



Original article

Does migration affect asthma, rhinoconjunctivitis and eczema prevalence? Global findings from the international study of asthma and allergies in childhood

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Abstract

Background: Immigrants to Westernized countries adopt the prevalence of allergic diseases of native populations, yet no data are available on immigrants to low-income or low-disease prevalence countries. We investigated these questions using data from the International Study of Asthma and Allergies in Childhood.

Methods: Standardized questionnaires were completed by 13–14-year-old adolescents and by the parent/guardians of 6–7-year-old children. Questions on the symptom prevalence of asthma, rhinoconjunctivitis and eczema, and a wide range of factors postulated to be associated with these conditions, including birth in or not in the country and age at immigration, were asked. Odds ratios for risk of the three diseases according to immigration status were calculated using generalized linear mixed models. These were adjusted for: world region; language and gross national income; and individual risk factors including gender, maternal education, antibiotic and paracetamol use, maternal smoking, and diet. Effect modification by gross national income and by prevalence was examined.

Results: There were 326 691 adolescents from 48 countries and 208 523 children from 31 countries. Immigration was associated with a lower prevalence of asthma, rhinoconjunctivitis and eczema in both age groups than among those born in the country studied, and

this association was mainly confined to high-prevalence/affluent countries. This reduced risk was greater in those who had lived fewer years in the host country.

Conclusions: Recent migration to high prevalence/affluent countries is associated with a lower prevalence of allergic diseases. The protective pre-migration environment quickly decreases with increasing time in the host country.

Key words: Asthma, eczema, epidemiology, ISAAC, migration, rhinoconjunctivitis

Key Messages

- The results of the present study, including 48 countries with 111 centres (adolescents 13–14 years old) and 31 countries with 72 centres (children 6–7 years old), show that the existing evidence that migration is a protective factor for asthma, rhinoconjunctivitis and eczema is applicable globally.
- The protective effect of migration on those conditions is demonstrated by the results from affluent countries, and it seems greater in migrants with fewer years in the host country.
- Immigration to non-affluent countries is not associated with differences in the prevalence of asthma, rhinoconjunctivitis or eczema.
- The protective effect of migration is confined to migrants moving to a country with a high prevalence of those conditions.

Introduction

In the general context of: the ‘healthy migrant’ phenomenon, by which the first generation of immigrants to higher-income countries tend to be healthier than residents of the same ethnic background;^{1–3} and the ‘assimilation’ and ‘acculturation’ effects by which those migrants acquire behaviours and cultural beliefs which may have some effects on health;⁴ the effect of migration on the symptom prevalence of asthma, rhinoconjunctivitis and eczema is of interest because of the insights it may give as to the role of the environment in causation and the time of life that is most influential. One of the earliest reports, in 1960, described the period needed to acquire hay fever to ragweed pollen in a group of immigrants.⁵ Since then, evidence has accumulated which suggests that immigrants moving from less developed countries with lower prevalences of asthma, rhinoconjunctivitis and eczema to more Westernized countries, with higher prevalences, tend to acquire the rates of local populations: the longer the time spent in the new environment, the less the difference in prevalence.^{6,7–12} However, some exceptions to this trend have been reported.^{13–18} Reports from the UK and the USA show that despite a later age of onset of asthma in immigrants, the proportion with positive skin-prick tests to specific allergens is similar to that among non-immigrants.^{19,20} Some authors have hypothesized that the ethnicity of immigrants might be relevant;^{21–23} however

within a given environment, children born into that environment have a similar risk of asthma symptoms regardless of ethnicity²⁴ and ethnic differences in diagnosed asthma could reflect the use of health services. So it may be reasonable to attribute migrant differences to environmental (including cultural) factors rather than to genetic differences associated with ethnicity. Some studies have also suggested that asthma is more severe in immigrants as compared with the native-born²² and that rhinoconjunctivitis may be a more sensitive marker than asthma or eczema to the change in the environment related to migration.²⁵ Some even have speculated that the very high prevalence of asthma, rhinoconjunctivitis and eczema in countries such as Australia or New Zealand might be related to the massive immigrant population which founded them.⁶

Trying to make overall sense of the various conflicting studies of migrant populations that have been conducted in single-country studies is fraught with difficulty due to the differences in methods used in defining diseases and sampling. The International Study of Asthma and Allergies in Childhood (ISAAC) is probably the only study which has the potential to provide new global insights into the role of migration in allergic disease, in view of its standardized methods and wide international coverage. ISAAC Phase Three included centres in a considerable number of developing countries, and obtained information about

whether children were born in the country where they or their parents were living now, and for how long they had been living there.

