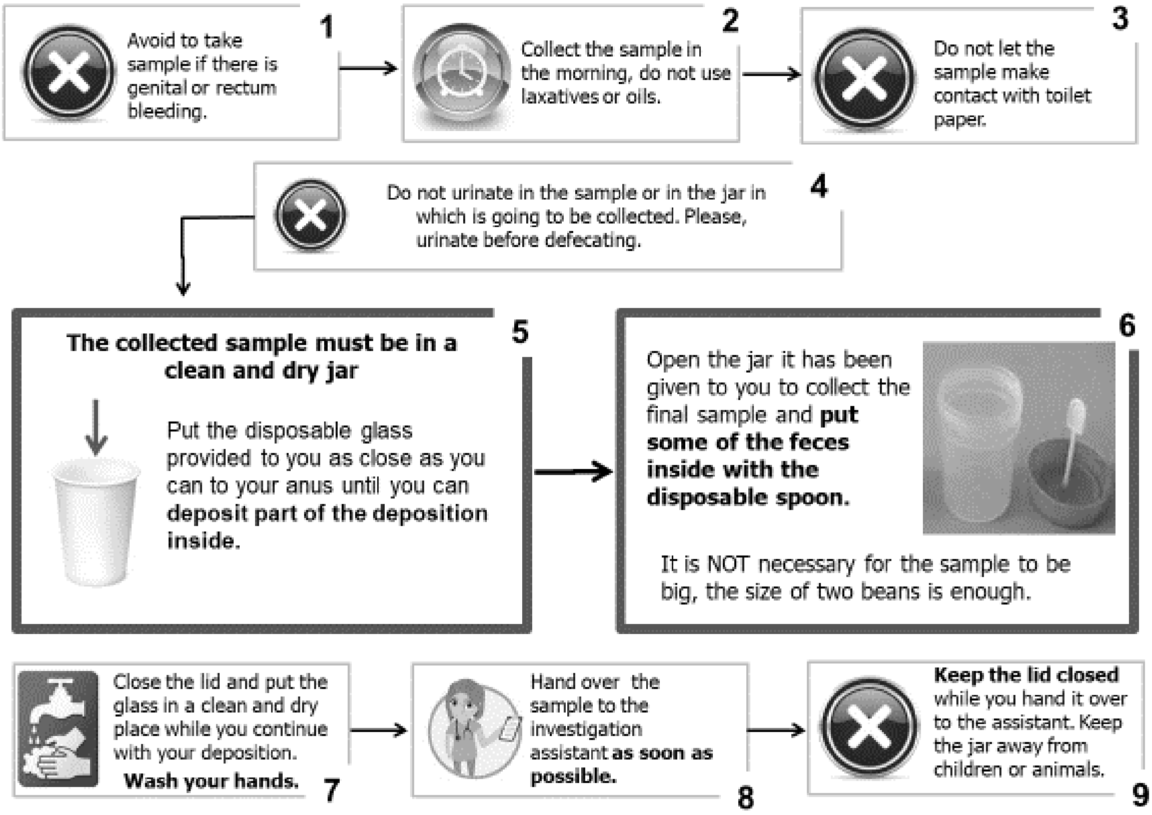
APPENDIX 3

Indications to collect fecal sample properly



APPENDIX 4

ENVIRONMENTAL RISK FACTORS ASSOCIATED WITH INTESTINAL PARASITES IN PREGNANT WOMEN IN FOUR DISTRICTS IN BOGOTÁ D.C.

DISTRICTS: BOSA-CIUDAD BOLÍVAR, KENNEDY AND USAQUÉN

ESCUELA DE MEDICINA Y CIENCIAS DE LA SALUD-UNIVERSIDAD DEL ROSARIO-UNIVERSIDAD DEL ROSARIO

CENTER FOR INTERNATIONAL HEALTH-LUDWIG MAXIMILIANS UNIVERSITY

INFORMED CONSENT

We are inviting you to participate in the study: "Environmental risk factors associated with intestinal parasites in pregnant women in four districts in Bogotá D.C."

AIM OF THE STUDY:

The aim of the study is to determine the number of pregnant women living in strata 1 and 2 of the districts Bosa, Ciudad Bolívar, Kennedy and Usaquén who are infected with intestinal parasites and the possible reasons that trigger the development of these kind of infections in that population.

JUSTIFICATION:

Intestinal parasites infections are very frequent worldwide. Almost one third of the world's population is infected. Children and pregnant women are the most susceptible to contract these kind of infections, leading to important consequences for their health, such us malnutrition and anemia. In Bogotá the number of pregnant women with intestinal parasites is unknown. In order to be able to implement health interventions it is important to know about the magnitude of the problem. This is the aim of this study.

PROCEDURE:

The participation in this research consists of (1) collecting two stool samples (collected on two different days) according to the indications given by the health care worker and (2) answering one survey during the house visit which will take 15 to 20 minutes.

The stool samples will be taken to a laboratory to determine whether intestinal parasites are present or not. These exams do not have any costs for you.

The house visit will be done by a person involved in the research. She will ask some questions and besides that she will ask your permission to view different spaces in the house.

RISKS

According to Resolution 8430 of 1993 of the Ministerio de la Protección Social, this research is considered to be without risks for you.

BENEFITS

The participation in this research will give you insight on whether you have intestinal parasites or not. After the examinations of the stool samples and the house visit you will receive the results of the examinations and recommendations for treatment or for prevention of the infections.

You will not receive payment for your participation in this research. With your participation you will contribute to improve the health of pregnant women in Bogotá.

