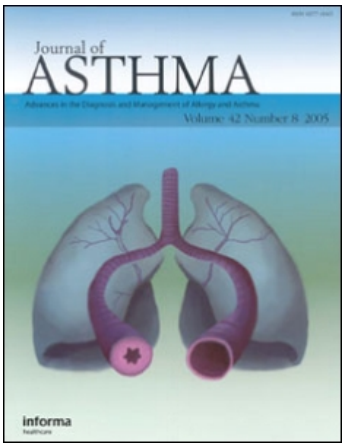
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Household Conditions, Eczema Symptoms and Rhinitis Symptoms: Relationship with Wheeze and Severe Wheeze in Adolescents Living in the Polokwane Area, South Africa

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ORIGINAL ARTICLE

Household Conditions, Eczema Symptoms and Rhinitis Symptoms: Relationship with Wheeze and Severe Wheeze in Adolescents Living in the Polokwane Area, South Africa

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Objective. Determine the prevalence and risk factors of wheeze and severe wheeze in 13- to 14-year-old children. *Methods.* The study was conducted August 2004 to February 2005 in the Polokwane area, South Africa. *Results.* The 12-month prevalence rate was 18.9% for wheeze and 9.2% for severe wheeze ($n = 3{,}926$). The presence of other allergic symptoms and industrial activities appear to increase the likelihood of wheeze, even more so for severe wheeze. Socioeconomic-related factors appear to have a protective effect on wheeze. *Conclusions.* Wheeze appears to be a substantial public health problem in the Polokwane area.

Keywords wheeze, children, risk factors, South Africa, International Study of Asthma and Allergies in Childhood

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INTRODUCTION

Asthma is the most common chronic disease among children globally. Recent global time trends indicate that the 12-month prevalence rates for wheeze among 6- and 7- year-old and between 13- and 14-year-old children have increased, decreased, and changed little in 42, 40, and 24 of the 106 centers, respectively, that participated in the International Study on Asthma and Allergies in Childhood (ISAAC) Phase I and III studies (1–3). Six African countries participated in Phase I (Algeria, Ethiopia, Kenya, Morocco, South Africa, and Tunisia). The majority of the centers involved in Phase I also participated in Phase III, along with new centers (1, 4). The prevalence of asthma symptoms increased in five of the African countries that participated in both Phases I and III, except Ethiopia (1).

Apart from the increase in asthma prevalence in many developing nations, the Global Burden of Asthma Report also stated that over 80% of asthma deaths occur in low– and lower–middle-income countries (5). The prevalence rate of asthma is higher in the Southern African Development Community than in many other regions of Africa (5). South Africa ranks 25th globally in terms of asthma prevalence and has the world's fifth highest number of asthma deaths among 5- to 34-year olds (5). Asthma is the third most common cause of hospital admission in children in South Africa, after pneumonia and gastroenteritis (6–8), with the number of admissions to hospital for asthma having increased markedly over the last few decades (6–8).

Medication is not the only way to control asthma. Understanding the global variation in asthma prevalence is important both for local health-care endeavors and for gaining insight into the epidemiology of asthma. The changes in asthma prevalence are likely to be a consequence of environmental factors that influence the risk in genetically susceptible individuals through gene-environment interactions (9, 10). Most asthma deaths in South Africa occur at home, during winter, and over weekends (8). For this reason the association between asthma and household conditions is an important one to investigate. Allergic rhinitis and eczema are also important risk factors for asthma development and exacerbation (11). One efficient way to prevent asthma development is to control and treat allergic rhinitis and eczema from their inception.

ISAAC Phase I and III studies were conducted in South Africa during 1995 and 2002 in the urban setting of Cape Town (12, 13). Both studies focused on 13- to 14-year-old children and did not investigate the association between potential risk factors and asthma symptoms.

This is the second study that has applied the ISAAC Phase III methodology in South Africa. It is, to the best of our knowledge, the first study that was conducted in an urban and rural setting in the northern part of the country. The aims of this study were (1) to compile information on the prevalence of and potential risk factors for wheezing in preceding 12 months (hereafter, "wheeze") and severe wheeze for 13- to 14-year-old children in the Polokwane area; (2) to compare results with other regions where ISAAC studies have been conducted; and (3) to contribute to the current body of knowledge regarding the prevalence of and potential risk factors for eczema in adolescents, specifically in the context of a developing country.

