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Food allergy, airborne allergies, and allergic sensitisation among adolescents living in two disparate socioeconomic regions in Ecuador: A cross-sectional study

Diana A. Morillo-Argudo[a], Dolores S. Andrade Tenesaca[a], Claudia R. Rodas-Espinoza[b], Michael R. Perkin[c], Tesfalem Lukas Gebreegziabher[d], Gabriela A. Zuñiga[e], Diana D. Andrade Muñoz[a], Patricia L. Ramírez[a], Ana A. García García[a] and Angélica M. Ochoa-Avilés[a]*

ABSTRACT

Background: Allergic diseases are under-investigated and overlooked health conditions in developing countries. We measured the prevalence of food allergy (FA), airborne allergic disease, and allergic sensitisation among adolescents living in 2 socio-demographically disparate regions in Ecuador. We investigated which risk factors are associated with these conditions.

Methods: A cross-sectional study involved 1338 students (mean age: 13 ± 0.9 years old) living in Cuenca (n = 876) and Santa Isabel (n = 462). History of allergic symptoms (noted by parents or doctor) to food, house dust mites (HDM), pollen, and pets were recorded. Sociodemographic characteristics, environmental exposures, and parental history of allergic disorders data were collected. Sensitisation to 19 food and 20 aeroallergens was measured by skin-prick testing (SPT). FA and airborne allergic diseases (to HDM, pollen, cat, or dog) were defined as a report of allergic symptoms noted by doctor, together with a positive SPT (wheal size ≥3 mm). Logistic regression models were used to identify environmental and parental factors associated with allergic conditions.

Results: FA was prevalent among 0.4% (95% CI 0.2%–0.9%), and food sensitisation among 19.1% of the adolescents. Shrimp was the most frequent food linked with FA and food sensitisation. Risk factors associated with FA could not be evaluated due to the low prevalence. Food sensitisation was higher among adolescents exposed to family smoking (OR 1.63, 95% CI 1.14–2.34, p = 0.008) and those with parental history of allergic disorders (OR 1.68, 95% CI 1.13–2.49, p = 0.01), but less common among adolescents owning dogs (OR 0.59, 95% CI 0.41–0.84, p = 0.003).
Airborne allergic diseases were prevalent amongst 12.0% of the adolescents (95% CI: 10.4–13.9, n = 1321), with HDM as the primary allergen (11.2%). Airborne allergic diseases were less common among adolescents with more siblings (OR 0.79, 95% CI 0.65–0.96, p = 0.02) and those who lived with farm animals in the first year of life (OR 0.47, 95% CI 0.23-0.95, p = 0.04), but, most common among adolescents with a smoking family (OR 1.67, 95% CI 1.04–2.70, p = 0.03) and

[a]Department of Biosciences, Faculty of Chemistry, University of Cuenca, Cuenca, Azuay, Ecuador
*Corresponding author. Department of Biosciences, Faculty of Chemistry, University of Cuenca, Avenue 12 Abril and Agustín Cueva, Cuenca, Azuay, Ecuador E-mail: angelica.ochoa@ucuenca.edu.ec
Full list of author information is available at the end of the article
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with a parental history of allergic disorders (OR self-perceived: 2.62, 95% CI 1.46-4.71, $p = 0.001$; OR diagnosed by a doctor: 4.07, 95% CI 2.44-6.80, $p < 0.001$).

Conclusions: FA and airborne allergies are less prevalent in Ecuador than in developed regions; there is a great dissociation between the prevalence of allergic disease and allergic sensitisation. Shrimp and HDM were the most prevalent allergens. Risk factors identified in this study to be related to allergic diseases should be considered by physicians, health practitioners, and epidemiologists in Ecuador.

Keywords: Adolescent, Allergic sensitisation, Food allergy, Ecuador

INTRODUCTION

The prevalence of allergy and sensitisation to food and airborne allergens amongst the adolescent population varies across regions and countries but, in general, has been found to be higher in affluent countries than low-and-middle-income countries.[1-4] Allergic diseases and allergic sensitisation are associated with complex interactions between sociodemographic attributes,[5,6] environmental exposures (eg, family smoking),[7] and genetic/epigenetic factors.[8] Food allergy (FA) varies by geographic region, probably as a result of differences in diets.[9] Likewise, aeroallergen counts differ by levels of urbanisation and meteorological conditions, enhancing variations in allergic sensitisation and cross-reactivity.[10]

Currently, there is scarce evidence regarding this topic in developing regions, especially in Andean Latin America.[9] FA estimates in the region are based on self-reports[11] and often involve non-representative samples or patients with previous allergic diseases.[12] In Ecuador, good-quality studies have been performed among urban and rural school children living in a tropical region on the northern coast, one of the poorest regions of the country.[13] However, FA and important aeroallergens (ie, *Blomia tropicalis)* were not assessed. Research is necessary for other at-risk populations with different socioeconomic backgrounds, such as the Andean population. This information could be the basis for future research questions. Furthermore, epidemiology research is crucial for the design and implementation of coherent prevention and management programs.

This paper is part of the "Allergy, Sensitisation and Environment" (AL-SEEN) project designed to assess risk factors associated with allergic disorders among Ecuadorian children and adolescents. The objective of this analysis is to estimate the prevalence of Immunoglobulin E (IgE) mediated FA, airborne allergies (to pollen, HDM, cat and dog), and allergic sensitisation to common foods and aeroallergens amongst a group of adolescents from 2 disparate regions (in terms of meteorological and socioeconomic conditions) in Ecuador. Additionally, we aimed to identify associations between allergic diseases and allergic sensitisation with sociodemographic attributes, environmental exposures, and parental history of allergic disorders.

METHODS

Study area and sampling

A cross-sectional survey was conducted from July 2013 until July 2014 in Ecuador. The study was performed in the urban area of 2 disparate cities: Cuenca, located in the Andean highlands, and Santa Isabel, located in the Inter-Andean subtropical mesothermal zone. Cuenca has an annual average temperature of 16 °C, and an altitude of 2560 meters above sea level.[14] According to the 2010 census, 75% of the population in Cuenca live within the urban boundaries of the city (505,585 inhabitants, 102,486 ten-nineteen year-olds), 35% are poor, and 5% are illiterate.[15] Santa Isabel has an average annual temperature of 20 °C, the altitude ranges from 800 to 3200 meters above sea level,[14] 35% of the total population live in the urban area (18,393 inhabitants, 4230 ten-nineteen year-olds) 30% are

