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Internal migration and its association with childhood asthma in Ecuador: a cross-sectional study

Migración interna y su asociación con el asma infantil en Ecuador: un estudio transversal

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Abstract

Background:

Differences in asthma prevalence between urban and rural areas have been observed worldwide. Epidemiological studies in middle- and low-income countries suggest that internal migration processes may partly explain these disparities.

Objective:

To investigate the association between internal migration and asthma in children living in transitional areas of Ecuador

Methods:

A cross-sectional study was conducted using data from a birth cohort of children living in a tropical coastal region in northwestern Ecuador. Asthma indicators included wheezing in the past 12 months, ever wheezing, and asthma diagnosis by a doctor. Internal migration was defined as a change of residence between geographical units: cantonal, parish, and census tract. The relationship between asthma and migration was analyzed using binary logistic regression.

Results:

Of 2,404 participants, 1,818 children met the inclusion criteria. Among them, 2.8% experienced cantonal migration, 11.9% parish migration, and 24.6% census tract migration. The prevalence of wheezing in the past 12 months, ever wheezing, and asthma diagnosis by a doctor was 13.1%, 33.3%, and 7%, respectively. Children with a history of cantonal migration were more likely to have experienced wheezing compared to those who did not migrate (OR 1.56; 95%CI 0.87-2.79).

Conclusions:

Changes in residence between smaller or adjacent geographic units appeared not to be associated with asthma prevalence. However, cantonal migration may play a role in respiratory health outcomes.

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The authors declare no conflicts of interest

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Resumen

Antecedentes:

Se han observado diferencias en la prevalencia de asma entre áreas urbanas y rurales en diferentes partes del mundo. Estudios epidemiológicos en países de ingresos bajos y medios sugieren que los procesos de migración interna podrían explicar parcialmente estas disparidades.

Objetivo:

Investigar la asociación entre la migración interna y el asma en niños que viven en áreas de transición en Ecuador.

Métodos:

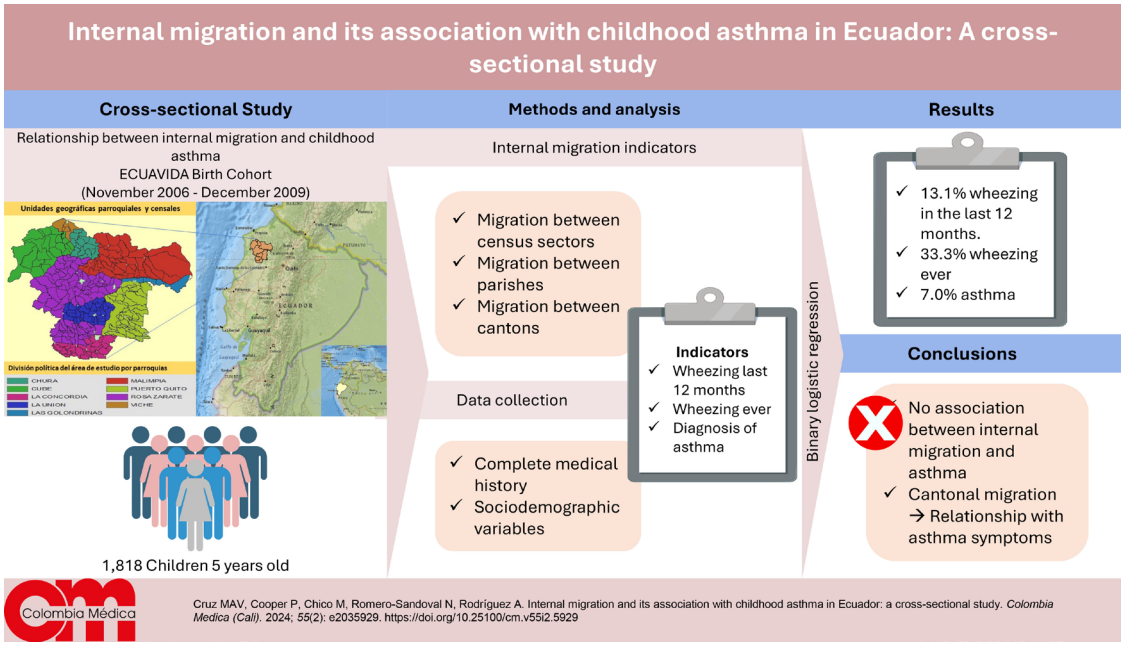
Se realizó un estudio transversal utilizando datos de una cohorte de nacimiento de niños que residen en una región tropical costera del noroeste de Ecuador. Los indicadores de asma incluyeron sibilancias en los últimos 12 meses, sibilancias alguna vez y diagnóstico de asma por un médico. La migración interna se definió como el cambio de residencia entre unidades geográficas: cantonal, parroquial y sector censal. La relación entre el asma y la migración se analizó mediante regresión logística binaria.

