ELSEVIER

Health & Place 14 (2008) 323–335

HEALTH & PLACE

www.elsevier.com/locate/healthplace

Association between children's household living conditions and eczema in the Polokwane area, South Africa

Janine Wichmann*, Jacqueline E. Wolvaardt, Chantelle Maritz, Kuku V.V. Voyi

School of Health Systems and Public Health, Faculty of Health Sciences, University of Pretoria, HW Snyman Building, 31 Bophelo Road, Gezina, Pretoria, 0001, South Africa

Received 31 July 2006; received in revised form 18 March 2007; accepted 3 August 2007

Abstract

The aim of the study was to determine the 12-month prevalence of eczema symptoms (ES), the prevalence of ever having had eczema (EE), and potential risk factors among 6–7-year-old children within a 60 km radius of Polokwane city centre, Limpopo Province, South Africa. This study applied the International Study of Asthma and Allergies in Childhood (ISAAC) Phase III protocol. It was conducted during August 2004 (winter) and February 2005 (summer). Among the 2437 participants, the 12-month prevalence of ES (17%) was much lower than the prevalence of EE (38%). The multivariate logistic regression model revealed that the likelihood of having ES was significantly increased by 43% in rural areas, and by 54% when exposed to environmental tobacco smoke (ETS) at home. The model also revealed that the likelihood of EE significantly increased with ETS exposure at home (37%), and by the use of coal, paraffin, gas and/or electricity for cooking (28%). Living in a formal house significantly decreased the likelihood of EE by 23%. Eczema appears to be a substantial public health problem in the Polokwane area. It is hoped that future studies will scrutinize these results in more detail, to inform and influence policy decisions, and form a basis for a health-promotion intervention in the community.

Keywords: Eczema; Children; Household; South Africa; International study of asthma and allergies in childhood

Introduction

Globally, the risk of developing eczema, a skin disease, is reported to be increasing among children and teenagers, with currently 5–20% being affected (Williams et al., 1999; Asher et al., 2006). Eczema is not life threatening, but the constant scratching associated with the condition may result in skin damage, secondary infection and sleep loss to both child and parents (Reid and Lewis-Jones, 1995).

In October 2003, the Nomenclature Review Committee of the World Allergy Organization (WAO) published an update of the European Academy of Allergology and Clinical Immunology (EAACI) document, which recommends terminology for skin allergies (Johansson et al., 2004). The WAO recommends that the umbrella term for local inflammation of the skin should be 'dermatitis' (Fig. 1). The term 'eczema' describes skin diseases with common clinical characteristics, involving a

*Corresponding author. Tel.: +27 12 354 1472; fax: +27 12 354 2071.

E-mail addresses: janine.wichmann@up.ac.za (J. Wichmann), academic@med.up.ac.za (J.E. Wolvaardt), eksteenmaritz@yahoo.co.uk (C. Maritz), kvoyi@med.up.ac.za (K.V.V. Voyi).

1353-8292/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.healthplace.2007.08.002

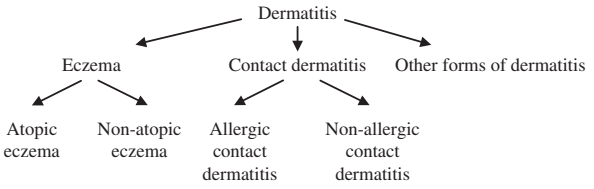

Fig. 1. The new World Allergy Organization classification of eczema/dermatitis (Johansson et al., 2004).

genetically determined skin-barrier defect. Decreased barrier function leads to increased water loss through the outermost layer of the skin, resulting in a decrease in water content of this particular layer of the skin, increased permeability to hydrophilic substances, decreased ceramides in the skin and decreased barrier to infectious agents.

The International Study on Asthma and Allergies in Childhood (ISAAC) was founded in 1992 to maximize the value of epidemiological research into asthma, eczema and allergic rhinoconjunctivitis by establishing a standardized methodology and facilitating international collaboration (Asher et al., 1995; ISAAC, 1998a). The ISAAC Phase I studies were conducted during 1992–1995 in 56 countries among 715,033 children between the ages of 6–7 and 13–14 years. The older group was selected to indicate the period when morbidity from asthma is common and to enable the use of self-completed questionnaires. The younger group was chosen to reflect the early childhood years, and involved parent completion of questionnaires.