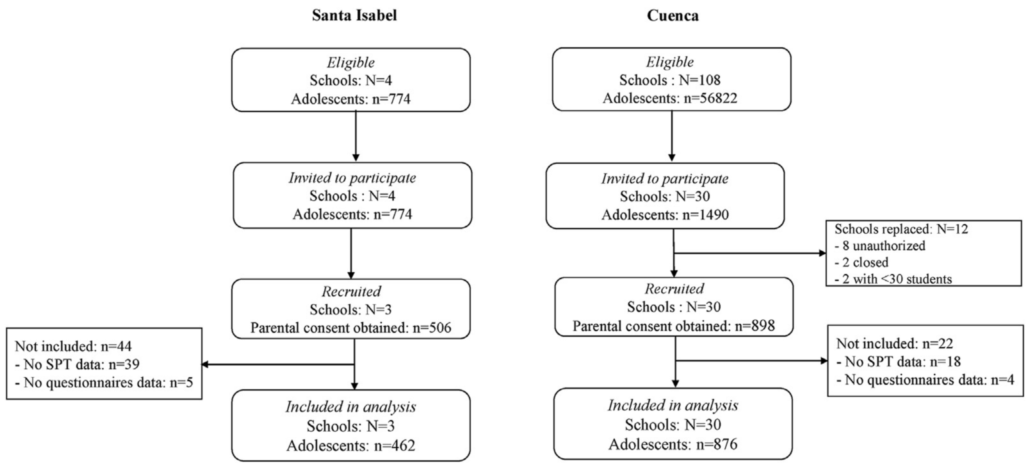

Fig. 1 Participation diagram. Abbreviation: SPT, skin prick test

poor, and 8% are illiterate.[15] In Ecuador, the health system includes public and private subsystems. The public sector comprises the Ministry of Health, the Ministry of Social and Economic Inclusion, Municipal health centers, the National Institute of Social Security (IESS), and the Army and Policy Institutes of Social Security Institutions. The Ministry of Health offers free health services to the entire population, the Ministry of Social Inclusion and Municipalities offer free or low price health services to the general population, but especially to unemployed populations without social security. Finally, social security covers the health attention of affiliated employees with a formal job.[16]

The study was performed in middle schools in Ecuador where the school system includes 4 levels: elementary schools for 3-5 year-olds, primary schools for 6-11 year-olds, middle schools for 12-15 year-olds, and high schools for 16-18 year-olds. Sampling was different in each region considering the differences in the size of the adolescent population and the number of middle schools (108 in Cuenca versus 4 in Santa Isabel). A cluster/random sampling was used in Cuenca, whilst all the 12-15 years-old students were invited to participate in Santa Isabel (n = 774). The sample size for Cuenca was determined to ensure sufficient participants to identify FA prevalence. The sample size required was 845 adolescents for an estimated FA prevalence of 3%,[17] with a precision of 0.05, a cluster effect of 2 and anticipating a dropout of 10%. Participant selection involved a two-stage cluster random sampling to select schools and students. From 108 middle schools available in Cuenca, 30 schools were randomly selected following a probability proportional to sample size procedure according to their type (public or private). Twelve schools originally selected were replaced with new schools following the same procedure; the reasons for replacing schools are shown in Fig. 1. For each school, a list of all 12–15 years old students was obtained. Based on acceptance rates from a previous study,[18] 50 students were randomly selected in each middle school (unless fewer students regularly attended the selected school; only 45 students were enrolled in 2 schools in Cuenca) (Fig. 1).

Measurements

In each school, the parents/guardians of the selected students were invited to the adolescents' school to be informed about the research objectives, to sign a written consent, and to fill in 2 questionnaires: a sociodemographic questionnaire, and a questionnaire on environmental and parental risk factors adapted from the International Study of Asthma and Allergies in Childhood (ISAAC) and used in previous research.[19] If the parents/guardians did not have enough time to complete the questionnaires and were literate, the form was sent to be completed at home and was returned by the adolescent the following school day. For illiterate parents or parents with low education level (incomplete primary education), the questionnaires were completed face-to-face by trained interviewers following standardised procedures.

In the absence of an international FA questionnaire, a clinical atopy questionnaire about symptoms (noted by the parents or by a doctor) consistent with FA and airborne allergic symptoms, was administered to the adolescents by trained interviewers. Any incomplete or divergent responses were clarified by a telephone call to the parent/guardian. Comprehension and readability of the questionnaires were tested among 30 adolescents and parents outside the final sample.

Sociodemographic questionnaire

A structured, standardised sociodemographic questionnaire, completed by the parents/guardians, collected the following data: adolescent's age, gender, place of residence, self-determined ethnicity (mestizo: mixed Spanish/indigenous descent), or other ethnic groups: white, black, or indigenous), maternal/paternal education (primary, secondary, university, or postgraduate education) and socioeconomic status determined by household unsatisfied basic needs. A household was classified as "poor" if at least one basic need (eg, education, health, housing, public services, and employment) was absent.[20]

Questionnaire on environmental and parental risk factors

Environmental data were collected from the parents which included: duration of exclusive breastfeeding (months); birth order; daycare attendance during the first 5 years of life; the presence of a cat and/or dog inside the house at any time since birth; the history of living on a farm in direct contact with farm animals (eg, cattle, sheep) during the first year of life; [5,21,22] having a smoking mother defined by the question: "Has the adolescent's mother ever smoked?"; and family smoking, defined when any family member smokes inside the house ever.[7]

Parental history of allergic disorders was defined by the question in relation to a list of allergic conditions: "Has the child's biological mother and/or biological father ever been found to have an allergic disease or hypersensitivity?". The allergic conditions included: animal dander allergy, pollen/flowers allergy, asthma, dust/mites allergy, and food allergy. The variable was classified as: No if the answer was "never" for all the allergic conditions and both parents; self-perceived if at least 1 parent reported any "self-perceived" condition; and, diagnosed if at least 1 parent has been "diagnosed by a doctor."

Clinical atopy questionnaire

Food allergic symptoms and IgE mediated food allergy

Adolescents were presented with a list of symptoms associated with FA or hypersensitivity including skin symptoms, respiratory symptoms, burning or itching in the mouth, eye symptoms, intestinal symptoms, or sudden generalised reaction (anaphylactic shock). They were then asked the following question in relation to consumption of a list of foods: "Have the following foods caused allergic symptoms, and who has noted this?". For each food, the possible answers included: Never tasted these foods, symptoms from these food items have never been experienced, symptoms noted by the parents, and symptoms noted by a doctor.

FA was diagnosed when a doctor had ever noted the symptoms and a positive skin prick test (SPT) to the food was identified (doctor diagnosed IgE-mediated FA).

Airborne allergies

Airborne allergies were defined as a positive adolescent response to the question: "Have you been noted or diagnosed with an allergy to any of the following, and by whom? Dust-mites, pollen, cats or dogs". For each aeroallergen, the possible answers included: Never, noted by the parents, and diagnosed by a doctor. Airborne allergic diseases (HDM allergy, pollen, cat, and dog allergies) were defined when the allergy had ever been diagnosed by a doctor, together with a positive SPT to the aeroallergen.