HANDLING OF INFORMATION

The obtained information from laboratory exams and the house visit will be handled in a confidential way. All people involved in the research have signed a confidentiality agreement in which they committed to keeping all information confidential. Both the laboratory exams and survey will be identified with a code in order to protect your identity. The identification number, your name and your signature will be asked in order to comply to the Colombian rules. The researchers will link your identification number with an assigned code in a file which only they will have access to. The aim of this is to be able to identify pregnant women that require treatment.

According to the Colombian rules both researchers and health care workers must comply to before written. If you consider that this criteria are not met, please contact the Ethical Committee of Universidad del Rosario with phone number 2970200 Ext 4019 or 3405.

INFORMED CONSENT DECLARATION

I read (or was read), and I have understood the information about the study “Environmental risk factors associated with intestinal parasites in pregnant women in four districts in Bogotá D.C.” and I had the opportunity to ask questions and to receive satisfactory answers.

My participation in this study is completely voluntary and I can drop out at any moment for any reason without any negative consequences for me.

My participation in this research does not have any costs for me. I understand that:

I GIVE MY VOLUNTARY CONSENT TO BE PART OF THIS STUDY

IDENTIFICATION NUMBER____

NAME: ____

SIGNATURE ____

I.NUMBER__________________________ I. NUMBER_________________________________

NAME: __________________________ NAME: _________________________________

ADDRESS __________________________ ADDRESS_________________________________

PHONE __________________________ PHONE_________________________________

_____________________________ _____________________________

SIGNATURE OF WITNESS I SIGNATURE OF WITNESS II

____

SIGNATURE OF THE MAIN RESEARCHER

NAME OF THE MAIN RESEARCHER

Bogotá, D.C, date (dd/mm/yy): ___________________________

If you have any questions, comments or suggestions or you wish to drop out of the study you can communicate directly with:

Ángela Fernanda Espinosa Aranzales, main researcher. Address office: Carrera 24 63C-74. Universidad del Rosario. Phone number 2970200 Ext. 3344

You can always communicate with the president of the Ethical Committee of Universidad del Rosario on phone number 2970200 Ext. 4019/3405

APPENDIX 5

ENVIRONMENTAL RISK FACTORS ASSOCIATED WITH INTESTINAL PARASITES IN PREGNANT WOMEN IN FOUR DISTRICTS IN BOGOTÁ D.C.
DISTRICTS: BOSA, CIUDAD BOLÍVAR, KENNEDY AND USAQUÉN
ESCUELA DE MEDICINA Y CIENCIAS DE LA SALUD-UNIVERSIDAD DEL ROSARIO-UNIVERSIDAD DEL ROSARIO
CENTER FOR INTERNATIONAL HEALTH-LUDWIG MAXIMILIANS UNIVERSITY

INFORMED ASSENT

We are inviting you to participate in the study: "Environmental risk factors associated with intestinal parasites in pregnant women in four districts in Bogotá D.C."

AIM OF THE STUDY:

The aim of the study is to count the number of pregnant women living in strata 1 and 2 of the districts Bosa, Ciudad Bolívar, Kennedy and Usaquén who have intestinal parasites (the most of them are known as a "lombrices and amebas"). We also want to study the possible reasons that trigger the development of these kind of infections in that population.

JUSTIFICATION:

When pregnant women are infected with intestinal parasites ("lombrices and amebas"), they and their babies could get sick. Therefore it is important to know whether pregnant women are infected in order to be able to help them.

PROCEDURE:

The participation in this research consists of (1) collecting two stool samples (collected on two different days) according to the indications given by the health care worker and (2) answering one survey during the house visit which will take 15 to 20 minutes.

The stool samples will be taken to a laboratory to determine whether intestinal parasites are present or not. Neither the exams nor the survey have any costs for you.

The house visit will be done by a person involved in the research. She will ask some questions and besides that she will ask your permission to view different spaces in the house.

RISKS

Your participation in this study does not have any risks for you.

BENEFITS

The participation in this research will give you insight on whether you have intestinal parasites or not. After the examinations of the stool samples and the house visit you will receive the results of the examinations and recommendations for treatment or for prevention of the infections.

You will not receive payment for your participation in this research. With your participation you will contribute to improve the health of pregnant women in Bogotá.

HANDLING OF INFORMATION
Your name and your identification data will be known by the researchers of the study only. They must handle your identity; the results of examinations and the information of the house visit in a secret way.
If you consider that this criterion is not met, please contact the Ethical Committee of Universidad del Rosario with phone number 2970200 Ext 4019 or 3405.

INFORMED ASSENT DECLARATION

I read (or was read), and I have understood the information about the study "Environmental risk factors associated with intestinal parasites in pregnant women in four districts in Bogotá D.C." and I had the opportunity to ask questions and to receive satisfactory answers.

My participation in this study is completely voluntary and I can drop out at any moment for any reason without any negative consequences for me.
My participation in this research does not have any costs for me. I understand that:

I GIVE MY VOLUNTARY ASSENT TO BE PART OF THIS STUDY

IDENTIFICATION NUMBER____
NAME: ____
SIGNATURE ____

SIGNATURE OF THE MAIN RESEARCHER
____
NAME OF THE MAIN RESEARCHER
____
Bogotá, D.C, date (dd/mm/yy): ____

If you have any questions, comments or suggestions or you wish to drop out of the study you can communicate directly with:

Ángela Fernanda Espinosa Aranzales, main researcher. Address office: Carrera 24 3 63C-74. Universidad del Rosario. Phone number 2970200 Ext. 3344

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