ISAAC Phase I studies aimed to describe the magnitude and geographic distribution of asthma, eczema and allergic rhinoconjunctivitis in as many countries as possible. This was done by using simple standardized, validated, questionnaire-based instruments (Asher et al., 1995). ISAAC Phase II studies have already been conducted at 30 centers in 22 countries, using detailed questionnaires and objective measurements of physiological variables and indoor exposure (Weiland et al., 2004a). Phase III involved a repeat of Phase I in about 100 centers after at least 5 years. This lag period enabled the time trends of symptom prevalence to be determined and the incorporation of new centers for the development of a more comprehensive 'world map' (Ellwood et al., 2005). This phase currently involves approximately 280 centers in 106 countries. The design of Phase III is similar to that of Phase I in that the same sampling frame, method of selecting schools and method of selecting children within schools are used.

Williams et al. (1999) published the first global comparison of the 12-month prevalence of eczema symptoms (ES) and the prevalence of ever having had eczema (EE) on the basis of the ISAAC Phase I studies. Prior to the 2003 WAO EAACI document, eczema was referred to as 'atopic eczema' in all ISAAC studies. The term is now referred to as 'eczema', as recommended by the WAO (Johansson et al., 2004). Atopy has been documented by the presence of IgE antibodies in serum or by a positive skin prick test. Recently, Asher et al. (2006) reported on the follow-up studies of ISAAC Phase I, namely the results from Phase III.

Despite the increase in the number of ISAAC studies conducted globally, the prevalence of eczema and risk factors among 6–7-year-old children from developing countries have been relatively ignored. This is largely due to the much higher prevalence of acute respiratory infections (ARIs) among children (<5 years) in developing countries. ARIs are the main cause of morbidity among young children (<5 years) and also the main cause of mortality in infancy (<12 months) in these regions (Bruce et al., 2000).

All three studies that were previously conducted in South Africa focused only on reporting the prevalence of ES and EE and did not investigate the association between potential risk factors and ES or EE (Mercer et al., 2004; Todd et al., 2004; Zar et al., 2004). The first study followed the ISAAC Phase I methodology, was conducted in the urban setting of Cape Town from February (summer) to August 1995 (winter), and focused on 13–14 year olds (Mercer et al., 2004). The second study was a follow-up of the study by Mercer et al. (2004) and followed the ISAAC Phase III methodology (Zar et al., 2004). It also focused on 13–14 year olds and was conducted from March (autumn) to September 2002 (spring). The third study by Todd et al. (2004) did not apply the ISAAC methodology. That study was conducted in the rural areas of Transkei and in the urban setting of Cape Town, with the focus on 3–11 year olds. Currently no ISAAC Phase II studies have been conducted in the country.

Epidemiological studies on twins suggest that genetic factors play a role in eczema development (Schultz-Larsen, 1993). However, the ISAAC Phase I studies reported large variations in the worldwide 12-month prevalence of ES, even in genetically similar groups (ISAAC, 1998b; Williams et al.,

1999). These findings suggested that environmental factors underlie the variations.

Some environmental factors have been examined in an ecological analysis of data from the ISAAC Phase I studies. These studies provided some support for the hypotheses that dietary factors (Ellwood et al., 2001), topography and climate (Weiland et al., 2004b), level of economic development (Stewart et al., 2001), as well as the use of paracetamol and antibiotics in the first year of a child's life (Cohet et al., 2004) might explain some of the variation in ES among the 6–7-year-old group at an ecological level. The ecological analysis did not indicate any significant relationship between ES and environmental tobacco smoke (ETS) (Mitchell et al., 2001) or immunization (Anderson et al., 2001).

The ecological analyses from the ISAAC Phase I data did not address the potential environmental risk factors prevalent in many developing countries, such as high indoor air pollution and lack of access to clean running water. The ecological analyses from the Phase III studies, which are currently in progress, will include these factors (Ellwood et al., 2005). However, an association at the ecological level may be due to complex biases, which may not apply at the individual level. Risk factor variations between countries are likely to reflect broader cultural and environmental differences, and may not be directly causal. It is therefore still necessary to investigate possible risk factors for ES and EE in individual level studies.

Environmental factors, such as traffic-related air pollution (Heinrich and Wichmann, 2004) and socio-economic factors (Goh et al., 1996; Williams et al., 1999; Hassan et al., 2002; Mercer et al., 2004) were investigated in some studies, but their roles are not yet fully clear. Genetic factors may also interact with environmental and socio-economic factors. The investigation of risk factors of eczema is also further complicated by the fact that associations have been reported between the disease and upper and lower respiratory tract infections (Meding and Swanbeck, 1990; Mortz et al., 2001).