Resultados:

De 2,404 participantes, 1,818 niños cumplieron con los criterios de inclusión. Entre ellos, el 2.8% experimentó migración cantonal, el 11.9% migración parroquial y el 24.6% migración sectorial. La prevalencia de sibilancias en los últimos 12 meses, sibilancias alguna vez y diagnóstico de asma por un médico fue del 13.1%, 33.3% y 7%, respectivamente. Los niños con antecedentes de migración cantonal tuvieron más probabilidades de haber experimentado sibilancias en comparación con aquellos que no migraron (OR 1.56; IC95% 0.87-2.79).

Conclusiones:

Los cambios de residencia entre unidades geográficas más pequeñas o adyacentes no parecieron estar asociados con la ocurrencia de asma. Sin embargo, la migración cantonal podría desempeñar un papel en los resultados relacionados con la salud respiratoria.



Remark

1) Why was this study conducted?

Scientific reports have proposed differences in asthma prevalence associated with international migration; however, there are no reports of such differences in low- or middle-income countries with internal migration, where environmental, social, and cultural changes may be associated with increased asthma prevalence

2) What were the most relevant results of the study?

Internal migration between medium-sized territor ies showed a higher probability of asthma symptoms, although this relationship was not statistically significant. Internal migration between small-sized territories did not suggest an increase in the occurrence of asthma.

3) What do these results contribute?

Internal migration between medium-sized and more distant territories could be related to an increase in asthma symptoms. This highlights the importance of considering distance, environmental and social changes in the analysis of asthma occurrence and symptoms.

Introduction

Asthma is a public health problem worldwide, affecting all age groups and is considered the most common chronic lung disease in children [1-4]. Worldwide, it is estimated that more than 334 million people suffer from this disease [5]. The International Study on Asthma and Allergies in Childhood (ISAAC III) reported an average prevalence of 15% in Latin America. In Ecuador, the prevalence was 10.9% in adolescents aged 13 to 14 [6,7].

Generally, asthma prevalence studies are accompanied by risk factor analysis that addresses genetic [8,9], environmental and social determinants of the disease [3,10]. Within the social determinants of asthma, urbanisation and migration processes have become the main factors associated with differences in asthma prevalence in countries with different levels of development and between urban and rural areas [11,12]. In the case of the migration process, epidemiological studies have focused mainly on the effects of international migration because this type of migration produces changes in exposure to allergens, lifestyles, diet, and the environment, all of which are related to the occurrence of asthma and other allergic diseases [1,2,13]. Studies of international migrants have shown that place of birth, age at migration, and length of residence are important factors in understanding differences in asthma occurrence between migrant and resident populations [14-16].

In Latin America, epidemiological studies in several countries have indicated that asthma is mainly associated with populations with fewer economic resources and living in urban areas. A large part of these populations are composed of internal migrants who arrive in cities in search of opportunities [17,18].

Like the process of international migration, internal migration entails a series of environmental, social and psychological changes that could be related to the occurrence of asthma. However, there is little information on the relationship between internal migration and asthma in low- and middle-income countries. It is likely that social processes such as internal migration, mobility, and urbanisation are associated with different types of clinical presentation and disease evolution [19,20]. For this reason, the present study evaluated the relationship between internal migration and asthma in a child population in Latin America.

Materials and Methods

Context of the study

The present study was part of a birth cohort named ECUAVIDA (Impact of early lifetime exposures to geohelminth infections on the development of vaccine immunity, allergic sensitisation, and inflammatory diseases in children living in tropical Ecuador) [21]. The ECUAVIDA project aimed to investigate the effects of prenatal and postnatal care for exposure to soil-transmitted helminths on developing atopy and allergic diseases from birth to eight years of age. The study recruited participants from November 2006 to December 2009 for a total of 2404. The sample in the ECUAVIDA study was calculated taking into account that approximately 50% of mothers would be infected by geohelminths and that 35% of children would have at least one documented geohelminth infection during early childhood, which would give the study a potency greater than 80% and a significance level of 0.05 to detect a difference in asthma prevalence of at least 6% [21,22].

The collection of information for each child was provided by the mother around the time of birth, seven and thirteen months, and at two, three and five years. Data collected for children included demographic, lifestyle, psychosocial, dietary, child morbidity, and clinical outcomes. Follow-up of participants up to the age of five was completed in June 2014. The recording of information on the migration history of the participants throughout the follow-up in the ECUAVIDA study allowed us to explore the relationship between internal migration and asthma.