The aim of this paper is to investigate whether the symptom prevalences of asthma, rhinoconjunctivitis and eczema in adolescents and children differ between migrants and native-born and if so, whether this association is affected by the duration of residence in the host country.

Methods

The rationale and methods of ISAAC Phase Three have been published in detail elsewhere.²⁶ Briefly, the study instruments were two simple standardized questionnaires completed by 13–14-year-old adolescents and by the parent/guardians of 6–7-year-old children. The first (prevalence) questionnaire obtained simple demographic information (e.g. age and gender) and data on the symptom prevalence of asthma, rhinoconjunctivitis and eczema. The second environmental questionnaire (EQ) obtained data on a wide range of putative protective and risk factors for the development of asthma, rhinoconjunctivitis and eczema symptoms, including immigration status. The questionnaires are on the ISAAC website at [<http://isaac.auckland.ac.nz>].

The present analysis compares the symptom prevalence of asthma, rhinoconjunctivitis and eczema symptoms between adolescents and children who were born in and those who migrated to the country where the survey took place. Participants were asked: 'Were you (was your child) born in [country of study]?' The length of the stay in the current country was assessed by the question: 'How many years have you (has your child) lived in [country of study]?' Country of birth was not recorded.

Symptoms of 'current wheeze' were determined by positive answers to the written question 'Have you (has your child) had wheezing or whistling in the chest in the past 12 months?' 'Severe wheeze' was defined as a positive answer to the previous question, followed by at least one of the following: ≥ 4 attacks of wheeze; ≥ 1 night per week sleep disturbance from wheeze; or wheeze affecting speech. Reported 'asthma ever' was defined from the question 'Have you (has your child) ever had asthma?' In the adolescent group an additional definition of 'current wheeze' (video) was included according to an affirmative answer to a video scene showing an adolescent wheezing while sitting quietly at a table writing.

'Current symptoms of rhinoconjunctivitis' were determined by positive answers to two questions: 'In the past 12 months have you (has your child) had a problem with sneezing or a runny or blocked nose when you (your child) did not have a cold or the flu?' If yes: 'In the past 12 months

has this nose problem been accompanied by itchy watery eyes?' 'Symptoms of severe rhinoconjunctivitis' were defined as a positive answer to the previous two questions together with the answer 'A lot' to the question: 'In the past 12 months, how much did this nose problem interfere with your (child's) daily activities?' (not at all, a little, a moderate amount, a lot). An affirmative answer to the question 'Have you (has your child) ever had hayfever?' defined 'hay fever ever'.

Current symptoms of eczema were determined by positive answers to: 'Have you (has your child) ever had an itchy skin rash which was coming and going for at least 6 months?' If yes: 'Have you (has your child) had this itchy rash at any time in the past 12 months?' If yes: 'Has this itchy rash at any time affected any of the following places—the folds of the elbows, behind the knees, in front of the ankles, under the buttocks or around the neck, ears or eyes?' 'Symptoms of severe eczema' were defined as having current symptoms of eczema and sleep disturbance one or more nights per week. 'Eczema ever' was determined by a positive answer to: 'Have you (has your child) ever had eczema?'

Questions on symptoms of asthma, rhinoconjunctivitis and eczema include both sensitive and specific questions which are repeatable and have good content, construct and concurrent and predictive validity.²⁷ Additionally, language deviations of those questions have been explained and the methods used to deal with them published.²⁸

Statistical analysis

To be included in the analysis, centres had to assess at least 1000 adolescents and children and have a response rate of more than 70% for the adolescent group and more than 60% for the children. Odds ratios (ORs) for risk of the three diseases according to birth in or not in the country were calculated with generalized linear mixed models, with a binomial distribution and logit link and with the centres being modelled as a random effect. Analyses of all study participants were adjusted for gender, region of the world, language and gross national income (GNI) categorized by the World Bank as low, lower-middle, upper-middle and high.²⁶ Socioeconomic status of each centre was based on its country's gross national income. Regression models incorporated the effect of sampling by schools, scaling the size of the sample by the design effect. All analyses were conducted separately for the two different age groups.