This is the first South African study in a predominantly rural setting in the north of the country. Polokwane is the capital city of Limpopo Province, the northern-most province of South Africa, with 73% of the people living in rural areas around the city (Polokwane Municipal Level Analysis, 2007). The municipality has a 2001 population of 483,000 (Statistics South Africa, 2001). It is the second poorest province in the country (Polokwane Municipal Level Analysis, 2007), with an estimated 11% of the population having no formal education and therefore being illiterate (Statistics South Africa, 2001). It is developing at a rapid pace, and the mining industry has boomed over the last decade. Rural marginalized areas, like those in Limpopo Province, are faced with environmental concerns and risks typical of those experienced by industrialized cities and many developing countries.

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. However, this study was extended to include all areas within a 60 km radius of the city center. Polokwane differs from previous studies in that it is located in a summer rainfall area with a bushveld biome, while Cape Town is in a winter rainfall area with a fynbos biome. Polokwane is 1736 km northeast of Cape Town (Fig. 2). Polokwane is situated 1300 m above sea level, with a summer average temperature of 27 °C, while Cape Town is at sea level with a 26 °C summer average.

The aims of this study were:

(1) To compile information on the prevalence rates of ES and EE for 6–7-year-old children in the Polokwane area of South Africa.
(2) To compile information on the associated risk factors of ES and EE.
(3) To compare the prevalence with results from other ISAAC studies.
(4) To contribute to the body of knowledge regarding the prevalence and potential risk factors of eczema amongst young children, in a developing country setup.

It is hoped that the results from this study will form the basis of more detailed intervention studies. Further investigation may inform and influence policy decision, which could form the basis for a health promotion intervention in the community.

Methods

Study design

The study had a cross-sectional design and followed the ISAAC Phase III protocol, namely a simple standardized, validated questionnaire

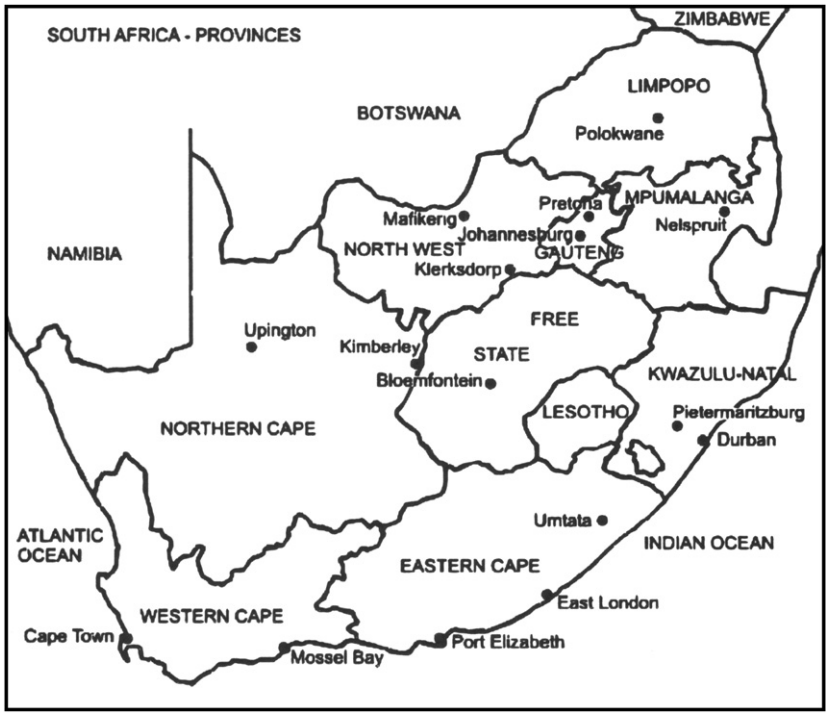

Fig. 2. Location of Polokwane and Cape Town in South Africa.

(Ellwood et al., 2005). Owing to the size of the area covered in the study, the primary school children (6–7 years old) participated in the study during August 2004 (winter), October 2004 (spring) and February 2005 (summer). The questionnaire was designed to assess the prevalence of eczema and its symptoms, as well as to assess potential risk factors including those related to air pollution from combustion of coal and paraffin for cooking.

