

Wheeze, allergic sensitization and geohelminth infection in Butajira, Ethiopia

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Summary

Background The effect of geohelminth infection on wheeze and allergen sensitization is inconsistent across different epidemiological studies.

Objective To investigate the association between self-reported wheeze, self-reported asthma, allergic sensitization and geohelminth infection in urban and rural areas of Butajira, southern Ethiopia.

Methods Questionnaire data on wheeze, asthma and a range of confounding variables was gathered in a cross-sectional study of 7649 people aged 5 years or more from the Butajira Rural Health Project database. Allergic skin sensitization to *Dermatophagoides pteronyssinus* and cockroach was measured, and a stool sample collected for qualitative and quantitative geohelminth analysis.

Results Wheeze was weakly associated with allergic sensitization to *D. pteronyssinus* and cockroach (odds ratios (OR) 1.21, 95% confidence interval (CI) 0.98–1.51, and 1.27, 95% CI 1.00–1.62, respectively). Self-reported asthma was related to sensitization to *D. pteronyssinus* only (OR 4.09, 95% CI 2.86–5.84). Geohelminths were present in 33.8% of participants, and the median egg load in infested individuals was 6 eggs/g. Overall, presence of any geohelminths was associated with a diminished risk of cockroach sensitization (adjusted OR 0.82, 95% CI 0.68–0.99) but there were no significant protective effects of any geohelminth infection against wheeze or asthma.

Conclusion In a developing country community with relatively low geohelminth prevalence and intensity, we found weak association between allergic sensitization and wheeze, but no evidence of a protective effect of geohelminths against wheeze or asthma.

Keywords asthma, *Dermatophagoides pteronyssinus*, dust mite, Ethiopia, geohelminths, hookworm, sensitization, wheeze

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Introduction

The hypothesis that geohelminth infections may protect against asthma and related allergic conditions, first proposed in the 1970s, has recently attracted more attention. Several studies in tropical developing countries have provided evidence of a reduced prevalence of allergic skin sensitization in the presence of infection with schistosomes or helminths [1–5], which may be reversed by anti-helminth therapy [6]. Asthma has been found to be less common in children infected with pinworm [7], and less severe in those infected with *Schistosoma* [8], but in a study among adults from the Gambia, there was no clear association with helminth infection [1]. Increased risks of childhood asthma and allergic sensitization have been reported in association with *Ascaris* infection in a study from China [9]. Our own data from epidemiological studies in Jimma in Ethiopia have provided evidence of a complex relation between geohelminths and asthma. We have shown a strong and intensity-related reduction in the risk of wheeze with geohelminth infection in independent studies of adults [10] and young children [11].

In addition, we found dissociation of sensitization to *Dermatophagoides pteronyssinus* from an increased risk of wheeze in the presence of high intensity geohelminth infection [10]. There was no clear relation between allergic sensitization and geohelminth infection in our studies [10, 11].

In view of the emergence of asthma as a public health problem in Africa and the inconsistencies in the epidemiological data, it is important to explore the role of geohelminth infections in the aetiology of asthma and allergy in independent populations with varying levels of geohelminth exposure. We now report a new cross-sectional survey of children and adults from urban and rural areas of Butajira, southern Ethiopia with the specific aims of determining the urban–rural difference in prevalence of wheeze, asthma and allergic sensitization, the association between allergic sensitization and wheeze in urban and rural areas, and the effect of geohelminth infection on the above.

Materials and methods

Study population

The Butajira Rural Health Project is a dynamic cohort with an established data collection system covering over 40 000 people living in 10 administrative areas of Meskan and

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Mareko district, 130 km south west of Addis Ababa in Ethiopia. The source population of Meskan and Mareko district is approximately 250 000. The district is divided into 82 Rural Peasants' Associations and four Urban Dwellers' Associations. At inception in 1987, a stratified random sample of these administrative areas was made such that nine Peasants' Associations and one Urban Dwellers' Association were selected with probability proportionate to size. Since inception, data on birth, death, marriage and in- and outmigration have been collected regularly from each household in the selected areas [12]. Approximately 15% of the cohort lives in Butajira town, the district capital, which has a hospital, health centre, secondary school, post office and hydroelectricity supply, and is connected to Addis Ababa by an all-weather road. The other participants live in villages served by unmade roads, and are predominantly agriculturalists growing coffee, pepper, the stimulant *khat* and the cereal *teff* [12].