Fully adjusted analyses were also conducted to investigate whether the association between symptoms and not being born in the country of study was confounded by other EQ variables. For inclusion in these analyses, centres

were required to have at least 70% data available for all covariates. Any participants who had a missing value for any of the covariates were removed. The covariates included: maternal education (none, primary, secondary, tertiary); antibiotic use in the first year of life (only for the children) (yes or no); current maternal cigarette smoking (yes or no); current intake (3 or more times a week, 1–2/week, never or occasionally) of the following foods: eggs, fruit, meat, milk, vegetables, nuts, pulses, seafood and potato; and current paracetamol use (never, at least once a year, at least once per month).

The primary effect measures were the associations (expressed as adjusted ORs) between birth in or not in the country and the symptom prevalence (current and severe) of asthma, rhinoconjunctivitis or eczema, for both age groups. ORs were calculated for all outcome variables on the whole sample and stratified according to the quartile of prevalence for symptoms of asthma, rhinoconjunctivitis and eczema. In order to assess the impact of time living in the current country, a comparison was made between those children who migrated when they were 2 years old or less and those who migrated after that age. For the adolescent group, the categories were: 2 years or less; more than 2 but less than 10 years; and more than 10 years. Until the age of about 2 years, the immune system is still developing its ability to react to most allergens. Thus following the rationale of an immune system 'open to the environment' during the first months of life, the base category for this specific stratified analysis was both those children born in the current country and those who migrated at the age of 2 years or less. Our choice of the second cut-off point of 10 years is because this age usually separates transient wheezers from those who go on to develop persistent adult asthma phenotypes, as other studies have chosen.^{8,10} To explore the possibility that countries with high prevalence of allergic diseases may 'offer' more numerous and/or more potent risk factors²⁹ (or less numerous and/or less potent protective ones) to which immigrants might be exposed, those analyses were also stratified according to the quartile of prevalence for current symptoms of asthma, rhinoconjunctivitis and eczema. Furthermore, the primary outcome measures (associations expressed as adjusted ORs) between immigrant status and the different symptoms of asthma, rhinoconjunctivitis or eczema, for both age groups, were stratified according to GNI. All analyses were carried out using SAS version 9.2 (SAS Institute Inc., Cary, NC, USA).

Results

There were 326 691 adolescents from 48 countries (111 centres); and 208 523 children from 31 countries (72 centres).

Among adolescents, the proportion of births outside the country of study tended to be higher in centres from affluent countries, such as Canada (31.3%) and Hong Kong (21.2%); however, several non-affluent countries, such as Ethiopia (19.0%), Bolivia (16.6%) or Sudan (16.1%) also had quite high proportions. In the group of children, which included a lower number of countries, the higher proportions of births outside the country of study were found in New Zealand (12.1%), Singapore (7.1%) and Barbados (7.5%). The Isle of Man was an extreme example: 38.4% of the adolescents and 25.5% of the children were born in a different country. A complete list of countries, centres, number of children per country, proportion of births outside the current country and current symptoms of asthma, rhinoconjunctivitis and eczema is shown in [Supplementary Tables 1 and 2](#) (available as [Supplementary data](#) at *IJE* online).

For the adolescent group, in the fully adjusted model there were significant associations between being born outside the country of study and having a lower prevalence of 'current wheeze', 'current wheeze (video)', 'asthma ever', 'current symptoms of rhinoconjunctivitis' and 'eczema ever'. For the children, the findings were similar except that immigration was associated with a lower prevalence of 'current symptoms of eczema' whereas the prevalence of 'current symptoms of rhinoconjunctivitis' was not. Odds ratios were quite similar in the adjusted and in the fully adjusted models ([Table 1](#)).

The stratified analysis per quartile of outcome prevalence showed that the aforementioned associations with current symptoms were mainly driven by the associations seen in the higher quartiles ([Table 2](#)), thus indicating that the protection conferred by being born outside the current country is higher when there is a context of higher symptom prevalence.

In the adolescents, migrating before the age of 10 was not statistically significantly associated with a lower prevalence of any outcome variable, except for 'eczema ever'; however, when they migrated at older than 10 years of age ([Table 3](#)), the pattern of statistically significant associations with lower prevalence of outcome variables were similar to the comparison between immigrants and native-born ([Table 1](#)).