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 it back to English in order to ensure consistency with the original. The questionnaire was also made available in English and Afrikaans, which are the two other languages spoken in the area. The Afrikaans version was already available from the first Cape Town ISAAC study (Mercer et al., 2004).

The children received the questionnaires at the schools, and were requested to take them home for completion by their parents or guardians. The majority (84.7%) of the 2876 questionnaires were completed in North-Sotho. The data analysis was therefore restricted to the North-Sotho group. The ISAAC protocol stipulated that separate analyses should be conducted for different ethnic groups (Asher et al., 1995; ISAAC, 1998a). Language was used as a proxy to indicate race, in this case North-Sotho to indicate Black/African ethnicity. English and Afrikaans are usually the mother languages 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 linked to both past and present access to resources, socio-economic status, and educational status.

In total, 55 of the identified 63 schools were included in the study, from a possible list of 263. North-Sotho-speaking children did not attend the eight excluded schools. 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:

(1) Permission was not received prior start of fieldwork.
(2) Roads were inaccessible at time of fieldwork.

(3) Inability to locate school due to remoteness of location.
(4) Administrative problems.
(5) School had closed down.
(6) Lack of cooperation from school.

Twelve field workers, who were Masters of Public Health students from the community, were selected and attended a 1-day training session on how to undertake the study. One of the researchers accompanied each of the six fieldwork teams on at least one of the days the survey was conducted to ensure adherence to the protocol.

Approval was granted by the University of Pretoria Ethics Committee and the Ministry of Education, Limpopo Province. Consent was sought from each participant's parent or guardian in the study individually before the questionnaire was completed. The field workers were instructed to keep all information confidential. Anonymity was maintained and the names of the respondents were not recorded.

Health outcomes and potential risk factors

In accordance with the ISAAC methodology and the new WAO nomenclature, participants were considered to have ES in the past 12 months prior to the study when their parents/guardians answered affirmatively to all three of the following questions:

(1) Did your child ever have an itchy rash that was coming and going for at least 6 months?
(2) Did your child 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?

To explore the effects of disease classification in relation to these symptoms, parents/guardians were asked whether their children had ever had eczema (EE).

The ISAAC steering committee selected the time period of 1 year for recall of symptoms for the following reasons:

(1) To minimize errors associated with recall of symptoms in infancy.
(2) To overcome seasonal variations in ES that might be present in some countries (Larsson and Lidén, 1980; Uehara and Saito, 1987; Asher et al., 1995).
(3) For consistency with the measures used for asthma and allergic rhinoconjunctivitis symptoms (Strachan et al., 1997; Asher et al., 1998).

Risk factors assessed included household conditions, demographic characteristics and health-seeking behavior (Table 1).

Data management and statistical analyses

Five data capturers were trained in how to capture 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 the relevant researcher, and documented. The data were double-entered by different data capturers 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 using univariate and multivariate logistic regression analyses (LRA) to estimate the likelihood of having a health outcome, given the presence of a potential risk factor. 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 logistic regression analyses. As mentioned previously, the majority (84.7%) of the 2876 questionnaires were completed in North-Sotho. The data analysis was therefore restricted to the North-Sotho group.

Results

The 12-month prevalence rate of ES was 17% ($n = 416$), whilst the prevalence rate of EE was 38% ($n = 925$). Approximately equal numbers of girls

Table 1
Characteristics of study participants (6–7 years) ($n = 2437$)

Characteristic	No.	Percentage (%)
Sex of child		
Male	1228	50.4
Female	1202	49.3
Not stated	7	0.3
Type of area[a]		
Urban	624	25.6
Rural	1815	74.4
Time period lived in current suburb/village		
<3 years	369	15.2
⩾3 years	1919	78.7
Other response	149	6.1
Travel time to nearest clinic or hospital from home		
15min walk or 5min drive	769	32.7
1h walk or 15min drive	862	35.4
>1h walk or >30min drive	658	27.0
Other response	121	5.0
Type of house[b]		
Formal	1752	71.9
Informal	685	28.1
Cooking fuel type[c]		
Combination of dirty and clean	1815	74.5
Clean	622	25.5
Having running water in house		
Yes	327	13.4
No	2038	83.6
Other response	72	3.0
ETS exposure at home		
Yes	299	12.3
No	2009	82.4
Other response	129	5.3
Having pets or animals in and around house		
Yes	1074	44.1
No	1290	52.9
Other response	73	3.0
Eczema symptoms in past 12 months		
Yes	416	17.1
No	787	32.3
Other response	1234	50.6
Ever had eczema		
Yes	925	38.0
No	1364	56.0
Other response	148	6.1