Design and procedures

At the outset of the study, we estimated that data from 4300 urban and 4300 rural participants would provide in excess of 90% power to detect an absolute difference in the prevalence of wheeze between urban and rural areas of 2.5%. We also calculated that this sample size would estimate rural and urban odds ratios (ORs) for wheeze in relation to allergen sensitization of 2 and 6, respectively, with sufficient precision to detect a difference between them at 5% significance.

In the urban area, we initially took a sample of 4300 individuals aged 5 years and over living in the single Urban Dwellers' Association, randomly selected from the Butajira Rural Health Project database. Soon after the fieldwork started it became apparent that significant migration had occurred to and from the town since the most recent database update, as the result of local drought. Fieldworkers were therefore instructed to substitute selected individuals who had left the town with someone of the same gender and age within 5 years living in the same or adjacent household. To select rural residents from each Peasants' Association with probability proportionate to the size of Peasants' Association, we took a systematic one in seven sample of those aged 5 years and above from a random start point in the Butajira Rural Health Project database, which is ordered by administrative area. A total of 4591 rural residents were selected in this way, and as the census list was much more reliable here, no additional sampling or substitution procedures were necessary.

We trained 50 data collectors and 10 supervisors to take written consent, administer the questionnaire, measure allergen skin sensitivity to *D. pteronyssinus* and cockroach (Biodiagnostics, Upton-upon-Severn, UK) and collect a stool sample in 10% formalin. The questionnaire was adapted from that used in our earlier studies in Jimma [10, 13]. Respiratory questions were derived from the International Union Against Tuberculosis and Lung Disease questionnaire [14] and questions were also included on occupation, level of education, income, ethnic group, duration of breastfeeding, birth order, family size, construction of the home, site of cooking, ownership of consumer goods, bedding materials, domestic fuel use, animals kept in the home, insecticide use, sanitation, active and passive smoking, parental smoking,

paracetamol consumption and vaccination history. Each question was read to the study subject in Amharic by the data collector, who recorded responses in pre-coded categories on the questionnaire. A parent or adult care-taker was asked to answer on behalf of children aged 12 years or under. Faecal samples were each analyzed by two laboratory technicians for geohelminth eggs qualitatively and quantitatively, using an adapted formalin-ether sedimentation test [15]. Field and laboratory work was conducted between February and June 2003. Approval for the study was granted by ethics committees in Addis Ababa and Nottingham.

Statistical analysis

Data were entered into EPI-Info (version 6) and exported into SPSS (version 11) for analysis. The primary outcome variables were self-reported wheeze in the past year (Have you had wheezing or whistling in your chest at any time in the last year?), self-reported asthma ever (Have you ever had asthma?), sensitization to *D. pteronyssinus* and sensitization to cockroach. A positive skin test was defined as an average of two perpendicular weal diameters of at least 3 mm greater than the saline control response. Binary variables representing the presence or absence of any geohelminth and of individual geohelminths in faecal samples were computed, and within the positive samples, the distributions of eggs per gram were examined and tertiles computed. Egg counts for all geohelminths were summed to give a measure of total geohelminth load. Univariate associations were assessed using the χ^2 test, and logistic regression was used to determine the independent effect of geohelminth infection on each outcome controlling for age, gender, urban-rural residence, educational status (of the father if the respondent was 12 years or less) and smoking status. The impact of further controlling for the other variables collected was also explored. If there was evidence that an effect differed significantly between the urban and rural areas, assessed by fitting an interaction term to the model, ORs were computed separately for the two areas.