Those who migrated when older than 10 years of age were at higher risk of suffering from 'current symptoms of severe eczema'. In the children, when comparing those older than 2 years of age when migration took place with those born in the current country or with those being younger than 2 years when they migrated, the results were largely unchanged in pattern and magnitude for the overall comparisons shown in [Tables 1 and 4](#). There is some indication that those migrating when older had a higher risk

Table 1. Associations (odds ratio^a and 95% confidence interval) between being an immigrant and symptoms of asthma, rhinoconjunctivitis and eczema. Associations which are statistically significant at the 95% level are shown in bold

Symptom	Adjusted ^b (all children)	Fully adjusted ^c (children with complete covariate data)
6–7 year age group		
Current wheeze	0.79 (0.72–0.88)	0.87 (0.77–0.98)
Current symptoms of severe asthma	0.78 (0.68–0.90)	0.87 (0.73–1.03)
Asthma ever	0.74 (0.67–0.81)	0.80 (0.71–0.91)
Current symptoms of rhinoconjunctivitis	0.91 (0.81–1.01)	0.93 (0.81–1.06)
Current symptoms of severe rhinoconjunctivitis	0.96 (0.65–1.39)	1.07 (0.68–1.70)
Hay fever ever	1.05 (0.94–1.17)	1.07 (0.94–1.22)
Current symptoms of eczema	0.74 (0.66–0.83)	0.80 (0.70–0.91)
Current symptoms of severe eczema	0.86 (0.63–1.16)	1.22 (0.86–1.73)
Eczema ever	0.61 (0.56–0.68)	0.64 (0.57–0.71)
13–14 year age group		
Current wheeze	0.86 (0.80–0.94)	0.88 (0.79–0.99)
Current wheeze (video)	0.82 (0.73–0.93)	0.86 (0.74–1.00)
Current symptoms of severe asthma	0.94 (0.85–1.04)	0.93 (0.81–1.05)
Asthma ever	0.79 (0.73–0.84)	0.82 (0.75–0.91)
Current symptoms of rhinoconjunctivitis	0.88 (0.82–0.95)	0.90 (0.82–0.99)
Current symptoms of severe rhinoconjunctivitis	1.13 (0.93–1.38)	1.04 (0.77–1.39)
Hay fever ever	0.94 (0.87–1.02)	0.91 (0.81–1.01)
Current symptoms of eczema	0.99 (0.91–1.09)	1.00 (0.88–1.13)
Current symptoms of severe eczema	1.17 (0.98–1.39)	1.25 (0.99–1.57)
Eczema ever	0.82 (0.74–0.88)	0.80 (0.72–0.90)

^aReference category: native-born participants.

^bAdjusted for region of the world, gender, language and GNI.

^cAdjusted for region of the world, gender, language, GNI, consumption of eggs, fruit, meat, milk, vegetables, nuts, pulses, seafood and potato, current paracetamol use antibiotic use in the 1st year of life (6–7-year age group only), maternal education and current maternal cigarette smoking.

for ‘symptoms of severe eczema’ in the fully adjusted model.

Those associations that were observed were largely confined to those in the higher quartiles of prevalence (Supplementary Tables 3 and 4, available as Supplementary data at *IJE* online). As shown in Supplementary Tables 5–7 (available as Supplementary data at *IJE* online), the main findings of reduced disease symptom risk for being born outside the country of study holds only for affluent countries. In fact, the only significant association in non-affluent countries was that for ‘current symptoms of severe eczema’: being born outside the country of study was a risk factor for severe eczema when immigration took place after 2 years of age for the children.

Discussion

Main findings

The results from this large international study show that that being born outside the country of residence during childhood is associated with a lower symptom prevalence

of asthma, rhinoconjunctivitis and eczema. Nearly all of these associations seem to be restricted to affluent countries and are accounted for mainly by those countries with highest disease prevalence. For children, the ‘protective’ effect of immigration only seems to occur if migration took place after 2 years of age; whereas for adolescents, migration shows an effect after the age of 10, indicating greater protective effect with fewer years spent in the host country.

The results from non-affluent countries show that immigration is not associated with any of the aforementioned factors, the only exception being that of ‘symptoms of severe eczema’. This condition was more prevalent in immigrants as compared with locals among children when they migrated after 2 years of age, indicating that although being protected from eczema in their new country, once they do acquire it is more severe.