Allergic sensitisation

Skin prick tests (SPT) were performed on the ventral area of the forearm using commercial extracts (ALK-Abelló). Histamine and saline solution (0.9%) were used as positive and negative controls, respectively. Nineteen food and 20 aeroallergens were tested (Table 1). Allergens selection was based on previous research, dietary patterns[23,24] and clinical experience. Positive allergic sensitisation to foods and aeroallergens was defined when the wheal size exceeded the negative control with at least 3 mm after 15 min pricking the skin.[25]

Statistical analysis

Data were entered in duplicate in Epi Data (EpiData Association, Odense, Denmark). Data analysis was performed using Stata version 13.0. (College Station, TX, USA). All the analyses were adjusted for the cluster design using the "*svy*" command in Stata with schools as primary sampling units. Descriptive data are expressed as mean (SD) and percentages. Prevalence of allergic sensitisation to any food, IgE-mediated FA and airborne allergic diseases to any allergen are reported as percentages with 95% confidence intervals (CI). Differences in environmental and parental risk factors, allergic symptom reporting, allergic sensitisation, FA, and airborne allergic disease between Cuenca and Santa Isabel, were tested using the Pearson Chi-Square test or Fisher test when necessary for categorical variables and two-sample *t*-test for continuous variables.

Associations between allergic diseases, food and aeroallergen sensitisation with the demographic, environmental and parental potential risk factors were assessed by using logistic regression models. Bivariate logistic regression models with clinical airborne allergy, food allergic sensitisation, and aeroallergen sensitisation as the dependent variables, and, each demographic, environmental, and parental risk factor in turn as the independent variables were performed. Adjusted multiple logistic regression models were set for each outcome, including independent variables significantly associated ($p < 0.1$) in the bivariate models, the adjusted analysis was stratified for location (Cuenca/Santa Isabel) only when significant interactions between the independent variable and location were identified ($p < 0.05$). Before inclusion in the models, collinearity of the independent variables was assessed with the

Food allergens	
Proteins	Cow's milk, Whole egg, Pork, Chicken, Shrimp, White fish, Blue fish, and Soybean
Tree nuts	Peanut and Walnut
Cereals	Rice and Wheat
Fruits	Peach, Apple, and Banana
Vegetables	Celery and Tomato
Tubers	White potato and Carrot
Aeroallergens	
Mites	*Dermatophagoides farinae*, *Dermatophagoides pteronyssinus* and *Blomia tropicalis*
Grasses	*Cynodon dactylon* and Mixed grasses (*Dactylis glomerata, Festuca pratensis, Phleum pratense, Poa pratensis, Lolium perenne*)
Pollens	English plantain, Goosefoot, Mugwort, Ragweed, *Parietaria*, Ash
Fungi	*Alternaria*, *Aspergillus*, *Cladosporium*, *Penicillium*
Animals	Cat, Dog, Feathers mixture (chicken, duck, goose), Cockroach
Other	Latex

Table 1. Allergens tested by skin prick testing among adolescents from Cuenca and Santa Isabel

	Total % (n)	Cuenca % (n)	Santa Isabel % (n)	P value[b]
Female	49.7 (665)	46.7 (409)	55.4 (256)	0.002
Mestizo	82.7 (1107)	81.2 (711)	85.7 (396)	0.04
Poor[c]	49.6 (663)	39.8 (349)	68.0 (314)	<0.001
Maternal low education[d]	52.4 (614)	40.1 (317)	78.0 (297)	<0.001
Paternal low education[d]	47.0 (499)	33.6 (243)	75.7 (256)	<0.001
EBF in months, mean (SD)[e]	7.1 (5.0)	6.7 (4.9)	7.8 (5.1)	<0.001
Birth order				0.001
1st	38.9 (520)	39.5 (346)	37.7 (174)	
2nd	27.4 (367)	29.2 (256)	24.0 (111)	
3rd	17.0 (228)	17.5 (453)	16.2 (75)	
4th or more	16.7 (223)	13.8 (121)	22.1 (102)	
Day-care attendance (up to 5 years)	26.5 (352)	33.0 (287)	14.2 (65)	<0.001
Cat inside the house (ever)	41.0 (528)	34.6 (293)	53.3 (235	<0.001
Dog inside the house (ever)	68.4 (878)	69.3 (586)	66.8 (292)	0.37
Living with farm animals(1st year of life)	23.0 (300)	19.2 (165)	30.3 (135)	<0.001
Mother smoking (ever)	12.7 (168)	15.3 (133)	7.7 (35)	<0.001
Family smoking (ever)	27.1 (359)	26.7 (232)	27.9 (127)	0.66
Any parental allergic disorder [f]				0.31
Self - Perceived	16.9 (173)	18.0 (122)	14.9 (51)	
Diagnosed by a doctor	22.6 (231)	21.5 (146)	24.8 (85)	

Table 2. Characteristics of the participants by geographic area[a] *Abbreviations: EBF, exclusive breastfeeding; SD, standard deviation. a. n = 1338, 876 in Cuenca and 462 in Santa Isabel. b. Differences between Cuenca and Santa Isabel tested by Pearson Chi-square test or Fisher exact test (when needed), adjusted to the cluster design. c. Poor: adolescents with at least one deprivation on basic needs. d. Low education: incomplete/complete primary education. e. Differences between Cuenca and Santa Isabel tested by Student's t-test, adjusted to the cluster design. f. Parental allergic disorders: animal dust allergy, pollen/flowers allergy, asthma, dust/mite allergy and food allergy.*

Pearson correlation coefficient. In the case of collinear variables ($r > 0.5$), only the variable most strongly associated in the bivariate models was kept. The strength of the association between the outcomes and independent variables was measured using adjusted odds ratios (aOR) with 95% CI ($p < 0.05$).

Secondary analysis

The relationships of cat/dog ownership inside the house on cat/dog allergy and allergic sensitisation (dependent variables) were assessed building-up multiple logistic regression models constructed as previously described to adjust the analysis for relevant covariates.

Cross-reactivity between shrimp-HDM, shrimp-cockroach, and peanut-soybean were tested using the Pearson Chi-Square test.