METHODS AND PROCEDURES

Study Location

This study was part of a bigger project that investigated the baseline prevalence rates of allergic diseases among children in the vicinity of a platinum smelter. The smelter is located 60 km from the Polokwane city center and several

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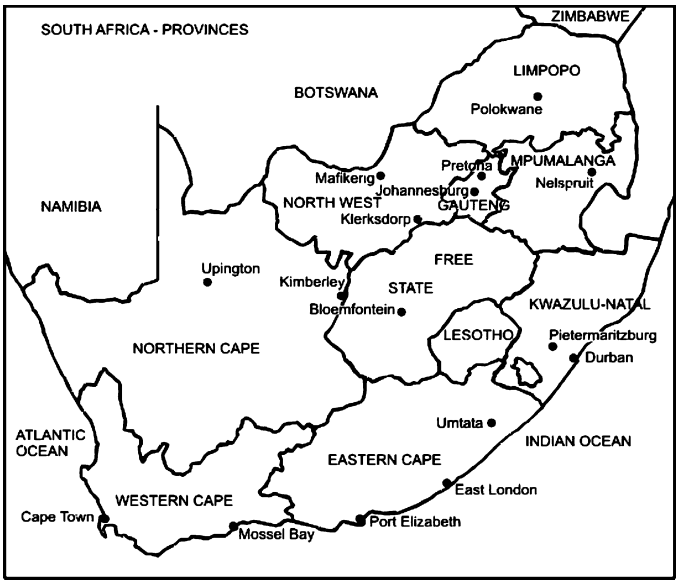


FIGURE 1.—Location of Polokwane and Cape Town in South Africa.

mining-related industries are found in the vicinity. This study was extended to include all areas within a 60-km radius of the city center.

Polokwane is the capital city of Limpopo Province, the northern-most province of South Africa (Figure 1). The population of the Polokwane municipality was 483,000 in 2001, of whom the majority (73%) lived in rural areas on the periphery of the municipality (14, 15). Limpopo is the second poorest province in the country (14), with an estimated 11% of the adult population having no formal education (15). The Polokwane municipality is developing at a rapid pace, and the mining industry has boomed over the last decade. The municipality is therefore faced with environmental concerns and risks that are typical of those experienced by industrialized cities and many developing countries.

Polokwane is 1,736 km northeast of Cape Town (Figure 1), the location of previous South African studies that have applied the ISAAC methodology. While Cape Town is in a winter rainfall area with a fynbos biome, Polokwane is located in a summer rainfall area with a bushveld biome. Fynbos is a unique vegetation type found in a small belt of the Western Cape of South Africa. The Fynbos biome is dominated by woody or herbaceous shrubs. The name fynbos is Afrikaans for fine bush and referes to the fine, needle-like leaves of many fynbos species. The majority of the plants are evergreen hard-leaf plants. Three of the characteristic fynbos plant families are proteas, ericas and restios. The Bushveld is a tropical savanna vegetation type, with grassed plains that are interpersed with dense clusters of tall shrubs, Acacia and/or Baobab trees. The grasses are generally tall and turn yellow or brown in winter. Whereas Cape Town is at sea level and has an average summer temperature of 26°C (78.8 deg F), Polokwane is situated 1,300 m above sea level, with an average summer temperature of 27°C (80.6 deg F).

Sampling and Procedures

The study had a cross-sectional design and followed the ISAAC Phase III methodology (16). Owing to the size of the area covered in the study, it was conducted during August 2004 (winter), October 2004 (spring), and February 2005 (summer). The questionnaire was designed to assess the prevalence of asthma symptoms, eczema symptoms, and rhinoconjunctivitis symptoms as well as to assess potential risk factors for these symptoms.

The questionnaire was translated into North-Sotho, which is the primary local language spoken by the communities in the study area. A different translator translated the questionnaire back to English to ensure consistency with the original. The questionnaire was also made available in English and Afrikaans, which are the other two languages spoken in the area. The Afrikaans version was already available from the first Cape Town ISAAC study (12).

A list of 163 secondary and combined schools was provided by the Limpopo Province Department of Education. Eighty-five secondary and combined schools were randomly selected from this list and eventually 76 secondary and combined schools participated in the study. Schools were contacted by telephone or fax to obtain permission for visits. Where necessary, at least three attempts were made to obtain such permission. Reasons for non-inclusion of a school were as follows: (1) Permission was not received before the start of fieldwork; (2) roads were inaccessible at the time of the fieldwork; (3) the inability to locate schools because of the remoteness of their location; (4) administrative problems; (5) a school having closed down; and/or (6) lack of cooperation from a school.