Possible explanation

The findings from both age groups suggest that if children spend enough time in the host country, they would lose

Table 2. Associations (odds ratio^a and 95% confidence interval) between being an immigrant and current symptoms of asthma, rhinoconjunctivitis and eczema, by quartile of outcome prevalence, 6–7-year age group. Associations which are statistically significant at the 95% level are shown in bold

Age group	Symptom	Adjusted ^b (all children)	Fully adjusted ^c (children with completecovariate data)	Immigrants (%)
6–7 years	Current wheeze			
	Current wheeze prevalence quartile 1	0.94 (0.53–1.66)	1.39 (0.55–3.47)	0.8
	Current wheeze prevalence quartile 2	1.13 (0.91–1.40)	1.09 (0.84–1.42)	2.7
	Current wheeze prevalence quartile 3	0.84 (0.72–0.99)	0.92 (0.72–1.19)	4.3
	Current wheeze prevalence quartile 4	0.65 (0.56–0.76)	0.67 (0.57–0.78)	4.0
	Current symptoms of rhinoconjunctivitis			
	Current rhinoconjunctivitis prevalence quartile 1	1.63 (0.98–2.72)	0.94 (0.41–2.17)	1.0
	Current rhinoconjunctivitis prevalence quartile 2	1.01 (0.80–1.28)	1.10 (0.80–1.50)	2.7
	Current rhinoconjunctivitis prevalence quartile 3	0.90 (0.77–1.05)	0.95 (0.78–1.15)	5.9
	Current rhinoconjunctivitis prevalence quartile 4	0.80 (0.64–0.98)	0.83 (0.65–1.07)	2.4
	Current symptoms of eczema			
	Current eczema prevalence quartile 1	1.60 (0.80–3.18)	1.32 (0.43–4.06)	0.9
	Current eczema prevalence quartile 2	0.78 (0.59–1.02)	0.78 (0.56–1.10)	3.1
	Current eczema prevalence quartile 3	0.70 (0.57–0.87)	0.76 (0.56–1.02)	3.0
	Current eczema prevalence quartile 4	0.73 (0.63–0.85)	0.79 (0.67–0.93)	4.7
13–14 years	Current wheeze			
	Current wheeze prevalence quartile 1	1.14 (0.75–1.72)	0.81 (0.44–1.51)	4.6
	Current wheeze prevalence quartile 2	0.97 (0.81–1.16)	1.01 (0.81–1.26)	4.1
	Current wheeze prevalence quartile 3	0.85 (0.73–0.99)	0.92 (0.76–1.11)	6.4
	Current wheeze prevalence quartile 4	0.82 (0.73–0.92)	0.78 (0.64–0.94)	7.6
	Current symptoms of rhinoconjunctivitis			
	Current rhinoconjunctivitis prevalence quartile 1	1.03 (0.80–1.32)	1.14 (0.79–1.66)	3.1
	Current rhinoconjunctivitis prevalence quartile 2	1.13 (0.94–1.36)	1.10 (0.88–1.38)	2.7
	Current rhinoconjunctivitis prevalence quartile 3	0.81 (0.71–0.92)	0.80 (0.67–0.95)	5.6
	Current rhinoconjunctivitis prevalence quartile 4	0.85 (0.77–0.95)	0.88 (0.76–1.01)	11.1
	Current symptoms of eczema			
	Current eczema prevalence quartile 1	0.95 (0.70–1.30)	0.83 (0.55–1.26)	3.0
	Current eczema prevalence quartile 2	0.93 (0.66–1.31)	0.93 (0.66–1.31)	3.9
	Current eczema prevalence quartile 3	1.08 (0.85–1.37)	1.08 (0.85–1.37)	3.7
	Current eczema prevalence quartile 4	0.98 (0.82–1.18)	0.98 (0.82–1.18)	11.9

^aReference category: native-born participants.

^bAdjusted for region of the world, gender, language and GNI.

^cAdjusted for region of the world, gender, language, GNI, consumption of eggs, fruit, meat, milk, vegetables, nuts, pulses, seafood and potato, current paracetamol use, antibiotic use in the 1st year of life, maternal education and current maternal cigarette smoking.

protection of their immigrant effect and would tend to match the prevalence of asthma, rhinoconjunctivitis and eczema in the indigenous population, provided they migrated to a host environment with a high prevalence of those diseases—a situation that is more frequently encountered in affluent countries.³⁰ This might indicate that the immune system could be re-programmed in response to a new environment if the exposure is long (and perhaps intense) enough. This idea of an allergy ‘catch-up’ among immigrants to affluent countries has been documented previously.^{24,31–33}