Study design

This is a cross-sectional study nested in the ECUAVIDA birth cohort. It evaluated the relationships between a history of internal migration and mobility and the occurrence of asthma at five years of age. The present study followed the STROBE guidelines for reporting observational studies.

Population and area of study

This study focused on the ECUAVIDA cohort population at age five. Participants were residents of the cantons of Quinindé, La Concordia and Puerto Quito, located in northwest Ecuador. The study area is characterised by a tropical climate with an average annual temperature of 30 ^{0}C and 75% humidity, where Quinindé is the most populated canton with 137,000 inhabitants with a rural predominance (76%). The most populated and important centre in the area is the capital of the canton Quinindé, with 30,000 inhabitants, concentrating most of the urban population. Apart from Quinindé, the other two important centres with populations greater than 15,000 inhabitants are La Concordia and La Unión, settlements considered rural towns by the political division of Ecuador when the study began.

Geographically, the study area included 3 cantons (territorial districts made up of urban and rural parishes and the cantonal capital), 9 parishes (lower-level political-territorial division) and 330 census sectors (extension of territory with perfectly defined limits for the national census, made up of an average of 70 dwellings), of which 38 represent settlements of different population sizes such as parish capitals, towns and communities (Figure 1). The main economic activities in this region are focused on livestock, agriculture, and the cultivation of African palm and tropical fruits.

Sample

The sample was non-probabilistic.

Inclusion criteria

Children aged five years or older who were recruited at birth for the ECUAVIDA cohort resided within the study area, had complete migration history data, and had information on clinical evaluations for asthma.

Exclusion criteria Tutors/parents of children who did not want to participate in the study and the inability to locate the children's homes.

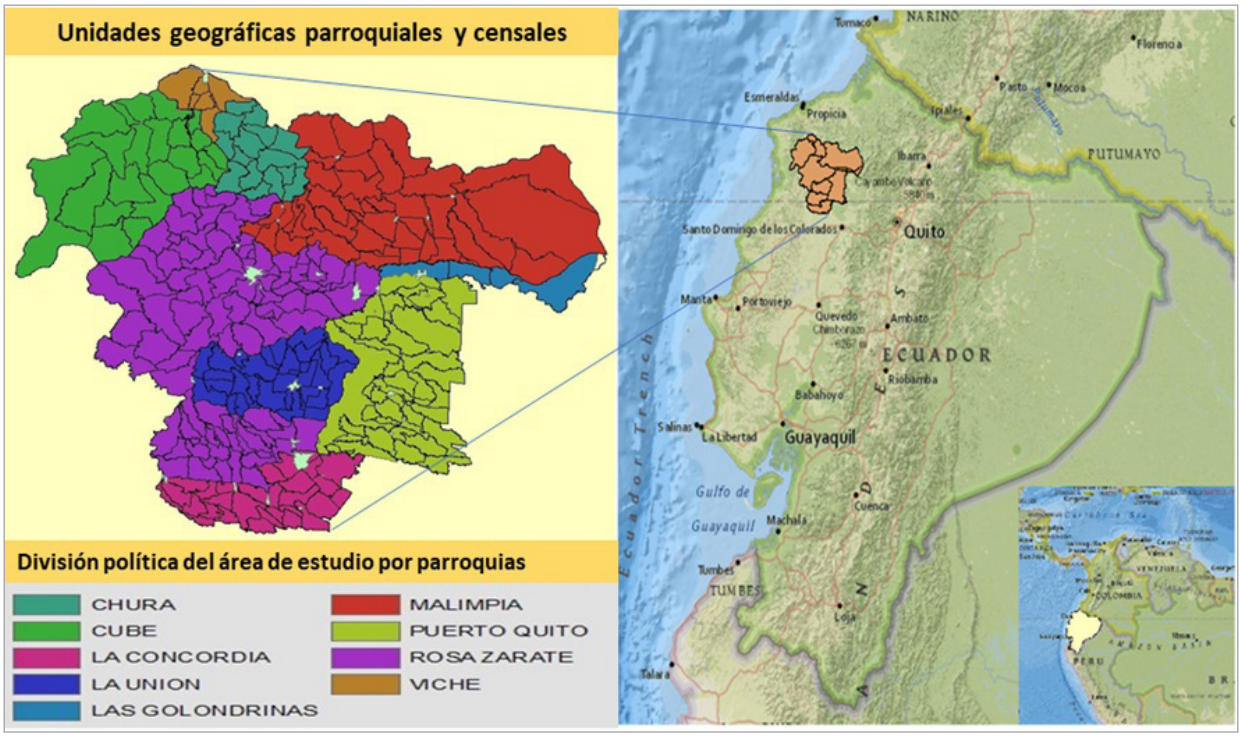


Figure 1. Description of the study area

Data collection

Data on migration history were collected through the addresses and geographic coordinates of each participant's households, which were obtained at each visit during the follow-up period. Based on these coordinates, it was possible to identify each participant's residence history.