RESULTS

Demographics

A total of 1338 adolescents with complete data, 876 from Cuenca (acceptance rate 58.8%, 876/1490), and 462 from Santa Isabel (acceptance rate

Food	Never tasted the food[b]			Symptoms noted by parents[b]			Symptoms noted by a doctor[b]		
	All % (n)	Cuenca % (n)	Santa Isabel % (n)	All % (n)	Cuenca % (n)	Santa Isabel % (n)	All % (n)	Cuenca % (n)	Santa Isabel % (n)
Any food	-	-	-	10.4 (139)	11.1 (97)	9.1 (42)	4.3 (57)	5.3 (47)	2.2 (10)*
Cow's milk	1.0 (13)	0.6 (5)	1.7 (8)*	2.8 (37)	3.4 (30)	1.5 (7)*	1.4 (19)	1.9 (17)	0.4 (2)*
Shrimp	6.0 (80)	5.5 (48)	6.9 (32)	1.9 (26)	5.5 (17)	6.9 (9)	0.8 (10)	1.0 (9)	0.2 (1)
Peanut	4.0 (53)	2.3 (20)	7.1 (33)**	1.2 (16)	1.3 (11)	1.1 (5)	0.6 (8)	0.7 (6)	0.4 (2)
Red meat	2.0 (27)	1.1 (10)	3.7 (17)*	2.5 (33)	2.1 (18)	3.3 (15)	0.6 (8)	0.8 (7)	0.2 (1)
Whole egg	0.6 (8)	0.6 (5)	0.6 (3)	1.1 (14)	1.1 (10)	0.9 (4)	0.5 (6)	0.7 (6)	0.0
Nuts	22.6 (302)	19.5 (171)	28.4 (131)**	0.8 (10)	1.0 (9)	0.2 (1)	0.4 (5)	0.5 (4)	0.2 (1)
Fish	1.1 (15)	0.8 (7)	1.7 (8)	1.3 (17)	1.4 (12)	1.1 (5)	0.3 (4)	0.5 (4)	0.0
Soybean	26.7 (357)	23.1 (202)	33.6 (155)**	0.3 (4)	0.5 (4)	0.0	0.2 (3)	0.1 (1)	0.4 (2)
Celery	17.5 (234)	12.1 (106)	27.7 (128)**	0.7 (9)	0.6 (5)	0.9 (4)	0.2 (3)	0.2 (2)	0.2 (1)
Wheat	5.5 (74)	4.1 (36	8.2 (38)**	0.4 (5)	0.3 (3)	0.4 (2)	0.2 (2)	0.1 (1)	0.2 (1)
Carrot	1.1 (14)	0.8 (7)	1.5 (7)	0.2 (2)	0.0	0.4 (2)	0.2 (2)	0.1 (1)	0.2 (1)
Tomato	0.5 (7)	0.6 (5)	0.4 (2)	1.1 (15)	1.7 (15)	0.0*	0.1 (1)	0.1 (1)	0.0
Peach	0.5 (7)	0.3 (3)	0.9 (4)	0.4 (5)	0.6 (5)	0.0	0.1 (1)	0.1 (1)	0.0
Banana	0.3 (4)	0.1 (1)	0.6 (3)	0.2 (3)	0.3 (3)	0.0	0.1 (1)	0.1 (1)	0.0
White potato	0.2 (3)	0.0	0.7 (3)*	0.2 (3)	0.2 (2)	0.2 (1)	0.1 (1)	0.1 (1)	0.0
Poultry	0.7 (10)	0.7 (6)	0.9 (4)	0.6 (8)	0.9 (8)	0.0*	0.0	0.0	0.0
Apple	0.0	0.0	0.0	0.3 (4)	0.3 (3)	0.2 (1)	0.2 (2)	0.3 (1)	0.2 (1)
Rice	0.4 (5)	0.2 (2)	0.7 (3)	0.1 (1)	0.1 (1)	0.0	0.0	0.0	0.0

Table 3. Food allergic symptoms (ever) among adolescents from Cuenca and Santa Isabel[a] - *All the adolescents have tested at least one food.*P value < 0.05.**P value < 0.001. a. n = 1338, 876 in Cuenca and 462 in Santa Isabel. b. Differences between Cuenca and Santa Isabel tested by Pearson Chi-square test or Fisher exact test (when needed), adjusted to the cluster design.*

	Total % (n)	Cuenca % (n)	Santa Isabel % (n)	P value[b]
Child were sensitized to the following				
Any food[c]	19.1 (254)	16.1 (141)	24.9 (113)	<0.001
Shrimp[c]	4.7 (62)	3.7 (32)	6.6 (30)	0.02
White fish	3.6 (48)	3.4 (30)	3.9 (18)	0.66
Peanut	3.4 (45)	3.1 (27)	3.9 (18)	0.43
Blue fish	2.8 (37)	2.9 (25)	2.6 (12)	0.79
Chicken	2.4 (32)	2.3 (20)	2.6 (12)	0.72
Tomato	2.2 (30)	1.7 (15)	3.2 (15)	0.07
Peach	2.0 (27)	1.7 (15)	2.6 (12)	0.27
Soybean	2.0 (27)	1.0 (9)	3.9 (18)	<0.001
Carrot	1.8 (24)	1.9 (17)	1.5 (7)	0.58
Pork	1.7 (23)	1.8 (16)	1.5 (7)	0.68
Walnut	1.7 (23)	1.8 (16)	1.5 (7)	0.68
Apple	1.6 (22)	1.4 (12)	2.2 (10)	0.28
Celery	1.3 (18)	1.0 (9)	1.9 (9)	0.17
Whole egg	1.2 (16)	1.4 (12)	0.9 (4)	0.42
Banana	1.1 (15)	0.9 (8)	1.5 (7)	0.32
Cow's milk	1.2 (16)	1.3 (11)	1.1 (5)	0.78
Rice	1.2 (16)	1.1 (10)	1.3 (6)	0.80
Wheat	1.0 (14)	1.4 (12)	0.4 (2)	0.11
White potato	1.0 (14)	1.0 (9)	1.1 (5)	0.93
Food allergy (children with symptoms noted by a doctor and sensitized to any food)[d]				
Any food[c]	0.4 (5)	0.5 (4)	0.2 (1)	0.51

Table 4. Prevalence of food sensitisation (skin prick test positive) and doctor endorsed IgE mediated Food Allergy among adolescents from Cuenca and Santa Isabel[a] *a. n = 1338, 876 in Cuenca and 462 in Santa Isabel. b. Differences between Cuenca and Santa Isabel tested by Pearson Chi-square test or Fisher exact test (When needed), adjusted to the cluster design. c. Data missing in Santa Isabel (n = 8). d. Prevalence of doctor diagnosed IgE mediated Food Allergy for each food could not be tested due to the low prevalence.*

59.7%, 462/774), were included in the analysis (mean age: 13 $\pm$ 0.9 years old), of whom 82.7% were mestizos and 49.7% were female. In Santa Isabel, 68.0% of adolescents were poor in comparison to 39.8% of adolescents in Cuenca ($p < 0.001$). Over 50% of the adolescents' mothers and fathers in Cuenca had secondary or higher education; whilst only 22.0% of mothers and 24.3% of fathers in Santa Isabel had secondary or higher education (Table 2).

Adolescents from Santa Isabel exclusively breastfed longer (7.8 $\pm$ 5.1 vs 6.7 $\pm$ 4.9 months; $p < 0.001$), were more likely to be the fourth or later-born sibling (22.1% vs. 13.8%; $p = 0.001$), lived more often in direct contact with cats inside the house at any time since birth (53.3% vs 34.6%; $p < 0.001$), and with farm animals during their first year of life (30.3% vs 19.2%; $p < 0.001$).