Results

General demographics

Questionnaire and skin test data were obtained from 7649 individuals, comprising 3485 urban residents and 4164 rural residents. The median duration of residence in the same area for urban and rural participants was 12 and 20 years, respectively. The response rate was 81% in Butajira town (62% prior to substitutions) and 91% in the rural area. Very few (<3%) actual refusals were encountered in those approached. Table 1 summarizes the distributions of basic socio-demographic characteristics of urban and rural respondents and Table 2 the distribution of potential confounders by area of residence. The age and sex of the 3485 urban respondents was compared with the original urban population from which the sample was drawn, and there was seen to be a slight under-representation of men (40.7% compared with 46.9% male in the original population), and a younger

Table 1. Distribution of socio-demographic characteristics of urban and rural respondents

Variable		Urban N (%)	Rural N (%)
Gender	Male	3485	4164
	Female	1420 (40.7)	1832 (44.0)
Age group	5–9	682 (19.6)	476 (11.4)
	10–19	1348 (38.7)	1297 (31.1)
	20–29	556 (16.0)	697 (16.7)
	30–39	371 (10.6)	650 (15.6)
	40–49	224 (6.4)	435 (10.4)
	50–59	118 (3.4)	273 (6.6)
	60–69	102 (2.9)	223 (5.4)
	70+	84 (2.4)	113 (2.7)
	Median (range)	17 (5 to 90)	24 (5 to 95)
	Ever-smokers		
Ever-smokers	Yes	120 (3.4)	120 (2.9)
	No	3365 (96.6)	4044 (97.1)
Educational status	Cannot read/write	889 (25.5)	2556 (61.4)
	Can only read/write	509 (14.6)	618 (14.8)
	Grade 1–6	924 (26.5)	833 (20.0)
	Grade 7–12	979 (28.1)	155 (3.7)
	Higher	184 (5.3)	2 (<0.1)

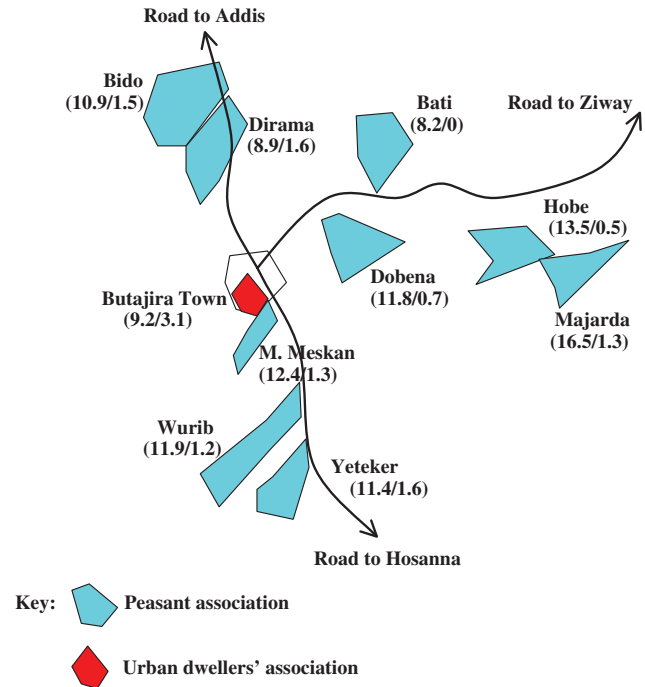
median age (20 years compared with 22 years in the original population).