In this study, migration was defined as a person's change of residence from one geographical unit to another. In this way, three types of internal migration indicators were considered according to the geographical unit available in the study area: migration between census tracts, migration between parishes, and migration between cantons. Additionally, it was possible to evaluate the mobility of the participants, understood as the number of house changes. Such changes could occur within the same geographic unit or different units. The study evaluated two mobility indicators: change of house in the last two years and change of house in the last five years.

Information related to the cumulative frequency of asthma in participants when they turned five years old came from the questionnaire applied to the participant's mother or guardian by an interviewer trained in the ECUAVIDA cohort. This instrument included sociodemographic information such as sex, mother's ethnic self-perception, area of residence, history of asthma and the mother's agricultural activities, humidity and tobacco smoke inside the house, as well as questions based on the ISAAC phase II study: Has the child wheezed in the last 12 months?, Has the child wheezed at any time in his/her life? and Has the child been diagnosed with asthma by a doctor? [,23].

Ethical aspects

The data come from the ECUAVIDA cohort, a project approved by the Ethics Committee of the Pedro Vicente Maldonado Hospital (June 13, 2005) and the Universidad San Francisco de Quito (November 6, 2010) and registered as an observational study (ISRCTN 41239086, https://www.isrctn.com/ISRCTN41239086).

Statistical analysis

Descriptive analyses using absolute frequencies and percentages were used to estimate the prevalence of migration and asthma indicators, as well as to characterise the study population. The associations between asthma and migration history were estimated with Odds Ratio (OR) and their respective confidence intervals (95%CI) adjusted for sociodemographic variables and asthma-related factors using multivariate analyses with binary logistic regression for each of the three response variables (wheezing in the last 12 months, wheezing at some time, and doctor's diagnosis of asthma). P values < 0.05 were considered statistically significant associations. Data analyses were performed using the SPSS statistical package version 29.

Results

Of the 2404 participants obtained during the recruitment period of the ECUAVIDA cohort, 1818 children (75.6%) met the criteria. Table 1 describes the sociodemographic variables, migration, and asthma. In the study, 51% (n= 928) were male, 26.8% (n= 488) of the children had mothers self-identified as Afro-descendant and 55.5% (n= 1,009) of the children lived in rural areas. Concerning migration variables, 2.8% (n= 51) of the children migrated from canton, 11.9% (n= 216) from parishes, and 24.6% (n= 447) from the census tract in the last five years. When asked about the change of address, 52.5% (n= 955) of the respondents stated the change of address in the last five years and up to 10.7% (n = 195) changed their address four or more times.

Regarding asthma variables, 13.1% (n= 238) had wheezing in the last 12 months, 33.3% (n= 605) had wheeze ever, and 7% (n= 127) were diagnosed with asthma by a doctor. In the study, 6.8% (n= 121) of the children's mothers had a history of asthma, 22.8% (n=415) of the children lived in damp houses, and 13% (n= 235) lived with the presence of tobacco smoke inside the homes in the last two years.

Table 2 presents the multivariate analyses of the three asthma indicators and the history of migration and mobility adjusted by sex, mother's ethnicity, agricultural activity, history of asthma of the mother, humidity in the house and presence of tobacco smoke in the child's home in the last two years. The multivariate model that analysed the association between wheezing in the last 12 months with migration and mobility history showed that children with history of cantonal migration had 39% more chances of asthma compared to those with no history of migration, but not statistically significant (OR: 1.39; 95% CI: 0.66-2.94). In the case of change of residence in the last two years, children with a history of change of residence presented 27% more asthma compared to those without a history (OR: 1.27; 95% CI: 0.95-1.70) with no statistical significance. Likewise, in the multivariate analysis for wheezing ever and cantonal migration, children with history of wheezing ever presented 56% more asthma (OR: 1.56; 95% CI: 0.87-2.79) but not statistically significant. No important associations were found for the other categories.

Discussion

The interest in migration and asthma is mainly based on international migration and seeks to understand how environmental, social and cultural factors influence the prevalence of asthma in migrant populations. We set out to analyse the relationship between internal migration and asthma in children at 5 years of age who were part of a birth cohort. For this study, internal migration was defined as the change of geographical units without considering whether the person migrated from a rural to an urban area. Migrations between census wards and parishes are migrations within the study area, while cantonal displacement is distant migrations within the country that are outside the study area. This definition considers the geographical context of the study area and is related to the distance of mobilisation.