More adolescents from Cuenca attended day-care (33.0% vs. 14.2%; $p < 0.001$) and had an at-home smoking mother (15.3% vs 7.7%, $p < 0.001$). No differences existed in the parental history of allergic disorders between the studied areas ($p = 0.31$). Parental history of allergic disorders diagnosed by a doctor was reported by 22.6% of the parents (Table 2).

Food allergic symptom reporting

Table 3 summarises the reporting of food allergic symptoms ever. Soybean and nuts had never been consumed by more than 20% of the adolescents, and adolescents from Santa Isabel were less likely to have consumed these foods ($p < 0.001$). In total, 10.4% of the adolescents reported that their parents noted them ever having experienced allergic symptoms to any food. The top 3 reported foods were cow's milk (2.8%), red meat (2.5%), and shrimp (1.9%).

With regard to symptoms ever having been noted by a doctor, 4.3% of the adolescents experienced doctor noted food allergic symptoms to any food, and adolescents from Cuenca reported symptoms noted by a doctor more frequently (5.3%, vs 2.2%, $p = 0.006$). The most common foods with doctor noted symptoms were cow's milk (1.4%), shrimp (0.8%), and peanut (0.6%). Cow's milk allergic symptoms noted by a doctor were more frequently reported in Cuenca (1.9%, vs 0.4%, $p < 0.05$) (Table 3).

Food sensitisation

Food allergic sensitisation was prevalent among 19.1% (95% CI: 17.1–21.3, n = 1330) of the adolescents and higher in Santa Isabel compared with Cuenca (24.9%, 95% CI 21.1–29.1 vs. 16.1%, 95% CI 13.8–18.6, respectively, $p < 0.001$). The most common food allergens were shrimp (4.7%), whitefish (3.6%), and peanut (3.4%). Shrimp (6.6% vs 3.7%, $p = 0.02$) and soybean allergic sensitisation (3.9%, vs. 1.0%, $p < 0.001$) were highly prevalent in Santa Isabel (Table 4).

Doctor diagnosed IgE-mediated FA

Doctor diagnosed IgE-mediated FA ever was very uncommon and only identified in 5 adolescents (0.4%, 95% CI 0.2%–0.9%, n = 1330) (Table 4). Three adolescents were allergic to shrimp, 1 to peanut and walnut, and 1 to soybean. Three adolescents reported symptoms in the last 12 months (to shrimp, peanut, and soybean).

Airborne allergies reporting

From 1326 adolescents with full available data, 19.3% reported parental-perceived allergies, and a greater number, 21.6% diagnosed by a doctor, with no differences between location. HDM was the most common aeroallergen with a positive response: parent-perceived (15.5%) and doctor-diagnosed (18.3%) (Table 5).

Aeroallergen	Self-perceived by the adolescent[b]			Diagnosed by a doctor[b]		
	All % (n)	Cuenca % (n)	Santa Isabel % (n)	All % (n)	Cuenca % (n)	Santa Isabel % (n)
Any aeroallergen	19.3 (256)	19.1 (166)	19.7 (90)	21.6 (287)	21.7 (188)	21.6 (99)
Mites	15.5 (206)	15.3 (133)	15.9 (73)	18.3 (243)	18.3 (159)	18.3 (84)
Pollen	4.4 (59)	4.4 (38)	4.6 (21)	5.1 (68)	5.0 (43)	5.5 (25)
Cat	7.2 (96)	7.6 (66)	6.6 (30)	11.6 (154)	11.6 (101)	11.6 (53)
Dog	6.5 (86)	6.9 (60)	5.7 (26)	11.7 (156)	12.0 (104)	11.4 (52)

Table 5. Airborne allergic diseases report among adolescents from Cuenca and Santa Isabel[a] *a. n = 1326, 869 in Cuenca and 458 in Santa Isabel, data missing (n = 8 in Cuenca and n = 4 in Santa Isabel). b. No significant difference between place of residence were identified.*

	Total % (n)	Cuenca % (n)	Santa Isabel % (n)	*P*-value[b]
Child found to be sensitized to the following				
Any aeroallergen[c]	53.8 (715)	52.6 (461)	55.9 (254)	0.24
HDM[c]	42.6 (566)	42.1 (369)	43.4 (197)	0.65
D. pteronyssinus[c]	36.4 (484)	37.1 (325)	35.0 (159)	0.45
D. farina	35.3 (472)	36.1 (316)	33.8 (156)	0.40
B. tropicalis	26.1 (349)	27.5 (241)	23.4 (108)	0.10
Grasses	17.4 (233)	20.5 (180)	11.5 (53)	<0.001
Mixed grasses[d]	15.3 (205)	19.1 (167)	8.2 (38)	<0.001
Cynodon dactylon	11.7 (156)	14.2 (124)	6.9 (32)	<0.001
Pollens	15.8 (211)	17.4 (152)	12.8 (59)	0.03
English plantain	9.8 (131)	12.6 (110)	4.5 (21)	<0.001
Mugwort	5.9 (79)	7.0 (61)	3.9 (18)	0.02
Goosefoot	7.5 (101)	8.6 (75)	5.6 (26)	0.05
Ragweed	5.2 (69)	5.6 (49)	4.3 (20)	0.32
Ash	3.7 (50)	3.9 (34)	3.5 (16)	0.70
Parietaria	2.5 (33)	3.1 (27)	1.3 (6)	0.05
Animals	29.6 (396)	28.2 (247)	32.3 (149)	0.12
Cockroach	22.5 (301)	19.4 (170)	28.4 (131)	<0.001
Cat	9.2 (123)	11.3 (99)	5.2 (24)	<0.001
Dog	5.5 (74)	7.1 (62)	2.6 (12)	<0.001
Feathers mixture[e]	3.6 (48)	3.9 (34)	3.0 (14)	0.43
Fungi	5.6 (75)	5.5 (48)	5.8 (27)	0.78
Alternaria	2.3 (31)	2.1 (18)	2.8 (13)	0.38
Penicillium	2.2 (29)	2.6 (23)	1.3 (6)	0.11
Cladosporium	1.8 (24)	2.1 (18)	1.3 (6)	0.32
Aspergillus	1.6 (21)	1.7 (15)	1.3 (6)	0.56
Latex	6.7 (89)	7.0 (61)	6.1 (28)	0.53
Children with allergic symptoms noted by a doctor and sensitized to the following:				
Any airborne allergic diseases[f]	12.0 (158)	13.0 (113)	10.0 (45)	0.10
HDM[f]	11.1 (147)	11.9 (103)	9.7 (44)	0.24
Pollen[g]	1.4 (18)	2.0 (17)	0.2 (1)	0.009
Cat[g]	2.4 (32)	2.8 (24)	1.7 (8)	0.25
Dog[g]	1.4 (19)	2.1 (17)	0.4 (2)	0.03

Aeroallergen sensitisation

Aeroallergen sensitisation was prevalent amongst 53.8% of the adolescents (95% CI: 51.1–56.4, n = 1330). The most prevalent aeroallergens were house dust mite (HDM) (*D. pteronyssinus* 36.4%; *D. farinae* 35.3%; and *B. tropicalis* 26.1%), cockroach (22.5%), and grasses (mixture 15.3% and Cynodon 11.7%). Adolescents from Cuenca were highly sensitized to mixed grasses ($p < 0.001$), Cynodon ($p < 0.001$), *English plantain* ($p < 0.001$), mugwort ($p = 0.02$), cat ($p < 0.001$) and dog ($p < 0.001$), whilst adolescents from Santa Isabel were highly sensitized to cockroach ($p < 0.001$) (Table 6).