The striking association between being an immigrant in a country of lower affluence and reporting more severe eczema is difficult to explain. It could reflect lack of familiarity in diagnosing eczema in darker skins compared with fair-skinned populations, or it might reflect differences in accessing medical care by immigrant populations with eczema. Alternative explanations might include: more frequent skin infections misdiagnosed as eczema or causing exacerbations; or a more aggressive environment for the skin barrier, such as outdoor or indoor pollution, increased exposure to irritants such as cleansing products and

Table 3. Associations (odds ratio^a and 95% confidence interval) between age at immigration and symptoms of asthma, rhinoconjunctivitis and eczema, 13–14-year age group. Associations which are statistically significant at the 95% level are shown in bold

Symptom	Adjusted ^b (all adolescents)		Fully adjusted ^c (adolescents with complete covariate data)	
	>2–10 years of age	>10 years of age	>2–10 years of age	>10 years of age
Current wheeze	0.89 (0.81–0.98)	0.77 (0.65–0.90)	0.89 (0.77–1.02)	0.81 (0.64–1.01)
Current wheeze (video)	0.91 (0.79–1.05)	0.67 (0.54–0.83)	0.92 (0.77–1.11)	0.71 (0.52–0.96)
Current symptoms of severe asthma	1.01 (0.90–1.13)	0.92 (0.77–1.10)	0.94 (0.81–1.10)	0.98 (0.77–1.26)
Asthma ever	0.91 (0.84–0.99)	0.65 (0.57–0.76)	0.96 (0.85–1.08)	0.68 (0.55–0.83)
Current symptoms of rhinoconjunctivitis	1.03 (0.95–1.13)	0.72 (0.62–0.83)	0.99 (0.89–1.11)	0.76 (0.62–0.92)
Current symptoms of severe rhinoconjunctivitis	1.22 (0.98–1.52)	1.29 (0.90–1.87)	1.00 (0.71–1.40)	1.03 (0.56–1.90)
Hay fever ever	0.98 (0.90–1.07)	0.76 (0.66–0.89)	0.97 (0.85–1.10)	0.80 (0.64–1.00)
Current symptoms of eczema	1.01 (0.90–1.12)	0.95 (0.80–1.13)	0.98 (0.84–1.15)	0.86 (0.66–1.12)
Current symptoms of severe eczema	1.13 (0.91–1.40)	1.31 (0.94–1.81)	1.16 (0.87–1.55)	1.54 (1.00–2.36)
Eczema ever	0.87 (0.78–0.96)	0.69 (0.58–0.81)	0.85 (0.74–0.97)	0.69 (0.56–0.86)

^aReference category: age at immigration 2 years or less (includes participants born in current country).

^bAdjusted for region of the world, gender, language and GNI.

^cAdjusted for region of the world, gender, language, GNI, consumption of eggs, fruit, meat, milk, vegetables, nuts, pulses, seafood and potato, current paracetamol use, maternal education and current maternal cigarette smoking.

Table 4. Associations (odds ratio^a and 95% confidence interval) between age at immigration older than 2 years and symptoms of asthma, rhinoconjunctivitis and eczema, 6–7-year age group. Associations which are statistically significant at the 95% level are shown in bold

Symptom	Adjusted ^b (all children)	Fully adjusted ^c (children with complete covariate data)
Current wheeze	0.81 (0.72–0.91)	0.86 (0.74–1.00)
Current symptoms of severe asthma	0.80 (0.67–0.94)	0.84 (0.67–1.04)
Asthma ever	0.75 (0.66–0.85)	0.82 (0.71–0.96)
Current symptoms of rhinoconjunctivitis	0.93 (0.81–1.07)	0.94 (0.79–1.11)
Current symptoms of severe rhinoconjunctivitis	1.30 (0.84–2.02)	1.05 (0.57–1.95)
Hay fever ever	1.00 (0.88–1.15)	0.98 (0.83–1.16)
Current symptoms of eczema	0.72 (0.63–0.83)	0.79 (0.67–0.93)
Current symptoms of severe eczema	1.04 (0.73–1.49)	1.39 (0.93–2.09)
Eczema ever	0.53 (0.47–0.60)	0.55 (0.48–0.63)

^aReference category: age at immigration 2 years or less (includes participants born in current country).

^bAdjusted for region of the world, gender, language and GNI.