Wheeze and asthma

Wheeze in the past year was reported by 802 participants (10.5%), and was more common in males than females (12.9% vs. 8.7%, $P < 0.001$), and more common in rural than urban areas (11.5% vs. 9.2%, $P = 0.001$). Asthma ever was reported by 146 participants (2.0% of responders to this question; 304 people did not answer this question), of whom 109 (75%) reported an attack in the past year. Asthma was more common in urban than rural residents (3.1% vs. 1.1%, $P < 0.001$), but with little difference between males and females (2.2% and 1.9%, respectively, $P = 0.33$). The spatial distributions of reported asthma and wheeze by administrative area differed significantly ($P < 0.001$ for both) and are shown in Fig. 1. Median age at self-reported onset of asthma was 22.0 years (interquartile range 15–34 years), and in 65% of individuals occurred after the age of 16 years. The median duration of time since onset of asthma symptoms was 8 years (interquartile range 3–15 years). The prevalence of both wheeze and asthma increased significantly with age (P for trend < 0.001 , Figs 2a and b). The OR for wheeze in the urban group compared to the rural group, adjusted for age and sex, was 0.89 (95% confidence interval (CI) 0.76–1.03), while that for asthma was 3.62 (95% CI 2.52–5.20). Wheeze and asthma were more common among smokers, but adjustment for smoking did not materially alter the ORs for area of residence (0.87 and 3.61, respectively).

Allergic sensitization

Skin sensitization to *D. pteronyssinus* was present in 10.8% of participants (11.1% urban vs. 10.5% rural, $P = 0.35$), and to cockroach in 8.2% (8.1% urban vs. 8.3% rural, $P = 0.77$). The distributions by administrative area differed for



Name of PA/UDA (wheeze prevalence/asthma prevalence)

Fig. 1. Spatial distribution of wheeze and asthma across study area.

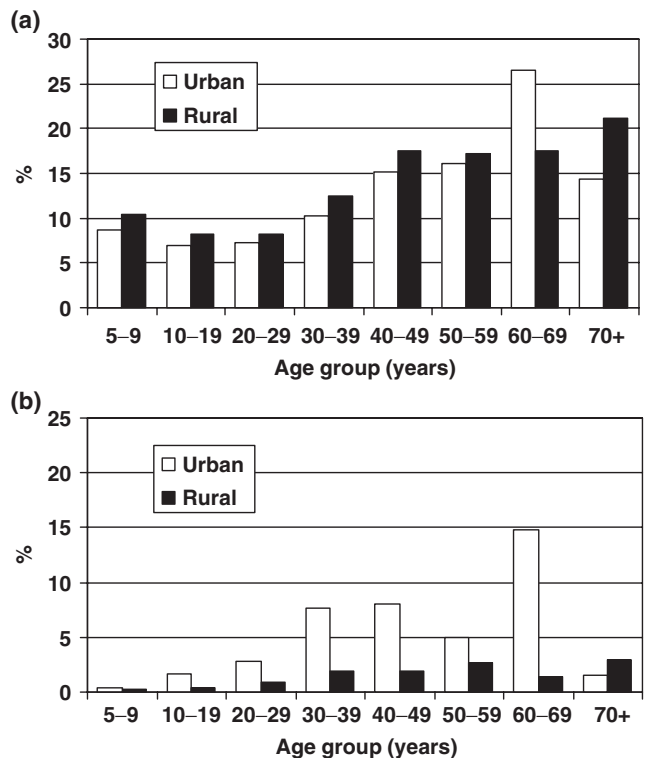


Fig. 2. (a) Prevalence of self-reported wheeze by age group and urban/rural residence. (b) Prevalence of self-reported asthma by age group and urban/rural residence.

D. pteronyssinus but not cockroach ($P = 0.03$ and 0.25, respectively) and are shown in Fig. 3. Sensitization was more prevalent among males than females (12.5% vs. 9.5% for