Airborne allergic diseases

IgE mediated airborne allergic diseases were prevalent amongst 12.0% of the adolescents (95% CI: 10.3–13.8, n = 1320). The most prevalent airborne allergic disease was to HDM (11.1%), the other airborne allergic conditions were prevalent among less than 3% of the adolescents. Pollen allergy (2.0% in Cuenca, vs. 0.2% in Santa Isabel, $p = 0.009$) and dog allergy (2.1% in Cuenca, vs. 0.4% in Santa Isabel, $p = 0.03$) were more common in Cuenca (Table 6).

Associations between the demographic, environmental, and parental risk factors and allergic diseases/allergic sensitisation

The low prevalence of FA precluded investigating associations with other sociodemographic factors. In the multivariable model with food sensitisation as an outcome, there were no significant interactions between the independent variables and location (Table 7). Food allergic sensitisation showed a positive association with family smoking exposure (aOR 1.63, 95% CI 1.14–2.34, $p = 0.008$) and with parental history of allergic disorders diagnosed by a doctor (aOR 1.68, 95% CI 1.13–2.49, $p = 0.01$). Food sensitisation was 40% less often among adolescents who lived with dogs in the house at any time of their lives (aOR 0.59, 95% CI 0.41–0.84, $p = 0.003$).

Airborne allergic diseases were 21% less prevalent among adolescents with a significant number of older siblings (aOR: 0.79, 95% CI: 0.65–0.96, $p = 0.02$) and 53% less common among those who lived with farm animals during the first year of life (aOR: 0.47, 95% CI: 0.23–0.95, $p = 0.04$). Adolescents with a smoking family had clinical airborne allergic diseases twice as often as those without a smoking family (aOR: 1.67, 95% CI: 1.04–2.70, $p = 0.03$). Parental history of allergic disorders was positively associated with adolescents' airborne allergic disease, either self-perceived (aOR: 2.62, 95% CI: 1.46–4.71, $p = 0.001$) or doctor's endorsed (aOR: 4.07, 95% CI: 2.44–6.80, $p < 0.001$).

Gender, maternal education, and exclusive breastfeeding showed significant interactions with location when aeroallergen sensitisation was the outcome. Aeroallergen sensitisation was 40% less frequent among female adolescents living in Santa Isabel when compared with males (aOR 0.60, 95% CI 0.39–0.92, $p = 0.02$). Maternal education was associated with higher airborne allergic sensitisation in Cuenca only (aOR 1.98, IC 95% 1.45–2.71, $p < 0.001$). The association between breastfeeding with aeroallergen sensitisation was marginally significant in Cuenca only, but the OR was around 1.0 (Cuenca: aOR 0.97, 95% CI 0.94–1.00, $p = 0.05$; Santa Isabel aOR 1.02, 95% CI 0.97–1.06, $p = 0.43$).

Secondary data

There were no association between having a cat indoors with cat allergic sensitisation (OR: 0.81, IC 95% 0.55–1.20, $p = 0.30$) or cat allergy (OR: 1.36, IC 95% 0.67–2.77, $p = 0.40$). Living with a dog inside the house was associated with 60% lower dog sensitisation (aOR 0.42, 95% CI 0.24–0.73, $p < 0.001$) but not with dog allergy (aOR: 0.43, IC 95% 0.14–1.34, $p = 0.15$).

We found significant shrimp-HDM, shrimp-cockroach and peanut-soybean cross-reactivities ($p < 0.001$). Among the 62 adolescents sensitized to shrimp, 89% were sensitized to HDM (55/62), and 71% to cockroach (44/62). Ninety-seven-percent (60/62) of the adolescents with shrimp

Table 6. Prevalence of aeroallergen sensitisation and airborne allergic diseases among adolescents from Cuenca and Santa Isabel[a]
Abbreviation: HDM, house dust mites. a. n = 1338, 876 in Cuenca and 458 in Santa Isabel. b. Differences between Cuenca and Santa Isabel tested by Pearson Chi-square test or Fisher exact test (when needed), adjusted to the cluster design. c. Data missing for D. pteronyssinus *aeroallergen sensitisation in Santa Isabel (n = 8). d. Mixed grasses:* D. glomerata, F. pratensis, P. pratense, P. pratensis *and* L. perenne. *e. Feathers mixture of chicken, duck, and goose. f. Allergic sensitisation data missing (n = 8 in Santa Isabel), and symptoms report data missing (n = 8 in Cuenca, and n = 2 in Santa Isabel). g. Symptoms report data missing (n = 8 in Cuenca, and n = 4 in Santa Isabel).*

	Food sensitisation		Any airborne allergic diseases		Aeroallergen sensitisation	
	Adjusted OR (95% CI)	*P*-value	Adjusted OR (95% CI)	*P*-value	Adjusted OR (95% CI)	*P*-value
Gender (Male/Female)	-	-	-	-	C: 0.89 (0.67–1.20)	0.46
	-	-	-	-	SI: 0.60 (0.39–0.92)	0.02
Socioeconomic status (Poor/Better off)[a]	-	-	ALL: 1.26 (0.78–2.01)	0.34	-	-
Maternal education (Low/High)[b]	ALL: 1.17 (0.84–1.64)	0.36	C: 1.30 (0.69–2.44)	0.42	C: 1.98 (1.45–2.71)	<0.001
			SI: 0.76 (0.26–2.24)	0.62	SI: 1.29 (0.77–2.17)	0.33
EBF (Months)	-	-	ALL: 1.02 (0.97–1.07)	0.36	C: 0.97 (0.94–1.00)	0.05
					SI: 1.02 (0.97–1.06)	0.43
Birth order	-	-	ALL: 0.79 (0.65–0.96)	0.02	-	-
Day-care attendance until 5 years old (No/Yes)	-	-	ALL: 1.54 (0.98–2.43)	0.06	-	-
Cats inside house ever (No/Yes)	-	-	ALL: 0.64 (0.38–1.07)	0.09	ALL: 0.83 (0.64–1.07)	0.16
Dog inside house ever (No/Yes)	ALL: 0.59 (0.41–0.84)	0.003	-	-	-	-
Living with farm animals in the first year (No/Yes)	-	-	ALL: 0.47 (0.23–0.95)	0.04	C: 0.76 (0.51–1.13)	0.18
					SI: 1.09 (0.68–1.76)	0.71
Family smoking (No/Yes)	ALL: 1.63 (1.14–2.34)	0.008	ALL: 1.67 (1.04–2.70)	0.03	-	-
Any parental allergic disorder						
Never	1.00		1.00			
Self-perceived	ALL: 1.40 (0.89–2.22)	0.15	ALL: 2.62 (1.46–4.71)	0.001	-	-
Diagnosed by a doctor	ALL: 1.68 (1.13–2.49)	0.01	ALL: 4.07 (2.44–6.80)	<0.001	-	-