Our study did not find enough evidence to indicate that migrations between census wards and parish had any association with asthma symptoms. However, those with a history of cantonal

Table 1. Univariate description of the variables of sociodemographic, migration and asthma.

Variable	Category	n	%
Sex	Male	928	51.0
Current residence area	Urban	809	44.5
	Rural	1,009	55.5
Mother's ethnicity	Mestiza	1,330	73.2
	Afroecuatoriana	488	26.8
Cantonal migration	Yes	51	2.8
Parish migration	Yes	216	11.9
Census ward migration	Yes	447	24.6
Moving house in the last 2 years	Yes	557	30.6
Moving house in the last 5 years	Yes	955	52.5
Number of house changes in the last 5 years	≥4	195	10.7
	3	176	9.7
	2	89	4.9
	1	495	27.2
	0	863	47.5
Wheezing in the last 12 months	Yes	238	13.1
Wheezing ever	Yes	605	33.3
Doctor's diagnosis of asthma	Yes	127	7.0
History of asthma of the mother	Yes	121	6.8
Mother's Agricultural Activities	Yes	108	6.1
Humidity in the house	Yes	415	22.8
Tobacco smoke inside the house	Yes	235	13.0

migration did present a higher prevalence of asthma symptoms, although this relationship was not statistically significant. This finding could suggest that, in the context of internal migration in low- and middle-income countries, the greater the distance of internal migration, the greater the occurrence of asthma cases. It is very common to expect more significant cultural, environmental, and lifestyle changes the further away the migrant's destination, factors related to variations in the prevalence of asthma [24].

Most of the evidence linking migration and asthma comes from studies that evaluate international migration because this type of geographic displacement is recorded by the country of origin as well as by the country of destination. These studies have shown that migrants from low—and middle-income countries have a lower prevalence of asthma compared to the host country population [14]. However, this prevalence increases with the years of residence in the new country until it equals the prevalence of the host population. For example, a U.S. study of 91,642 children ages 0 to 17 found that children born outside the U.S.

Table 2. Multivariate models of migration, mobility variables and asthma

		Wheezing in the last 12 months		Wheezing Ever		Doctors' diagnosis of asthma	
Variable	**Category**	**OR***	**IC 95%**	**OR***	**IC 95%**	**OR***	**IC 95%**
Cantonal migration	Yes Vs. No	1.39	0.66-2.94	1.56	0.87-2.79	1.04	0.36-3.04
Parish migration	Yes Vs. No	0.92	0.59-1.44	0.97	0.70-1.33	1.10	0.61-1.95
Census ward migration	Yes Vs. No	0.88	0.63-1.23	0.92	0.72-1.16	0.79	0.49-1.26
Moving house in the last two years	Yes Vs. No	1.27	0.95-1.71	1.03	0.83-1.28	0.98	0.65-1.48
Moving house in the last five years	Yes Vs. No	1.01	0.77-1.34	0.98	0.80-1.20	0.90	0.62-1.32
Number of house changes in the last five years	≥4 Vs. 0	1.01	0.62-1.63	0.95	0.67-1.35	1.08	0.58-2.01
	3 Vs. 0	0.87	0.52-1.47	0.94	0.65-1.34	0.50	0.21-1.20
	2 Vs. 0	0.98	0.50-1.91	0.91	0.56-1.47	1.05	0.43-2.55
	1 Vs. 0	1.07	0.77-1.49	1.03	0.81-1.31	0.95	0.61-1.49

*OR adjusted for sex. mother's ethnicity. The mother's agricultural activity. A history of asthma in the mother. humidity in the house and presence of tobacco smoke in the child's home for the past two years

compared to those born in the U.S. were less likely to experience wheezing at some point (OR: 0.53) and wheezing in the past year (OR: 0.34). In the U.S. study, the associations between the child's place of birth and asthma remained significant when the multivariate model included age, sex, ethnicity, annual household income, residence in metropolitan areas, and the child's history of moving to a new home [15].

Regarding the association between internal migration and asthma, there are few studies evaluating this relationship, even though this type of migration is the most frequent. These studies have used different approaches and different dimensions of internal migration to evaluate the effects of this process on the occurrence of asthma. For example, some studies have evaluated the effects of internal migration on the occurrence of asthma in populations that have been relocated or evacuated after some natural or social event. Thus, a study conducted in Japan showed that the population evacuated after the 2011 earthquake presented an increase in asthma cases during and after the participants migrated to temporary housing, which could suggest a sensitisation to allergens in temporary housing despite later leaving the housing [25]. However, the study does not describe the distance to which they were mobilised. limiting the analysis of the influence on asthma cases in the new residence environment.