[a]Urban = living in Polokwane or Seshego; rural = living in Mankweng, Mogodumo, Bahlaloga, Maraba or Maune.
[b]Formal = brick; informal = corrugated iron, mud, or combination with or without bricks.
[c]Clean = gas and/or electricity; mix of clean and polluted = coal, paraffin, gas and/or electricity.

and boys participated in the study. The sex of seven children was not indicated in the completed questionnaires (Table 1). The majority of the children lived in the rural areas (74%), had lived in the same area for longer than 3 years (78%) and currently lived in formal housing (72%). The travel time to the nearest clinic/hospital was spread equally amongst the participants. Three-quarters of the children lived in houses where a combination of gas, electricity, coal and/or paraffin is used. The majority (80%) of the children lived in houses without running water. A small percentage of children were exposed to ETS at home (12%). Approximately equal numbers of children lived in households with pets and/or animals in and around the house (44%).

Table 2 outlines the prevalence rates of ES and EE in more detail. Of the 925 children who had EE, 37% of them also had ES in the past 12 months and for 36% of them it was not known whether they had ES in the past 12 months. Of the 787 children who never had ES in the past 12 months, 66% of them did not have EE during their lifetimes and for 3% of them it was not known whether they had EE. The majority (63%) of the 1234 children, for whom it was not known whether they had ES in the past 12 months, never had EE. Of the 148 children, for whom it was not known whether they had EE, 14% never had ES in the past 12 months and for 80% of them it was not known whether they had ES in the past 12 months.

Table 3 indicates that for the univariate LRA, the following potential risk factors significantly increased the likelihood of having ES in the past 12 months prior to the study: living in a rural area (OR = 1.53, 95% CI = 1.14–2.07), using a combination of polluting fuels (coal or paraffin) with clean

Table 2
Detailed outline of the 12-month prevalence of eczema symptoms (ES) and the prevalence of ever having had eczema (EE)

Ever had eczema	Eczema symptoms in past 12 months			Total
	Yes[a]	No	Other response	
Yes	346	246	333	925
No	62	520	782	1364
Other response	8	21	119	148
Total	416	787	1234	2437

[a]Numbers

Table 3
Prevalence of eczema symptoms in the 12 months prior to the study along with crude and adjusted odds ratios of children (6–7 years) according to their characteristics and household living conditions

Characteristic	No.[a]	Yes	No	OR	95% CI	Adjusted OR	95% CI
Sex of child							
Female	594	209	385	1		–	–
Male	607	206	401	0.95	0.75–1.20	–	–
Type of area							
Urban	270	74	196	1		1	
Rural	933	342	591	1.53	1.14–2.07	1.43	1.06–1.95
Time period lived in current suburb/village							
<3 years	196	68	128	1		–	–
⩾3 years	944	331	613	1.02	0.74–1.40	–	–
Travel time to nearest clinic or hospital from home							
15min walk or 5min drive	372	129	243	1		–	–
1h walk or 15min drive	440	154	286	1.01	0.76–1.36	–	–
>1h walk or >30min drive	346	120	226	1.00	0.74–1.36	–	–
Type of house							
Informal	358	121	237	1		–	–
Formal	845	295	550	1.05	0.81–1.36	–	–
Cooking fuel type							
Clean	273	80	193	1		1	
Combination of dirty and clean	930	336	594	1.36	1.02–1.83	1.32	0.98–1.80
Having running water in house							
No	1049	361	688	1		–	–
Yes	133	44	89	0.94	0.64–1.38	–	–
ETS exposure at home							
No	1000	330	670	1		1	
Yes	156	67	89	1.53	1.08–2.15	1.54	1.09–2.18
Having pets or animals in and around house							
No	620	211	409	1		–	–
Yes	565	200	365	1.06	0.84–1.35	–	–

[a]Totals for each characteristic are different due to difference in missing values.

fuels (gas or electricity) for cooking (OR = 1.36, 95% CI = 1.02–1.83), and being exposed to ETS at home (OR = 1.53, 95% CI = 1.08, 2.15).