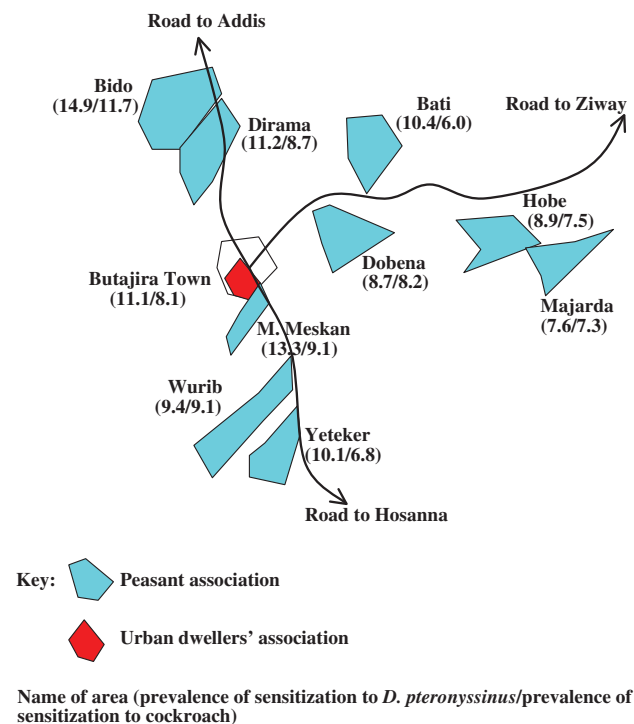


Fig. 3. Spatial distribution of allergic sensitization across study area.

D. pteronyssinus, $P < 0.001$; and 9.6% vs. 7.2% for cockroach, $P < 0.001$). Sensitization to both allergens was strongly associated with increasing age (P for trend across age groups < 0.001). After adjustment for age and sex, urban residents appeared more likely to be sensitized to *D. pteronyssinus* (OR 1.23, 95% CI 1.06–1.43), while there remained no significant difference between urban and rural residents in terms of sensitization to cockroach (OR 1.06, 95% CI 0.90–1.26). Further control for smoking did not alter these results.

Relation between wheeze, asthma and allergic sensitization

Wheeze was significantly associated with *D. pteronyssinus* sensitization in the urban area (OR adjusted for age, sex and smoking status 1.60, 95% CI 1.17–2.18), but not in the rural area, and this interaction was significant ($P = 0.02$; Table 3). Adjustment for other potential confounders (listed on page 6) made little difference to these results. Asthma was strongly associated with *D. pteronyssinus* sensitization in urban and rural areas (adjusted ORs 4.93, 95% CI 3.22–7.54 and 2.62, 95% CI 1.34–5.13, respectively, Table 3). Those sensitized to cockroach had an increased risk of wheeze, which reached borderline significance (adjusted OR = 1.27 (1.00–1.62)), but not of asthma (Table 3).

Geohelminths

Samples for qualitative and quantitative geohelminth estimation were available from 90.2% (6902) of participants. One or more geohelminths were present in 2332 (33.8%) overall; *Ascaris* in 16.6%; hookworm in 14.7%; *Trichuris trichura* in 2.5%; *Hymenolepis nana* in 2.2%; *Taenia* spp. in 1.3%;

Table 2. Distribution of potential confounders, by area of residence

Variable		Urban N (%)	Rural N (%)
Monthly income*		3485	4164
	≤ 50 Birr/month	2264 (65.0)	3174 (76.2)
	> 50 Birr/month	1221 (35.0)	990 (23.8)
Duration of breastfeeding			
	≤ 1 year	366 (10.5)	186 (4.5)
	> 1 year	3119 (89.0)	3978 (95.5)
Birth order			
	Firstborn	537 (15.4)	635 (15.2)
	Not firstborn	2948 (84.6)	3529 (84.8)
Type of roof			
	Corrugated iron	3377 (96.9)	434 (10.4)
	Thatch	108 (3.1)	3730 (89.6)
Site of cooking			
	Inside	801 (23.0)	3756 (90.2)
	Outside	2684 (77.0)	408 (9.8)
Consumer goods			
	Yes	2641 (75.8)	1497 (36.0)
	No	843 (24.2)	2667 (64.0)
Use of mattress			
	Yes	3340 (95.8)	4069 (97.7)
	No	145 (4.2)	95 (2.3)
Use of kerosene indoors			
	Yes	3037 (87.1)	4121 (99.0)
	No	448 (12.9)	43 (1.0)
Animals kept inside			
	Yes	2006 (57.6)	3949 (94.8)
	No	1479 (42.4)	215 (5.2)
Insecticide used inside			
	Yes	3365 (96.6)	4148 (99.6)
	No	120 (3.4)	16 (0.4)
Water source			
	Piped	3358 (96.4)	1371 (32.9)
	Not piped	127 (3.6)	2793 (67.1)
Paracetamol use last month			
	Yes	1440 (41.3)	1776 (42.7)
	No	2045 (58.7)	2388 (57.3)
Ever vaccinated			
	Yes	2693 (77.3)	2575 (61.8)
	No	792 (22.7)	1589 (38.2)