On the other hand, a good part of the studies that relate internal migration with the occurrence of asthma have focused on the comparison of urban population groups with a history of rural-urban migration. A study conducted in Salvador de Bahia-Brazil showed that people with a history of rural-urban migration had 57% more cases of moderate-severe asthma and 80% more cases of uncontrolled asthma symptoms compared to those without a history of rural-urban migration [26]. Likewise, a previous study carried out in the city of Esmeraldas, Ecuador, reported a higher prevalence of wheezing in the last 12 months in those with a history of rural-urban migration (OR: 1.66; 95% CI: 1.15-2.41) compared to people without a history of migration [27].

However, not all studies show the same relationship. A study conducted in an urban area of Argentina showed that adolescents aged 13 to 14 with a history of rural residence had the same prevalence of wheezing as those who had always lived in the urban area [28]. Finally, a study in Ecuador evaluated migratory patterns in children living in rural areas, finding that children from rural areas who migrated during the first year of life had a higher risk of wheezing than those who did not migrate [29]. The lack of association between internal migration and asthma, in the case of changes in parish and census tract, could be explained by the short travel distances between these two geographical units. Migration between parishes and census tracts likely occurs in the same environmental and social environment, so it does not have a relevant impact on changes in people's lifestyles. That is, after the residential change, people continue with the same activities as the previous home, such as raising pets, the presence of pets, environmental exposure, and agricultural activities that are very similar to the previous place of residence, given the proximity of migration.

In addition to migratory movements, the present study had the opportunity to evaluate the effect of house changes on the occurrence of asthma. This relationship was studied mainly in the 1960s and 1990s, although the results of these studies were contradictory [30-32]. The first study to look for an association between sociodemographic variables, house changes and asthma was conducted in the United Kingdom in a cohort of more than 14,000 participants from the National Child Development Study (NCDS) in England. In this study, the distribution of asthma according to social class was associated with the fact that fewer people with asthma resided in rented houses compared to those who owned the homes. Similarly, it was observed that the fewer people in the child's room, the fewer cases of asthma [30]. Another study conducted in the outskirts of Plymouth, United Kingdom, with a sample of 11,000 participants aged 4 to 16 years, also found no significant differences between change of address and asthma (OR: 1.12; 95% CI: 0.89-1.41) or in the number of changes of address [31].

In the present study, it was found that 52.5% of the participants moved house at least once until the age of five and that 10.7% of this group did so at least four times. However, neither the change of house nor the frequency of change of residence was associated with the occurrence of asthma. One of the possible reasons for not finding this association between changes in residence and the occurrence of asthma in our study would be related to the fact that there is no complete information on the state of the homes. Studies on the internal conditions of homes have shown that homes in poor condition, especially those with mould and moisture, are associated with more asthma cases [33]. For example, in a study conducted in southern Poland on 3,237 primary school students, they found that dwellings with the presence of dampness were associated with higher cases of asthma and wheezing in the last 12 months [10].

Another study in Japan, between January 2011 and March 2014, with a follow-up of 13 years, looked at 60,529 participants to examine the associations between the presence of mould and smoke from wood or chimneys and the occurrence of wheezing in children. The authors found statistical significance for the occurrence of wheezing in children in the presence of mould growth (OR: 1.13; 95% CI: 1.06-1.22) and smoke from wood or chimney (OR: 1.23; 95% CI: 1.03-1.46) in dwellings [33]. In the present study, it was found that 22.8% of the children's houses had humidity, and in 13% of the homes, the respondents declared the presence of tobacco smoke, variables used in our statistical models.

Our study faces several limitations that must be considered when interpreting the results. First, there is no universally accepted consensus for the definition of asthma nor a gold standard for its diagnosis. This implies that when using indicators such as clinical asthma symptoms, there is a risk of misdiagnosis, either in the form of underdiagnosis or overdiagnosis. However, most epidemiological studies use this definition, as it is a practical and accepted definition for studies of large populations [34]. Second, the data analysed came from a birth cohort, and an inherent challenge to this type of longitudinal study is the loss of participants over time, especially due to migration. In our case, many children moved between cantons, some of whom eventually returned, while others migrated without return. These losses in follow-up could affect the study's ability to detect robust associations between cantonal migration and asthma prevalence, thereby reducing power and potentially skewing the results. However, the sample for the cohort was calculated with 20% more population in case of losses to reduce the impact of losses on our results. Finally, our study did not investigate the direction of migration or other factors related to the migration process that could influence the onset of asthma; for example, aspects such as the socioeconomic conditions of the place of destination, air quality, access to health services, and other environmental and social determinants related to migration that could play a crucial role in the development of asthma.