Informed consent forms were distributed in all the grade 7 and grade 8 classes of the 76 schools. Children who returned signed parental consent forms were requested to complete the questionnaires at the school. Children in grades 7 and 8 are usually 13 to 14 years of age—the target population of this study.

Twelve postgraduate students from the community were selected as field workers and attended a 1-day training session on how to conduct the study. One of the researchers accompanied each of the 6 fieldwork teams on at least 1 day during the survey to ensure adherence to the protocol.

Approval was granted by the University of Pretoria Ethics Committee and the Ministry of Education, Limpopo Province. The consent forms were sent to the parents. The data collectors were instructed to keep all information confidential. Anonymity was maintained and the names of the respondents were not recorded.

Definitions of Health Outcomes and Household Living Conditions

Wheeze in the previous 12 months was defined by a positive answer to the written question: "Have you had wheezing or whistling in the chest in the past 12 months?"

Severe wheeze was evaluated by considering the following: (1) four or more attacks in the last 12 months; (2) speech disturbance in the last 12 months; (3) more than one night of sleep disturbance in the last 12 months; and (4) wheezing with exercise in the last 12 months.

Severe wheeze was considered in those with wheeze who gave at least two of the above-mentioned responses. The questions were (1) "How many attacks of wheezing have you had in the past 12 months?"; (2) "In the past 12 months, has

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wheezing ever been severe enough to limit your speech to only one or two words at a time between breaths?"; (3) "In the past 12 months, how often, on average, has your sleep been disturbed due to wheezing?"; (4) "In the past 12 months, has your chest ever sounded wheezy during or after exercise?"

Eczema symptoms were defined by affirmative answers to these three questions: (1) "Did you ever have an itchy rash that was coming and going for at least 6 months?"; (2) "Did you have this itchy rash at any time in the last 12 months?"; (3) "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?"

Rhinoconjunctivitis symptoms were defined by affirmative answers to the three questions: (1) "Have you ever had a problem with sneezing or a runny or blocked nose, when you did not have a cold or the flu?"; (2) "In the past 12 months, have you had a problem with sneezing or a runny or blocked nose when you did not have a cold or the flu?"; (3) "In the past 12 months, has this nose problem been accompanied by itchy watery eyes?"

TABLE 1.—Demographic characteristics and household conditions of the study participants (n = 3,926).

Variable	Total	Percentage
Sex of child		
Male	1,641	41.8
Female	2,278	58.0
Not stated	7	0.2
Language		
Afrikaans	384	9.8
English	1,163	29.6
North-Sotho	2,379	60.6
Type of area*		
Urban	1,920	48.9
Rural	2,006	51.1
Lived close to the smelter**		
Yes	1,809	46.1
No	2,117	53.9
Smelter area type***		
Far from smelter and rural	1,711	43.6
Far from smelter and urban	406	10.3
Close to smelter and rural	295	7.5
Close to smelter and urban	1,514	38.6
Time period lived in current suburb/village		
<3 years	849	21.6
≥3 years	2,938	74.8
Other response	139	3.5
Travel time to nearest clinic or hospital from home		
15 min walk or 5 min drive	1,891	48.2
1 hour walk or 15 min drive	1,295	33.0
>1 hour walk or > 30 min drive	601	15.3
Other response	139	3.5
Type of house§		
Informal	701	17.9
Formal	3,225	82.1
Cooking fuel type§§		
Clean	1,954	49.8
Combination of clean and polluting	1,972	50.2
Having running water in house		
Yes	1,644	41.9
No	2,187	55.7
Other response	95	2.4
ETS exposure at home		
Yes	935	23.8
No	2,875	73.2
Other response	116	3.0
Having pets or animals in and around house		
Yes	2,241	57.1
No	1,622	41.3
Other response	63	1.6

*Urban: Seshego and Polokwane districts, Rural: Mankweng, Bahlaloga, Maraba, Maune, and Mogodumo districts.

**Yes: Mogodumo and Polokwane districts, No: Mankweng, Bahlaloga, Maraba, Maune, Mogodumo, and Seshego districts.

***Far from smelter and rural: Mankweng, Bahlaloga, Maraba, and Maune districts, Far from smelter and urban: Seshego district, Close to smelter and rural: Mogodumo district, Close to smelter and urban: Polokwane district.