Inserting only these three potential risk factors in the multivariate LRA revealed that residing in a rural area (OR = 1.43, 95% CI = 1.06–1.95) and exposure to ETS at home (OR = 1.54, 95% CI = 1.09–2.18) significantly increased the likelihood of having ES in the past 12 months prior to the study by 43% and 54%, respectively.

The univariate LRA results listed in Table 4 indicate that a slightly different combination of potential risk factors significantly increased the likelihood of EE during the child's lifetime: living more than a 15-min walk or more than a 5-min drive from a clinic (OR = 1.25, 95% CI = 1.02–1.53), ETS exposure at home (OR = 1.41, 95% CI = 1.10–1.82) and using a combination of fuels for cooking (OR = 1.34, 95% CI = 1.10–1.63). Two potential factors were protective: living in formal housing (OR = 0.74, 95% CI = 0.62–0.89) and living more than 3 years in the current village/suburb (OR = 0.73, 95% CI = 0.58–0.93). Inserting only these five potential risk and protective factors in the multivariate LRA revealed that ETS exposure at home (OR = 1.37, 95% CI = 1.05–1.78) and the use of a combination of fuels for cooking (OR = 1.28, 95% CI = 1.04–1.58) significantly increased the likelihood of EE by 37% and 28%, respectively. In the multivariate LRA, living in a formal house significantly decreased the likelihood of EE by 23% (OR = 0.77, 95% CI = 0.63–0.94).

Table 4
Prevalence of ever having had eczema along with crude and adjusted odds ratios of children (6–7 years) according to their characteristics and household living conditions

Characteristic	No.[a]	Yes	No	OR	95% CI	Adjusted OR	95% CI
Sex of child							
Female	1145	480	605	1		–	–
Male	1140	443	697	0.88	0.74–1.04	–	–
Type of area							
Urban	573	213	360	1		–	–
Rural	1716	712	1004	1.20	0.99–1.46	–	–
Time period lived in current suburb/village							
<3 years	348	162	186	1		1	
⩾3 years	1832	715	1117	0.73	0.58–0.93	0.79	0.62–1.00
Travel time to nearest clinic or hospital from home							
15min walk or 5min drive	753	285	468	1		1	
1h walk or 15min drive	821	355	466	1.25	1.02–1.53	1.18	0.95–1.46
>1h walk or >30min drive	632	250	382	1.07	0.86–1.34	1.03	0.82–1.29
Type of house							
Informal	617	282	335	1		1	
Formal	1672	643	1029	0.74	0.62–0.89	0.77	0.63–0.94
Cooking fuel type							
Clean	590	208	382	1		1	
Combination of dirty and clean	1699	717	982	1.34	1.10–1.63	1.28	1.04–1.58
Having running water in house							
No	1941	796	1145	1		–	–
Yes	311	114	197	0.83	0.65–1.07	–	–
ETS exposure at home							
No	192	746	1174	1		1	
Yes	279	132	147	1.41	1.10–1.82	1.37	1.05–1.78
Having pets or animals in and around house							
No	1230	489	741	1		–	–
Yes	1024	424	600	1.07	0.90–1.27	–	–

[a]Totals for each characteristic are different due to difference in missing values.

Discussion

The 12-month prevalence of ES and the prevalence of EE were 17% and 38%, respectively. A possible explanation for the wide difference between the 12-month prevalence of ES and the prevalence of EE might be that not every child who had ever been diagnosed with eczema is expected to still have ES within 12 months prior to the study. In general, there is a big difference between the 12-month prevalence of ES and the prevalence of EE in all the ISAAC studies from various regions of the world (Björkstén et al., 1998; Zhao et al., 2000).

Table 5 summarizes the prevalence rates from this study and other ISAAC Phase I and Phase III studies in which 6–7 year olds were surveyed (Williams et al., 1999; Asher et al., 2006). The lowest prevalence of ES was 0.8% in Tehran, Iran, and the highest prevalence was found in the cities of Stockholm and Uppsala in Sweden (18.4%) during

Table 5
Comparison between the Polokwane study's 12-month prevalence of ES and prevalence of EE for 6–7 year old children, and other ISAAC Phase I and Phase III studies

Location	Phase I		Phase III	
	ES	EE	ES	EE
Polokwane, South Africa			17%	38%
Tehran, Iran	0.8%		1.1%	
Stockholm and Upsala, Sweden	18.4%		19.5%	
Singapore City, Singapore		1.3%		
Fukuoka City, Japan		57.2%		
Nigeria	4.5%		5%	

Phase I. The lowest and highest prevalence of EE was 1.3% and 57.2% in Singapore city, Singapore, and Fukuoka city, Japan, respectively, during Phase I. The only ISAAC Phase I study that was conducted in Africa for this particular age group was from Nigeria (Asher et al., 2006). The prevalence of ES in Nigeria (4.5%) was three times lower than that of the Polokwane study (17%). The lowest prevalence of ES was again in Iran (1.1%) during Phase III, and the highest prevalence was again reported in Sweden (19.5%). The prevalence of ES in the follow-up Phase III study in Nigeria was again three times lower than that of the Polokwane study (5% compared with 17%).