Conclusions

In the present study, no statistically significant associations were found between internal migration and asthma. However, of the three migration dimensions evaluated, the one that required a more distant transfer (cantonal migration) was related to a higher probability of asthma symptoms. This could suggest that internal migrations between more distant geographic units could be related to a higher prevalence of asthma. It is important to carry out other studies that evaluate not only the history of migration but also other elements, such as the direction and distance of migration.

References

1. Cabieses B, Uphoff E, Pinart M, Antó JM, Wright J. A systematic review on the development of asthma and allergic diseases in relation to international immigration: the leading role of the environment confirmed. PLoS One. 2014; 9(8): e105347. doi: 10.1371/journal.pone.0105347.

2. Global Asthma Network. The Global Asthma Report 2018. Auckland, New Zealand; 2018. Available from: http://

3. Grant T, Croce E, Matsui EC. Asthma and the social determinants of health. Ann Allergy, Asthma Immunol. 2022; 128(1): 5-11. Doi: 10.1016/j.anai.2021.10.002

4. Kwong CG, Bacharier LB. Phenotypes of wheezing and asthma in preschool children. Curr Opin Allergy Clin Immunol. 2019; 19(2): 148-53. Doi: 10.1097/ACI.0000000000000516

5. Global Initiative for Asthma. Global Strategy for Asthma Management and Prevention; 2021. Available from: https://ginasthma.org/reports/

6. Mallol J, Solé D, Baeza-Bacab M, Aguirre-Camposano V, Soto-Quiros M, Baena-Cagnani C. Regional variation in asthma symptom prevalence in Latin American children. J Asthma. 2010; 47(6): 644-50.

7. Forno E, Gogna M, Cepeda A, Yañez A, Solé D, Cooper P, et al. Asthma in Latin America. Thorax. 2015; 70(9): 898-905. Doi: 10.1136/thoraxjnl-2015-207199

8. Ober C, Yao T-C. The genetics of asthma and allergic disease: a 21st century perspective. Immunol Rev. 2011; 242(1): 10-30. Doi: 10.1111/j.1600-065X.2011.01029.x

9. Ntontsi P, Photiades A, Zervas E, Xanthou G, Samitas K. Genetics and Epigenetics in Asthma. Int J Mol Sci. 2021; 22(5): 2412. Doi: 10.3390/ijms22052412

10. Wypych-Slusarska A, Krupa-Kotara K, Niewiadomska E. Social inequalities: do they matter in asthma, bronchitis, and respiratory symptoms in children? Int J Environ Res Public Health. 2022; 19(22): 15366. doi: 10.3390/ijerph192215366.

11. Grant TL, Wood RA. The influence of urban exposures and residence on childhood asthma. Pediatr Allergy Immunol. 2022; 33(5): e13784. Doi: 10.1111/pai.13784

12. Rodriguez A, Brickley E, Rodrigues L, Normansell RA, Barreto M, Cooper PJ. Urbanisation and asthma in low-income and middle-income countries: a systematic review of the urban-rural differences in asthma prevalence. Thorax. 2019; 74(11): 1020-30. doi: 10.1136/thoraxjnl-2018-211793.

13. Tham EH, Loo EXL, Zhu Y, Shek LP-C. Effects of migration on allergic diseases. Int Arch Allergy Immunol. 2019; 178(2): 128-40. Doi: 10.1159/000494129

14. Lombardi C, Canonica GW, Passalacqua G. The possible influence of the environment on respiratory allergy: A survey on immigrants to Italy. Ann Allergy, Asthma Immunol. 2011; 106(5): 407-11. Doi: 10.1016/j.anai.2011.01.023

15. Silverberg JI, Simpson EL, Durkin HG, Joks R. Prevalence of Allergic Disease in Foreign-Born American Children. JAMA Pediatr. 2013; 167(6): 554-60. Doi: 10.1001/jamapediatrics.2013.1319

16. Wang H-Y, Wong GWK, Chen Y-Z, Ferguson AC, Greene JM, Ma Y, et al. Prevalence of asthma among Chinese adolescents living in Canada and in China. CMAJ. 2008; 179(11): 1133-42. Doi: 10.1503/cmaj.071797

17. Robinson CL, Baumann LM, Gilman RH, Romero K, Combe JM, Cabrera L, et al. The Peru Urban versus Rural Asthma (PURA) Study: methods and baseline quality control data from a cross-sectional investigation into the prevalence, severity, genetics, immunology and environmental factors affecting asthma in adolescence in Peru. BMJ Open. 2012; 2(1): e000421. doi: 10.1136/bmjopen-2011-000421.