§Formal: brick; informal: corrugated iron, mud, or combination with or without bricks.

§§Clean: gas and/or electricity; combination of clean and polluting: coal, paraffin, gas, and/or electricity.

TABLE 2.—Health outcomes of study participants (n = 3,926).

Variable	Total	Percentage
Wheeze in previous 12 months		
Yes	740	18.9
No	1,877	47.8
Other response	1,309	33.3
Severe wheeze in previous 12 months		
Yes	361	9.2
No	379	9.7
Other response	3,186	81.1
Eczema symptoms in previous 12 months		
Yes	377	9.6
No	3,361	85.6
Other response	188	4.8
Rhinoconjunctivitis symptoms in previous 12 months		
Yes	664	16.9
No	3,262	83.1

Risk factors assessed included household conditions, demographic characteristics, health-seeking behavior, and the presence of eczema symptoms and rhinoconjunctivitis symptoms (Tables 1 and 2).

The ISAAC protocol stipulates that separate analyses should be conducted for different ethnic groups (2,3). Ethnicity was not assessed directly in the questionnaire. Language was used as a proxy to indicate race; in this case, North-Sotho was used as a proxy to indicate Black/African ethnicity. English and Afrikaans are mostly the mother tongue of the other three race groups. Under apartheid, South Africans were categorized into one of four socially defined race or ethnic groups: White (mainly European ancestry), Asian (Indian sub-continent ancestry), African or Black (descent primarily from one of a number of Bantu language groups in Southern Africa), and Coloured (general grouping, including a mixture of Black, Malay, European, and indigenous Khoisan ancestry). Race is currently still linked to socioeconomic status and educational status.

Data Management and Statistical Analyses

Five data collectors were trained in how to enter the information digitally into a customized information system. The data were entered into a database set up in EPIDATA. The data capture screen mirrored the forms onto which the data had been recorded. Any changes made to the data entered into the system were done in consultation with one of the co-authors and documented. The data were double-entered by different data collectors and the two sets of records compared, after which discrepancies were checked against the original questionnaire and corrected.

The data were extracted from EPIDATA and statistically analyzed with the statistical package STATA V9. Prevalence rates for the health outcomes and the proportion of risk factors under investigation were calculated by dividing the number of participants who responded affirmatively to a particular question by the number of questionnaires completed. This resulted in each question having a slightly different sample size.

Crude and adjusted odds ratios (OR) and 95% confidence intervals (CI) were calculated to estimate the likelihood of

wheeze or severe wheeze given the presence of a potential risk factor, using univariate and multivariate logistic regression analyses (LRA). Not all children who were in grades 7 and 8 ($n = 4,677$) were 13 or 14 years old at the time of the survey and the data analysis was therefore restricted to data from 13- and 14-year- old children ($n = 3,926$). Observations to all questions marked as "do not know," "not stated," or "other response" were set as missing. All missing values were excluded from the LRA. The introduction of the factors in the multivariate LRA used p values less than 0.2 obtained in the univariate LRA, according to the methodology of binary logistic regression analysis. p values less than 0.05 were considered statistically significant (17).

RESULTS

Table 1 shows the demographic characteristics and household conditions of the participants. Table 2 indicates the prevalence rates of wheeze, severe wheeze, eczema symptoms, and rhinoconjunctivitis symptoms. The prevalence rates of wheeze and severe wheeze were 18.9% and 9.2%, respectively. The prevalence rates of eczema symptoms and rhinoconjunctivitis symptoms were 9.6% and 16.9%, respectively.

More girls than boys participated in the study. The sex of 7 children was not indicated in the completed questionnaires (Table 1). The majority of the 3,926 questionnaires were completed in North-Sotho (60.6%), followed by English (26.9%) and Afrikaans (9.8%). Approximately equal numbers of children lived in rural and urban areas and 54% of the children lived close to the platinum smelter. The majority of the children had lived in the same area for longer than 3 years (74.8%), lived in formal housing (82.1%), and were not exposed to environmental tobacco smoke (ETS) at home (73.2%). Nearly half of the children lived within a 15-minute walk or a 5-minute drive from the nearest clinic/hospital. Half of the children lived in houses where a combination of gas, electricity, coal, and/or paraffin was used for cooking. Fifty-six percent of the children lived in houses without running water and 57% lived in households with pets and/or animals in and around the house.