Table 7. Association between sociodemographic, environmental factors, and parental history of allergy with allergic sensitisation and airborne allergic disease among Ecuadorian adolescents *Abbreviations: ALL, no significant interaction predictor/location, OR is presented for the whole sample; C, significant interaction predictor/location, OR for Cuenca; CI, confidence interval; EBF, exclusive breastfeeding; OR, odds ratio; SI, significant interaction predictor/location, OR for Santa Isabel.– Variables with p-values >0.1 in bivariate models, excluded in the adjusted analysis. a. Better off: all the basic needs satisfied & poor: at least one deprivation (education. health. housing. urban services and employment). b. Low: incomplete/complete primary education & High: incomplete/complete secondary, university or postgraduate education.*

sensitisation reported having consumed shrimp. Among the 27 participants with soybean sensitisation, 19% (5/27) were sensitized to peanuts (in comparison with only 3% (40/1311) for those not sensitized to soybean). Thirty-seven-percent (10/27) of the adolescents with soybean sensitisation reported never having consumed soybean. The cross-reactivity soybean-peanut was found among 30% (3/10) of the adolescents who have never consumed soybean in comparison with only 12% (2/17) of the adolescents that reported soybean consumption ever.

DISCUSSION

To the best of our knowledge, this is the first study documenting the prevalence of and associated risk factors for FA and other allergic conditions, among a representative sample of adolescents living in an Andean country. In addition, objective measures of allergy, with testing to a wide range of foods and aeroallergens extracts was undertaken. The most notable finding was that food and airborne allergic sensitisation rates are very high (over 50% for the latter), whilst the prevalence of food and airborne allergies are considerably lower (and negligible for the former), in comparison with developed countries. Previous studies in developing regions such as Asia have demonstrated such dissociations between allergic sensitisation and allergic diseases, including FA.[26] The reasons for the great imbalance have not been elucidated. Allergic sensitisation development is still poorly understood. The immune system has evolved to protect the host against parasitic infections, xenobiotics, irritants and venoms present in adverse environments.[27] It is still not understood why certain individuals develop an allergy to an allergen whilst others do not. Genetic and epigenetic factors might be involved and need to be further investigated in both developed and developing regions.[8]

Food allergy and food sensitisation

Available data in Latin America have tended to be questionnaire-based, and reporting of doctor-diagnosed food allergy has yielded estimates of 5% in Mexico, 5.7% in El Salvador, and 5.5% in Chile.[28-30] Our doctor noted food allergic symptoms estimate (4.3%) was similar to these reports. However, the importance of confirming objective sensitisation was shown, with a much lower prevalence of doctor-noted FA with confirmed food sensitisation, being present in only 0.4% of the adolescents in our study. Our FA estimate was lower than previous reports at similar ages in developed countries (United Kingdom 1.4% at 11 years;[31] Berlin 1% at 15–17 years old).[32]

This is the first research in the region using objective measures of sensitisation and a doctor diagnosis and has allowed a more accurate estimation of the prevalence of FA, as well identifying the most common allergens to which adolescents from two regions with different socioeconomic demography in Ecuador are sensitized. Shrimp was the most frequent allergen for both FA and food allergic sensitisation, and these results were in line with other studies in this group age.[1,33] Reports from Thailand also identified shrimp as the leading food for allergic sensitisation and crab for FA.[34] Our data differ from western countries, where FA estimates are higher, and peanut and nuts are the main allergens in the adolescent population; potentially, the result of variations in food exposure.[1] Consistent with the latter, 23% of the adolescents in our study reported never having consumed nuts. Furthermore, an epidemiological study performed in Cuenca documented that only 38% and 12% of the adolescent population reported the consumption of seafood and nuts (including peanuts and almonds) respectively and these food groups were rarely consumed raw.[18]

Although there were no differences in FA prevalence between Cuenca and Santa Isabel, food sensitisation was higher amongst Santa Isabel adolescents, due to differences in shrimp and soybean. The higher rate of shrimp sensitisation in Santa Isabel and the fact that shrimp was the food allergen to which sensitisation most frequently occurred could be explained by cross-reactivity with tropomyosin, present in cockroach[35] and mosquito (*A. aegypti*).[36] The mosquito *A. aegypti* is only prevalent in Santa Isabel.[37] There is also cross-reactivity between shrimp and mites, the so-called "house dust mites-crustaceans-mollusks syndrome", in which the HDM are the primary IgE sensitising allergens. Our results are consistent with a significant cross-reactivity between shrimp with mites and cockroaches.[38]

Although allergic symptoms to milk, either self-perceived or doctor noted, were most common, none of the adolescents was found to have milk FA (allergic symptoms together with a positive SPT). Recent research confirms that cow's milk allergy is disproportionately overestimated. The existing cow's milk allergy guidelines frequently have potentially significant conflicts of interest.[40] On the other hand, it is well established that food allergies to cow's milk and egg tend to resolve with age.[1-4] Further studies should investigate the accuracy in cow's milk allergy diagnosis in different age groups, the potential conflicts of interest and the true prevalence of cow's milk and egg allergy among infants in the Ecuadorian population.

The higher soybean allergic sensitisation in Santa Isabel could be the result of a micronutrient fortification program with soybean implemented in 2000 in Ecuador. Since the supplement was freely distributed in Health Centers, it could be that poorest communities might have had higher coverage.[39] Along with this situation, the major soybean sensitisation could be due to cross-reactivity with peanuts. Peanut allergens show structural homology with proteins from other legumes, like soybean. Despite this, the clinical significance of this fact is still uncertain.[41] The results of this study support a significant cross-reactivity between peanut and soybean.