*Of father for respondents aged 12 years or less.

Strongyloides stercoralis in 0.8%; and *Entrobis vermicularis* in 0.3%. Geohelminths present in less than 5% of participants were not considered individually for further analysis. The median total egg load in infested individuals was 6 eggs/g (range 1–315), and was similar in the urban area (7 eggs/g, 1–253) and the rural area (5 eggs/g, 1–315). *Ascaris* was more common in women than men (OR 1.18, 95% CI 1.04–1.35) and more common in urban than rural residents (OR 2.91, 95% CI 2.54–3.33), whereas hookworm was found more in men (OR 1.34, 95% CI 1.18–1.54) and rural residents (OR 5.08, 95% CI 4.29–6.02). *Ascaris* prevalence and intensity of infection were inversely related to age (P for trend < 0.001), whereas hookworm prevalence was positively related to age (P for trend < 0.001).

Geohelminths, wheeze, asthma and allergic sensitization

Although the effects of geohelminths on wheeze and asthma were generally protective, none of these associations reached statistical significance (Table 4). Presence of any geohelminth was associated with a significantly diminished risk of cockroach sensitization overall (OR adjusted for age, sex, smoking, educational status and residence 0.82, 95% CI 0.68–0.99) and in the rural population (OR 0.75, 95% CI 0.58–0.97) (Table 4). Control for other potential confounders made little difference to these results. The effect of hookworm on cockroach sensitization was of similar magnitude to that of any geohelminth, reaching statistical significance in the rural area only (0.74, 95% CI 0.55–0.99, respectively), whereas that

Table 3. ORs for wheeze and asthma in relation to skin sensitivity to *D. pteronyssinus* and cockroach, by residence

Allergen	Total		Urban		Rural	
	OR* (95% CI)	P-value	OR† (95% CI)	P-value	OR† (95% CI)	P-value
Wheeze in the past year (n = 7649)						
Dustmite‡	1.21 (0.98–1.51)	0.08	1.60 (1.17–2.18)	0.003	0.96 (0.71–1.31)	0.81
Cockroach	1.27 (1.00–1.62)	0.05	1.16 (0.79–1.71)	0.45	1.36 (0.99–1.86)	0.06
Asthma ever (n = 7345)						
Dustmite	4.09 (2.86–5.84)	<0.001	4.93 (3.22–7.54)	<0.001	2.62 (1.34–5.13)	0.005
Cockroach§	0.75 (0.40–1.41)	0.37	0.37 (0.13–1.02)	0.06	1.82 (0.80–4.15)	0.15

*Adjusted for age, sex and smoking status and urban–rural residence. †Adjusted for age, sex, and smoking status. ‡Interaction with area of residence, $P = 0.02$.

§Interaction with area of residence, $P = 0.01$.

Dustmite, *Dermatophagoides pteronyssinus*; OR, odds ratio; CI, confidence interval.