Tables 3 and 4 show the totals for each risk and protective factor, respective odds ratios, 95% CIs, and significance levels (p). The multivariate LRA indicated that living close to the smelter in a rural area significantly increased the likelihood of wheeze by 79% ($_{\text{adjusted}}\text{OR} = 1.79$; 95% CI = 1.27–2.53 and $p = 0.001$) (Table 3). Living a 1-hour walk or a 15-minute drive from the nearest clinic or hospital increased the likelihood of wheeze by 31% ($_{\text{adjusted}}\text{OR} = 1.31$; 95% CI = 1.06–1.62 and $p = 0.012$). The following factors were protective for wheeze: Using a combination of dirty and clean fuels for cooking ($_{\text{adjusted}}\text{OR} = 0.77$; 95% CI = 0.61–0.97 and $p < 0.001$), being North-Sotho ($_{\text{adjusted}}\text{OR} = 0.61$; 95% CI = 0.41–0.92 and $p = 0.017$) and living in a formal house ($_{\text{adjusted}}\text{OR} = 0.67$; 95% CI = 0.52–0.86 and $p = 0.02$). The presence of eczema symptoms and rhinoconjunctivitis symptoms increased the likelihood of wheeze by 124% ($_{\text{adjusted}}\text{OR} = 2.24$; 95% CI = 1.68–3.00 and $p < 0.001$) and 190% ($_{\text{adjusted}}\text{OR} = 2.90$; 95% CI = 2.34–3.60 and $p < 0.001$), respectively.

The multivariate LRA indicated that the presence of eczema symptoms and rhinoconjunctivitis symptoms increased the likelihood of severe wheeze by 70% ($_{\text{adjusted}}\text{OR} = 1.70$; 95% CI = 1.11–2.60 and $p = 0.014$) and 199% ($_{\text{adjusted}}\text{OR} = 2.99$; 95% CI = 2.14–4.18 and $p < 0.001$), respectively (Table 4).

DISCUSSION

This study has provided some insight into the association between wheeze and severe wheeze and household conditions, eczema symptoms, and rhinitis symptoms in adolescents from a predominantly rural area in the north of South Africa. Wheeze and severe wheeze appear to be a substantial public health problem in the Polokwane area. The 12-month prevalence rate was 18.9% for wheeze and 9.2% for severe wheeze.

Ait-Khaled et al. reported on the 12-month prevalence rate of wheeze from ISAAC Phase III studies that were conducted in 22 centers in 16 African countries (4). Considerable variation was observed between the prevalence rates at various centers (4.0–21.5%). There was a large variation both between countries and between centers in the same country. Several African centers, including Cape Town, South Africa (20.3%), Reunion Island (21.5%), Brazzaville, Congo (19.9%), Nairobi, Nigeria (18.0%), Urban Ivory Coast (19.3%), and Conakry, Guinea (18.6%) had higher wheeze 12-month prevalence rates than almost all European countries (1, 4). The 12-month prevalence rate of wheeze in the Polokwane area is comparable to those from Reunion Island, Congo, Nigeria, Ivory Coast, and Guinea. Asthma symptoms (such as wheeze) are clearly, therefore, an emerging public health crisis in Africa.

It would be relevant to know which household conditions in the ISAAC Phase III studies from the 15 African countries other than South Africa are significantly associated with wheeze and severe wheeze so that results from these studies can be compared with the findings of the Polokwane study. However, the results of the association between environmental risk factors and wheeze are not currently available for these African ISAAC Phase III studies. The ecological analyses from the Phase III studies are in progress at present (18).

The type of fuel used for cooking, exposure to ETS at home, and the proximity of the household to the smelter are all surrogate measures for indoor and outdoor exposure to the criteria air pollutants and various other air pollutants. The criteria air pollutants are oxides of nitrogen, ozone, particulate matter, sulfur dioxide and lead (19). Although the debate is still ongoing on as to whether exposure to the criteria air pollutants may cause asthma and not merely exacerbate asthma symptoms (20, 21), there is sufficient evidence that ETS exposure exacerbates symptoms of asthma and that ETS exposure probably increases the likelihood of developing asthma. Personal exposure to a pollutant is dependent on the magnitude of the pollutant concentration in the exposed environment, along with the duration and time pattern of exposure (22). Exposure to ETS and outdoor industrial air pollution may be minute compared to the exposure to smoke emissions from a mixture of the 2 to 4 kg of dirty fuels that are used for cooking in each of 4.5 million households in South Africa

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TABLE 3.—Prevalence of wheeze in previous 12 months along with crude and adjusted odds ratios, by risk or protective factors.