^cAdjusted for region of the world, gender, language, GNI, consumption of eggs, fruit, meat, milk, vegetables, nuts, pulses, seafood and potato, current paracetamol use, antibiotic use in the 1st year of life, maternal education and current maternal cigarette smoking.

sensitization to nickel from ear piercing, which may be higher in some ethnic groups.

Comparison with other studies

To the best of our knowledge, no previous study has offered data on the association between migration to non-affluent countries and the symptom prevalence of asthma, rhinoconjunctivitis and eczema. There are numerous studies in the literature indicating that the symptom prevalence of asthma, rhinoconjunctivitis and eczema is lower among individuals who were not born in the country where the study was carried out. The main body of evidence also suggests that the prevalence of those diseases among immigrants tends to match to that of the local population if enough time elapses. This was observed in adolescent migrants from China to Canada using the ISAAC methodology. In a Canadian study of Chinese-born Chinese, Canadian-born Chinese and Canadian-born non-Chinese, the prevalence of wheezing symptoms was lowest in Chinese-born and highest in Canadian-born non-Chinese adolescents.⁷ Similar findings were described in an Australian population of teenagers (13–19 years of age): when they had been born outside Australia their likelihood of suffering from wheezing was very low as compared with that of locals, but increased 2-fold after living 5–9 years in Australia, and even 3-fold after living there 7–10 years.⁸ In Albanian adults recruited in the European Respiratory Health Survey in Italy, the likelihood of sensitization increased 10-fold and for rhinitis 2-fold after a period of

7–10 years living in Italy, in spite of having a similar prevalence of asthma.¹⁰ Also in Italy, the SIDRIA-2 study, which is based on the ISAAC questionnaire and uses the same age groups, found that migrant children and adolescents to Italy had a higher prevalence of respiratory symptoms, including current wheeze, when migration took place more than 5 years previously, although it was still lower than children/adolescents born in Italy from Italian parents.¹¹ In an Israeli study¹² the prevalence of asthma at age 17 was 2-fold higher in Israel-born adolescents as compared with Ethiopian immigrants of the same age. Furthermore, the younger the immigrants were from Ethiopia who migrated to Israel, the higher their prevalence of asthma.

Although the environment of the Westernized lifestyle of the country of destination may explain part of this conversion, genetic predisposition of immigrants might modify the time needed to respond immunologically in the same way as the indigenous population. Furthermore, if immigrants are more predisposed than the indigenous population, the prevalence of these diseases among the former may even surpass that among the latter. For instance, children 5–13 years of age of Puerto Rican background (but for the most part born in the USA) in South Bronx (New York) had lower prevalence of asthma than children in San Juan and Caguas (Puerto Rico).¹³ The results from some other studies support this view.^{14,34,35} In line with this, several studies have shown that the country of origin may be important and that immigrants coming from Latin America are at higher risk of allergic diseases when moving to an industrialized European city.²³ Some authors assert that ethnicity and migration have significant and independent effects on asthma incidence.^{21,24}

Strengths and limitations of this study

The present study has several limitations. First, asthma, rhinoconjunctivitis and eczema symptoms are described by the adolescents themselves and by the parents of the children and there is no objective assessment. However, this is arguably the only way we could have obtained such a large sample from so many different parts of the world in a standardized way; and additionally, this large sample allowed us to exclude from the analyses, in order to reduce error, all children with missing values, which is particularly important when studying migrant populations. Second, the design was cross-sectional; however, given the nature of the immigration variable, reverse causation is most unlikely. Third, GNI is unlikely to be representative of a particular centre in a particular country. Fourth, and most importantly, we were not able to explore whether country of origin of immigrants (e.g. coming from tropical to cooler countries, or from low allergic disease prevalence to

high) was important in determining the risk of these conditions in the adopted country, as this was not recorded in the study.

Implications for health and further research

These data from ISAAC Phase Three show that being born in a country different to the adopted one is generally associated with a lower symptom prevalence of asthma, rhinoconjunctivitis and eczema. This association is present mainly for those migrating to affluent countries and seems greater in those with fewer years in the host country. Immigration to non-affluent countries does not appear to be associated with a change in the prevalence of those disease symptoms. Furthermore, for immigrants to show protection they have to move to a country with a high prevalence of those conditions. These findings underline the importance of environmental over genetic factors in determining the prevalence of asthma, rhinoconjunctivitis and eczema; and they further support the idea of a window of opportunity early in life when individuals are more susceptible to those factors.

Supplementary Data

Supplementary data are available at *IJE* online.

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