Table 4. ORs for wheeze, asthma and sensitization for different geohelminths, by residence

Outcome	Geohelminth	Total	Urban	Rural
		OR* (95% CI)	OR† (95% CI)	OR† (95% CI)
Wheeze in past year (n = 6900)	Any	0.98 (0.83–1.15)	0.85 (0.65–1.11)	1.07 (0.86–1.33)
	Hookworm	0.92 (0.73–1.14)	0.61 (0.33–1.15)	0.98 (0.77–1.25)
	<i>Ascaris</i>	1.00 (0.80–1.25)	0.88 (0.65–1.18)	1.21 (0.87–1.68)
Asthma ever (n = 6613)	Any	0.77 (0.52–1.15)	0.84 (0.52–1.36)	0.64 (0.31–1.31)
	Hookworm	0.89 (0.48–1.63)	1.52 (0.64–3.59)	0.61 (0.27–1.39)
	<i>Ascaris</i>	0.86 (0.52–1.41)	0.97 (0.58–1.64)	0.29 (0.04–2.16)
Dustmite sensitization (n = 6900)	Any	1.08 (0.91–1.27)	1.08 (0.85–1.37)	1.09 (0.87–1.36)
	Hookworm‡	1.03 (0.83–1.29)	0.59 (0.32–1.07)	1.17 (0.92–1.49)
	<i>Ascaris</i>	1.19 (0.97–1.47)	1.19 (0.92–1.55)	1.21 (0.85–1.70)
Cockroach sensitization (n = 6900)	Any	0.82 (0.68–0.99)	0.94 (0.71–1.24)	0.75 (0.58–0.97)
	Hookworm	0.79 (0.61–1.03)	1.13 (0.66–1.93)	0.74 (0.55–0.99)
	<i>Ascaris</i>	0.92 (0.72–1.18)	0.97 (0.71–1.32)	0.88 (0.58–1.34)

*ORs adjusted for age, sex, smoking status, educational achievement and urban/rural residence. †ORs adjusted for age, sex, smoking status and educational achievement. ‡interaction with area of residence, $P = 0.02$.

Dustmite, *Dermatophagoides pteronyssinus*; OR, odds ratio; CI, confidence interval.

of *Ascaris* was closer to unity. There was no significant association between geohelminths and dustmite sensitization, and we found no clear evidence of any intensity-related effects.

Discussion

In this large cross-sectional study, we found wheeze prevalence was not increased in relation to urban residence and was only weakly associated with skin sensitization, whereas asthma was more prevalent in urban areas and positively related to sensitization. We found no significant protective effects of geohelminths against self-reported asthma or wheeze, but did identify a weak protective effect of geohelminths on cockroach sensitization. The study was carried out primarily to determine whether the main findings of our previous studies in Jimma in southwest Ethiopia [10, 11] could be replicated independently in a different Ethiopian population. We chose to study Butajira because the Butajira Rural Health Project and associated infrastructure was already established there. No such infrastructure existed in Jimma. Butajira is however a much smaller town than Jimma, the respective populations at the time of our studies being approximately 25 000 and 80 000, respectively, and is much closer and more

accessible to the Ethiopian capital city, Addis Ababa (3 h by road compared to 8 h for Jimma). Butajira is located in a drier region of Ethiopia, and the majority ethnic group is different to that in Jimma. The rural populations included in the Butajira Rural Health Project are also predominantly much closer to the urban area than was the case in our Jimma studies, and in particular, access to clean water supplies was much more common throughout the study population in Butajira than in Jimma. Although 98% of rural people were born in a rural area and 65% had not lived elsewhere, only 65% of urban residents had been born there and 35% had not lived elsewhere, suggesting the urban population to be more mixed in respect of urban or rural origins. In general, the urban–rural difference in lifestyle was less marked in Butajira than in Jimma.

The prevalence and intensity of geohelminth infection were much lower in the Butajira than in the Jimma populations (prevalences 33.8% vs. 77.3%, respectively; median number of geohelminth eggs per gram among infected individuals 6 (interquartile range 4–11), compared with 62 (interquartile range 18–191), respectively), and differences in humidity, soil type and vegetation may account for this [16].