Variable	Total*	Wheeze (%)	$_{\text{Crude}}$OR (95%CI)	*p*	$_{\text{Adjusted}}$OR**	*p*
Sex of child						
Female	1,527	28.4	1		-	-
Male	1,085	28.0	0.98 (0.82-1.17)	0.822	-	-
Language						
Afrikaans	258	37.6	1		1	
English	689	37.9	1.01 (0.75-1.36)	0.936	1.06 (0.76-1.48)	0.750
North-Sotho	1,670	22.9	0.49 (0.37-0.65)	<0.001	0.61 (0.41-0.92)	0.017
Smelter area type						
Far from smelter and rural	1,187	22.0	1		1	
Far from smelter and urban	288	26.7	1.29 (0.96-1.74)	0.086	0.84 (0.59-1.19)	0.315
Close to smelter and rural	240	31.7	1.64 (1.21-2.23)	0.001	1.79 (1.27-2.53)	0.001
Close to smelter and urban	902	36.1	2.01 (1.66-2.44)	<0.001	1.04 (0.73-1.48)	0.827
Time period lived in current suburb/village						
<3 years	595	30.6	1		-	
≥3 years	1,933	28.1	0.89 (0.73-1.09)	0.249	-	
Travel time to nearest clinic or hospital from home						
15 min walk or 5 min drive	1,241	27.6	1		1	
1 hour walk or 15 min drive	859	31.2	1.19 (0.98-1.44)	0.078	1.31 (1.06-1.62)	0.012
>1 hour walk or > 30 min drive	424	26.2	0.93 (0.72-1.19)	0.560	1.18 (0.90-1.56)	0.239
Type of house						
Informal	463	32.4	1		1	
Formal	2,154	27.4	0.79 (0.63-0.98)	0.030	0.67 (0.52-0.86)	0.002
Cooking fuel type						
Clean	1,289	32.7	1		1	
Combination of dirty and clean	1,328	24.0	0.65 (0.55-0.77)	<0.001	0.77 (0.61-0.97)	0.026
Having running water in house						
No	1,564	24.1	1		1	
Yes	1,013	34.7	1.68 (1.41-1.99)	<0.001	1.14 (0.86-1.51)	0.350
ETS exposure at home						
No	1,943	27.2	1		1	
Yes	611	32.6	1.29 (1.06-1.57)	0.011	1.06 (0.84-1.32)	0.633
Having pets or animals in and around house						
No	1,532	29.0	1		-	-
Yes	1,063	27.6	0.93 (0.78-1.11)	0.431	-	-
Eczema symptoms in previous 12 months						
No	2,349	26.0	1		1	
Yes	268	48.1	2.64 (2.04-3.41)	<0.001	2.24 (1.68-3.00)	<0.001
Rhinoconjunctivitis symptoms in previous 12 months						
No	2,105	23.0	1		1	
Yes	512	49.8	3.31 (2.71-4.05)	<0.001	2.90 (2.34-3.60)	<0.001

*Totals for each risk factor are different due to difference in missing values.
**The final model included 2,430 participants.

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on a daily basis (15, 23). It is therefore surprising that polluting fuel use had a significant protective effect on wheeze and that the variable was not associated with severe wheeze. It is also surprising that living close to the smelter in an urban area is not significantly associated with wheeze, as was found for living close to the smelter in a rural area. Urban areas usually have higher levels of traffic-related air pollution, such as oxides of nitrogen and particulate matter. A possible mechanism to explain the effect of air pollution on allergic diseases is that nitrogen dioxide and carbon particles interact or bind to allergen particles and thereby increase their allergenicity (24–26).

Living close to as opposed to far from the smelter in a rural area significantly increased the likelihood of wheeze, but not of severe wheeze. The association found between the smelter area type and wheeze only suggests that industrial activities may play a role in the prevalence of asthma symptoms, as was observed in other studies (27–29). Various other industrial air pollution sources are located close to the smelter and no source apportionment or air pollution measurements were conducted during this study. Other limitations of the study are addressed later.