18. Moncayo AL, Vaca M, Oviedo G, Erazo S, Quinzo I, Fiaccone RL, et al. Risk factors for atopic and non-atopic asthma in a rural area of Ecuador. Thorax. 2010; 65(5): 409-16. Doi: 10.1136/thx.2009.126490

19. Sanchez J, Sánchez A, Cardona R. Clinical differences between children with asthma and rhinitis in rural and urban areas. Colomb Med (Cali). 2018; 49(2): 169-74. doi: 10.25100/cm.v49i2.3015

20. Bel EH. Clinical phenotypes of asthma. Curr Opin Pulm Med. 2004; 10(1): 44-50.

21. Cooper P, Barreto M. Cohort Profile: The Ecuador Life (ECUAVIDA) study in Esmeraldas Province, Ecuador. Int J Epidemiol. 2015; 44(5): 1517-27. doi: 10.1093/ije/dyu128.

22. Cooper PJ, Chico ME, Vaca MG, Sandoval CA, Loor S, Amorim LD, et al. Effect of early-life geohelminth infections on the development of wheezing at 5 years of age. Am J Respir Crit Care Med. 2018; 197(3): 364-72. doi: 10.1164/rccm.201706-1222OC.

23. Weiland SK, Björkstén B, Brunekreef B, Cookson WOC, von Mutius E, Strachan DP, et al. Phase II of the International Study of Asthma and Allergies in Childhood (ISAAC II): rationale and methods. Eur Respir J. 2004; 24(3): 406-12. Doi: 10.1183/09031936.04.00090303

24. Rodriguez A, Vaca MG, Chico ME, Rodrigues LC, Barreto ML, Cooper PJ. Rural to urban migration is associated with increased prevalence of childhood wheeze in a Latin-American city. BMJ open Respir Res. 2017; 4(1): e000205. doi: 10.1136/bmjresp-2017-000205.

25. Oshikata C, Watanabe M, Ishida M, Kobayashi S, Hashimoto K, Kobayashi N, et al. Association between temporary housing habitation after the 2011 Japan earthquake and mite allergen sensitization and asthma development. Int Arch Allergy Immunol. 2021; 182(10): 949-61. doi: 10.1159/000515870.

26. Ponte EV, Lima A, Almeida PCA, de Jesus JPV, Souza-Machado A, Barreto ML, et al. Rural to urban migration contributes to the high burden of asthma in the urban area. Clin Respir J. 2019; 13(9): 560-6. Doi: 10.1111/crj.13058

27. Rodriguez A, Vaca MG, Chico ME, Rodrigues LC, Barreto ML, Cooper PJ. Migration and allergic diseases in a rural area of a developing country. J Allergy Clin Immunol. 2016; 138(3): 901-3. Doi: 10.1016/j.jaci.2016.01.052

28. Han Y-Y, Badellino HA, Forno E, Celedón JC. Rural residence, farming environment, and allergic diseases in Argentinean adolescents. Pediatr Pulmonol. 2017; 52(1): 21-8. doi: 10.1002/ppul.23511.

29. Cooper PJ, Chico ME, Vaca MG, Rodriguez A, Alcântara-Neves NM, Genser B, et al. Risk factors for asthma and allergy associated with urban migration: background and methodology of a cross-sectional study in Afro-Ecuadorian school children in Northeastern Ecuador (Esmeraldas-SCAALA Study). BMC Pulm Med. 2006; 6: 24. doi: 10.1186/1471-2466-6-24.

30. Kaplan BA, Mascie-Taylor C. Biosocial factors in the epidemiology of childhood asthma in a British national sample. J Epidemiol Community Health. 1985;(39):152-6.

31. Jones RC, Hughes CR, Wright D, Baumer JH. Early house moves, indoor air, heating methods and asthma. Respir Med. 1999;93(12):919-22.

32. Strachan DP, Butland BK, Carey IM, Anderson HR. Moving house unlikely to pose substantial risk of childhood asthma. BMJ. 1996;312(7026):315.

33. Saijo Y, Yoshioka E, Sato Y, Azuma H, Tanahashi Y, Ito Y, et al. Relations of mold, stove, and fragrance products on childhood wheezing and asthma: A prospective cohort study from the Japan Environment and Children's Study. Indoor Air. 2022; 32(1): e12931. Doi: 10.1111/ina.12931

34. Dubovyi A, Chelimo C, Schierding W, Bisyuk Y, Camargo CAJ, Grant CC. A systematic review of asthma case definitions in 67 birth cohort studies. Paediatr Respir Rev. 2021; 37: 89-98. doi: 10.1016/j.prrv.2019.12.005.