Our finding that wheeze was more common in the rural areas was unexpected in the light of our previous work [11, 13], and of many other studies, predominantly in children, from

other African countries [17–22]. However the extent of these differences may be influenced by the relatively small contrasts between urban and rural lifestyles in Butajira, since one study in childhood found a relatively similar prevalence of exercise-induced bronchoconstriction in rural and poor urban populations [23]. One other African study, to our knowledge, also found relatively little difference in the prevalence of wheeze in urban and rural populations, though the overall prevalence figures were lower than in our study [24]. We explored the possibility that our 806 urban substitutes differed from those 2679 arising from the original urban sample. Substitutes were slightly less likely to have lived in Butajira for at least 3 years (90.4% compared with 96.5% of non-substitutes, and reported slightly less wheeze (8.4% compared with 9.5% of non-substitutes), but the urban–rural difference in wheeze prevalence persisted following exclusion of these substitutes (9.5% in urban vs. 11.5% in rural, $P = 0.008$). Prevalence of the other main outcome variables showed no statistically significant difference between the substituted and original subjects.

Whilst the contrast in lifestyle between the urban and rural populations was less marked in Butajira than Jimma, the general level of urbanization here was not high and therefore does not account for the overall high prevalence of wheeze. Although we asked the same question on wheeze as that in the Jimma study, by relying on reported symptoms it is possible that we have included some subjects with a different disease entity (for example infection-related wheeze, or COPD, rather than allergic wheeze). The age-related increase in prevalence of self-reported wheeze might be explained by increasing severity of symptoms in seasonal viral-related wheeze in older respondents. The prevalence of chronic phlegm production (on most days of 3 months per year) also increases with age (results not presented, P for trend across age groups <0.001), so this may partially explain wheeze symptoms. Excluding children under 15 years of age (among whom wheeze is more likely to be infection-related) did not materially alter the urban–rural difference (prevalence 9.9% and 12.2%, respectively, $P = 0.009$). Validation of symptoms using spirometry and methacholine challenge in a future study would therefore be valuable.

In contrast to our findings on wheeze, the prevalences of self-reported asthma in urban and rural areas (3.1% and 1.1%, respectively) were very similar to those found in Jimma (3.6% and 1.3%). The urban–rural difference is likely to be explained at least partly by labelling or ascertainment bias arising from differences in access to health care facilities. Again, some form of objective validation such as reactivity or peak flow variability would establish whether the ‘asthma’ reported is indeed asthma.

The association between dust mite sensitization and wheeze was stronger in the urban area, but still relatively weak in comparison with studies from the developed world. This finding is consistent with previous work in developing countries [1, 25–29], and supports the hypothesis that allergic sensitization in the context of life in a developing country environment is relatively dissociated from the risk of allergic disease, although the explanation for this phenomenon remains unknown.

We have previously reported protection against wheeze by current infection with helminth parasites [10, 11], particularly

the systemic parasites *Ascaris* and hookworm [10]. This hypothesis attracted substantial attention in the 1970s and 1980s [30], and several other epidemiological studies have recently added further evidence in favour of protection against either allergic sensitization, asthma, or both [1–5, 7, 8], although not all of the available evidence is directly supportive of this hypothesis [9, 31]. This study failed to provide strong evidence that geohelminth infection is associated with a reduced risk of allergic disease. Although the direction of effect of geohelminths on wheeze and asthma was broadly protective, none of the associations reached statistical significance. The prevalence and intensity of geohelminth infection was relatively low in this study population in comparison with the Jimma studies, which may account for the fact that we found no intensity-related effects. We found evidence of a protective effect of geohelminth infection on cockroach sensitization, but not *D. pteronyssinus* sensitization. Evidence from other studies is still conflicting as to whether geohelminths protect against allergen skin sensitization, and whether this is a highly geohelminth-specific effect or a more general effect [2].

In conclusion, in this study we have been unable to replicate the protective effects of geohelminths on asthma and wheeze that were demonstrated in earlier studies. This may be accounted for by the low prevalence and intensity of geohelminth infection in the Butajira area. However, there are points that are consistent with our previous study in Jimma. In particular, we confirmed relatively weak associations between allergic sensitization and wheeze in the present study, and no clear association between *D. pteronyssinus* sensitization and geohelminth infection. These findings clearly merit further investigation.

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