No significant increased risk was observed for living close to the smelter in an urban area as opposed to living far from the smelter in a rural area. Studies from Africa (30, 31), India (32), and Southeast Asia (33) have reported an increase in the prevalence of allergic diseases among children living in or migrating to urban areas. However, urbanization is associated with a combination of exposures, some risk, and other protective factors for allergic disease. Within urban communities the net effect of these exposures appears to vary according to socio-economic status (SES) (34).

Then again, unlike atopy, which is more common in higher SES groups (35), the study of the influence of SES on asthma has produced conflicting results (34, 36, 37). Some studies have reported both increased and decreased prevalence of asthma in higher socio-economic groups, while others have found no relationship. Differences in study methodologies may be one of various reasons for these conflicting findings. The use of polluting fuels for cooking, being North-Sotho, and living in a formal house may be related to SES, and all three variables were found to have a protective influence on wheeze in the Polokwane study.

Living within a 1-hour walk or a 15-minute drive as opposed to a 15-minute walk or a 5-minute drive from the nearest clinic or hospital was found to increase the likelihood of wheeze. This might indicate that having closer access to a clinic or a hospital may reduce wheeze. The Global Burden of Asthma Report also identified poor access to health care as an obstacle to reducing the prevalence of asthma (5).

TABLE 4.—Prevalence of severe wheeze in previous 12 months along with crude and adjusted odds ratios, by risk and protective factors.

Variable	Total*	Severe wheeze (%)	$_{\text{Crude}}$OR (95%CI)	*p*	$_{\text{Adjusted}}$OR**	*p*
Sex of child						
Female	434	49.5	1			
Male	304	47.7	0.93 (0.69-1.25)	0.622	-	-
Language						
Afrikaans	97	48.5	1		1	
English	261	56.7	1.39 (0.87-2.22)	0.164	1.45 (0.87-2.40)	0.152
North-Sotho	382	43.5	0.82 (0.52-1.28)	0.377	0.96 (0.52-1.77)	0.892
Smelter area type						
Far from smelter and rural	261	42.9	1		1	
Far from smelter and urban	77	46.8	1.17 (0.70-1.95)	0.551	0.90 (0.51-1.59)	0.725
Close to smelter and rural	76	47.4	1.20 (0.72-2.00)	0.491	0.92 (0.53-1.61)	0.769
Close to smelter and urban	326	54.3	1.58 (1.14-2.19)	0.006	1.24 (0.72-2.13)	0.436
Time period lived in current suburb/village						
<3 years	182	49.5	1			
≥3 years	544	48.5	0.96 (0.69-1.35)	0.830	-	-
Travel time to nearest clinic or hospital from home						
15 min walk or 5 min drive	343	52.2	1			
1 hour walk or 15 min drive	268	47.0	0.81 (0.59-1.12)	0.205	-	-
>1 hour walk or > 30 min drive	111	45.9	0.78 (0.51-1.20)	0.254	-	-
Type of house						
Informal	150	48.0	1			
Formal	590	49.0	1.04 (0.73-1.49)	0.830	-	-
Cooking fuel type						
Clean	421	49.2	1			
Combination of dirty and clean	319	48.3	0.96 (0.72-1.29)	0.810	-	-
Having running water in house						
No	377	45.4	1		1	
Yes	352	52.8	1.35 (1.01-1.81)	0.044	0.91 (0.58-1.43)	0.685
ETS exposure at home						
No	529	48.4	1			
Yes	199	51.3	1.12 (0.81-1.55)	0.491	-	-
Having pets or animals in and around house						
No	444	49.5	1			
Yes	293	47.8	0.93 (0.69-1.25)	0.638	-	-
Eczema symptoms in previous 12 months						
No	611	45.8	1		1	
Yes	129	62.8	1.99 (1.35-2.95)	0.001	1.70 (1.11-2.60)	0.014
Rhinoconjunctivitis symptoms in previous 12 months						
No	485	39.4	1		1	
Yes	255	66.7	3.08 (2.24-4.23)	<0.001	2.99 (2.14-4.18)	<0.001

*Totals for each risk factor are different due to difference in missing values.
**The final model included 729 participants.