We were unable to identify factors associated with FA due to its very low prevalence. Adolescents owning dogs were less likely to have food allergic sensitisation, and family smoking exposure was positively associated with food allergic sensitisation and airborne allergic diseases. A strong protective effect of early dog ownership on allergic sensitisation has previously been demonstrated;[42] likewise, early life environmental smoking exposure has been widely associated with aeroallergen sensitisation during adolescence.[7] The lower allergic sensitisation among indoor dog owners might be related to chronic microbial exposure through animal contact which reduces the immunological inflammatory status and in turn, prevents the development of allergic sensitisation or allergic disorders, as a part of the hygiene hypothesis.[21]

Clinical airborne allergic diseases and aeroallergen sensitisation

Airborne allergic diseases were prevalent amongst 12% of the adolescents, with HDM being the primary source of both allergic sensitisation and allergy, a result in line with research in tropical regions. In contrast, pollen allergy was considerably lower than previous reports from developed regions.[3] HDM allergy has been shown to have a more significant impact on patients' quality of life compared to seasonal pollen allergy. However, HDM allergy is usually ignored as a potentially important source of school absenteeism.[43] The progression from HDM allergic sensitisation to allergy is still not well understood, and the relationship between HDM exposure and allergy development is complicated, with some evidence showing a protective effect among populations with higher exposure.[2] Therefore, the dissociation between allergic sensitisation and HDM allergy prevalence might be explained by exposure to high doses of HDM in early childhood occurring in our adolescents. Future studies should measure HDM exposure in the Latin American context and the impact of HDM allergy on adolescents' quality of life.

Regarding the main aeroallergens associated with airborne allergic diseases, our data differ from developed regions where pollen are the most important allergens associated with allergic diseases.[44] Besides, our dog allergy prevalence (1.5%) was lower than a previous study in Sweden adolescents (5.5%).[4]

Surprisingly, doctor-diagnosed airborne allergies were reported more frequently than parent-perceived allergies. Further studies are needed to clarify this issue; nevertheless, there are some possible explanations: (i) in Ecuador allergic conditions are more often addressed by primary care professionals rather than by specialists, and evidence has demonstrated that general practitioners overdiagnose allergic conditions;[45,46] (ii) a Mexican study reported that physicians overestimated the proportion of patients with persistent rhinitis by 20%;[47] (iii) some adolescents with doctor-diagnosed rhinitis might be presenting with nonallergic rhinitis: previous reports have determined that 25% of the patients with a rhinitis diagnosis have nonallergic rhinitis.[48]

This paradox confirms the need for future studies aiming at improving the diagnosis and treatment of allergic diseases in the primary care setting in Ecuador.

Airborne allergic diseases (but not allergic sensitisation) were more frequent in Cuenca, with significant differences for dog allergy. Considering that the studied population is highly exposed to indoor dogs in both regions, and that pet exposure was not associated with dog allergy, other factors must be linked with the higher dog allergy prevalence in Cuenca. We did not analyse the timing of pet exposure, and adolescents from Cuenca might be less exposed to pets during their first year of life.[42]

Urbanisation, geography, and living conditions seem to be essential factors for airborne allergic diseases and allergic sensitisation. Adolescents from Santa Isabel were highly sensitized to the cockroach, while for adolescents from Cuenca, aeroallergen sensitisation occurred to mixed grasses, pollen, cat and dog. Higher maternal education was a risk factor associated with aeroallergen sensitisation only in Cuenca (where maternal education rates are higher). Meteorological conditions,[49] poor hygiene related to poverty levels,[15] and traffic pollutants,[50] might explain these differences.[51] Cuenca has lower annual temperatures, better satisfaction of basic needs, and, has a higher proportion of the population living in urban areas when compared with Santa Isabel. In addition, educated parents might reduce their children's microbial exposure during the first year of life by increasing the effort to adopt cleaning habits, thus reducing the opportunity to develop tolerance to allergen exposures.[6] Living with farm animals was negatively associated with airborne allergic diseases while attending daycare was positively associated. A large body of evidence has demonstrated the protective effect of farm animals exposure on allergic diseases.[52] Previous reports have documented that early attendance to crowded daycare facilities is associated with bacterial or viral infections respiratory infections, which in turn may interfere with the immune system maturation. Future studies should investigate daycare facilities conditions in Latin America and its association with allergic sensitisation and allergic diseases.[53]

Parental history of allergic disorders was strongly associated with airborne allergic diseases, highlighting the importance of inheritance and therefore, of genetic factors in the development of allergic diseases. The prevalence of allergic sensitisation was lower among female adolescents in Santa Isabel only. Previous research has demonstrated that females are less likely to have high levels of IgE than male children.[54] It is not clear why female gender was a protective factor in Santa Isabel only. The last could be the result of cultural gender differences in less affluent rural areas, causing differential exposure to protective risk factors.

This is the first large scale systematic study of FA, airborne allergies, and allergic sensitisation in this region and tested for an extensive array of food allergens and aeroallergens as well as undertaking significant measures to minimise bias, including using trained interviewers and standardised assessment procedures. With a cross-sectional design, recall bias is a potential issue. Although other studies must confirm the findings, the results are the basis for testing new hypotheses in the region. The gold standard for FA diagnosis is a food challenge; future studies should ideally consider incorporating food challenges in their design, and this would be likely to yield a lower prevalence of FA. We were also unable to control for some factors that may have confounded the studied relationships, such as objective measures of air pollution and pesticide contamination.

Conclusion

In conclusion, the prevalence of FA was 0.4%, airborne allergy was 12%, and allergic sensitisation amongst adolescents was considerably high. Food sensitisation was present in 2 out of every 10 adolescents and aeroallergen sensitisation in 6 out of every 10 adolescents. Shrimp, white fish, and peanut constituted the most common food allergens, whereas HDM, grass and cockroach were the most prevalent aeroallergens. Future studies of FA, airborne allergy and allergic sensitisation in Ecuadorian adolescents can focus on the most prevalent food and aeroallergen allergens identified. Modifying exposure to tobacco smoke and reassuring families that dog ownership confers a protective effect are important public health messages that need to be disseminated to health professionals in Ecuador.

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Submission declaration
All the authors agree to publish the final version, declare that it has not been published previously (except in the form of an abstract, a published lecture or academic thesis) and it is not under consideration for publication elsewhere. Further, the authors confirm that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright holder.

Ethics approval
The study was approved by the Human Research Ethics Committee at Universidad San Francisco de Quito (2013–67E) and was conducted according to the ethical principles of the Declaration of Helsinki. All adolescents and their parents/guardians provided informed consent before participating.

Authors contribution
SA, CR and AO designed the study and obtained the research grant; DM, PR, DA, GZ and AG collected data; SA, LT, DM, AG and AO performed the statistical analysis; DM and AO drafted the original manuscript; MP made significant content contributions; ALL the authors contributed to the manuscript development and approved the final version.

Declaration of competing interest
The authors report no competing interests.

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Author details
[a]Department of Biosciences, Faculty of Chemistry, University of Cuenca, Cuenca, Azuay, Ecuador. [b]Faculty of Medicine, University of Azuay, Cuenca, Azuay, Ecuador. [c]Population Health Research Institute, St George's, University of London, Cranmer Terrace, London, SW17 0RE, England, United Kingdom. [d]University of Ghent, Ghent, East Flanders, Belgium. [e]Nutrition School, Faculty of Medicine, Cuenca, Azuay, Ecuador.

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