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The association between the presence of eczema symptoms and severe wheeze was a bit weaker than for wheeze, whereas the association between the presence of rhinoconjunctivitis and severe wheeze was a bit stronger than for wheeze. A recent review discussed the evidence of an association between rhinitis and asthma and also addressed possible mechanisms to explain the causative effect of rhinitis on asthma (38). The most basic evidence linking upper- and lower-airway disease is the observation that asthma and rhinitis coexist at a higher frequency than would be expected from the prevalence of each in the general population (4, 38). In this study 91% and 59% of the 218 participants who had rhinoconjunctivitis symptoms in the absence of eczema symptoms also had wheeze and severe wheeze, respectively. Ten percent, 3.8%, and 5.6% of the 3,926 participants had exclusively wheeze, exclusively severe wheeze, and exclusively rhinoconjunctivitis symptoms, respectively. Evidence for a link between the upper and lower airway is also strengthened by various studies that report a reduction in asthma symptoms after treatment of rhinitis (38).

Eczema is often the first sign of atopy that occurs in genetically predisposed individuals. Evidence is provided by a cohort study that followed asthma-free children with eczema over 4 years (39). At the end of this period, 45% of them showed asthma-like symptoms and 35% of them were diagnosed as having asthma by a specialist. The Early Treatment of Atopic Children study evaluated the preventive effect of cetirizine administered for 18 months on the onset of asthma in children with eczema. In the placebo group 50.4% developed asthma at a mean age of 27 months, and in those, 40% had a family history (father or mother) of asthma (40, 41). Results from this study also reinforce the importance of eczema as a risk factor for asthma. In this study 72% and 40% of the 100 participants who had eczema symptoms in the absence of rhinoconjunctivitis symptoms also had wheeze and severe wheeze, respectively. Very few of the 3,926 participants (2.5%) had eczema symptoms exclusively.

Limitations

There are some important limitations in this study that should be taken into account in the interpretation of the results. First, the study had a cross-sectional design, like all the other ISAAC studies.

Second, the extent to which the findings from the data can be generalized is determined by the non-response rate. The response rate is difficult to estimate as no record was kept of the number of questionnaires distributed in relation to the number of questionnaires completed and returned. As most of the schools do not have either an official or unofficial class

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list, it was also not possible to retrospectively estimate the response rate on the basis of the number of forms returned. Despite the absence of a response rate, the Polokwane data were included in the ISAAC database, as the ISAAC committee also considers other data qualities (4). This study focused only on those children who were at school and participated in the survey on the day the field workers visited the school. It was not possible to trace those children who were absent. One of the co-authors who conducted the fieldwork assured the other co-authors that most of the children were present at the time of the fieldwork, which coincided with an examination period. We are confident that the school attendance was high during the study. Thus, the bias that might be introduced by non-response is assumed to be relatively low for this study.

Third, reliance on self-reported data does include a risk of misclassification of disease and exposure status resulting in statistical significance arising by chance. No quantitative exposure assessment was conducted during this study, such as location, frequency and duration of fuel use for cooking, or number of cigarettes smoked at home per day. Many households in South Africa in general use a combination of cooking and heating fuels. The calculated effects may be underestimated if the use of high-polluting fuels (coal) are considered exclusively and not in combination with paraffin, gas, and/or electricity. The effects may also be underestimated when medium polluting fuels (paraffin) are used exclusively and not in combination with gas and/or electricity. However, none of the households under investigation used coal or paraffin exclusively. It is recommended that future studies include a question on type of fuels use for heating. Exposure to smoke from polluting fuels during heating lasts longer than exposure during cooking.

Fourth, other factors not recorded in this study that may contribute to wheeze and severe wheeze included a family history of asthma, participant's smoking status, allergens such as pollen, dust mites, fungal spores, birth weight, duration of breast feeding, experience of stress and violence, body mass index, frequency and duration of respiratory tract infections, as well as the likelihood of HIV infection within the sample, given South Africa's high HIV prevalence.

Excluding these risk factors from the analysis might introduce bias (differential or nondifferential). Thus, the direction of bias in the calculated association measures is not easy to predict. As the association between these excluded risk factors and those investigated in this study is not available from the literature, it is impossible to predict the direction of the potential bias on the association measure.

Fifth, it was not possible to administer the video questionnaire due to the lack of access to electricity in the majority of the schools.

Despite these limitations, we think that our study contributes to existing literature because limited data are available about the prevalence of asthma symptoms, rhinitis symptoms, and eczema symptoms in rural marginalized areas in South Africa. This baseline data provides public health practitioners and health service planners an opportunity to improve services and health promotion and serve as a benchmark for future prevalence studies. To improve health for the South African population through epidemiological studies, it is imperative that future investigations of the risk factors for asthma, rhinitis, and eczema should attempt to minimize systematic and random errors and subsequently strengthen the validity and accuracy of their findings.

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