The results of the association between environmental risk factors and ES are not currently available for the Nigerian ISAAC Phase III study. As mentioned previously, the ecological analyses from the Phase III studies are currently in progress (Ellwood et al., 2005).

A Demographic and Health Survey (DHS) conducted in Nigeria during 2003 reported that 96.2% of households used polluting fuels for cooking (such as wood, animal dung, crop residues, coal or paraffin exclusively or in combination), although 52.2% of homes were connected to electricity (Nigerian Demographic and Health Survey, 2003). Only 0.6% of Nigerian households had piped water. A third of Nigerian households belonged to the informal category. Very few women (1.1%) smoked during 2003. The Nigerian DHS did not report statistics on the smoking status of adult men.

Among the study participants of the Polokwane study, eczema is more prevalent amongst children who live in informal homes, households that use a mixture of clean and polluting fuels for cooking, households that are located in rural areas and households with ETS exposure. All but the last of these potential risk factors might be indicators for socio-economic status. Studies have found that a lower socio-economic status increases the risk of developing eczema (Goh et al., 1996; Williams et al., 1999; Hassan et al., 2002; Mercer et al., 2004). A review that focused on studies conducted in Europe indicated that traffic-related air pollution increased the risk of developing eczema (Heinrich and Wichmann, 2004). The air pollution mix from traffic is different to that of ETS or indoor smoke from coal and paraffin. Therefore, the association found in this study between ES and EE with ETS exposure or indoor air pollution exposure from polluting fuels used for cooking needs further investigation.

In the preliminary statistical analysis, the likelihood of having ES or EE was estimated for children who lived closest to the platinum smelter compared with those who lived further away. Polokwane and Mogodumo are located closest to the platinum smelter. Living in the Polokwane or Mogodumo districts did not significantly increase the likelihood of having ES and EE, when compared with the other five districts (Bahlaloga, Mankweng, Maraba, Maune and Seshego) (OR = 0.99, 95% CI = 0.75–1.31 for ES; OR = 0.94, 95% CI = 0.77–1.15 for EE). It was therefore decided to categorize the districts on urban/rural area type and not on the proximity to the platinum smelter.

European studies report mixed results on whether household pets increase the likelihood of having eczema (Svartengren and Wickman, 2001). Pets or animals did not have a detrimental impact on the health outcomes in this study. It may be that the risk of indoor air pollution, ETS exposure and lack of clean water overwhelm the risk posed by pet allergens in developing countries, and therefore needs further investigating.

The strengths of the study included its adherence to the ISAAC methodology, which has been tested and validated worldwide. While the sample size was lower than the sample size of 3000 participants recommended by ISAAC, the ISAAC protocol stipulates that a sample size of over 1000 is also acceptable (ISAAC, 1998a).

There are some important limitations in this study, which should be taken into account in interpreting the results. First, the study had a cross-sectional design, such as in all the other ISAAC studies. Cross-sectional studies are weak in proving causation as they are subject to difficulties in interpreting the temporal sequence of events since health status and determinants are measured simultaneously. However, our findings are supported by other studies, as discussed previously.

Second, the generalization of data is determined by the non-response rate. The response rate is difficult to estimate as no record was kept about 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 list, it was also not possible to retrospectively estimate the response rate on the basis of the number of questionnaires returned. A representative from the ISAAC

executive committee informed the authors that not having an accurate response rate does not automatically rule out the inclusion of the Polokwane data from the ISAAC database as the committee also considers other data qualities. The questionnaires were distributed to all the children in a particular education level, namely those attending grade 1, instead of all children that belong to the specific age group. However, it is most likely that the majority of 6–7 year olds were in grade 1. This study focused only on those children who attended 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. The feeding scheme in the primary schools encourages parents to keep their children in school as it provides a very important meal for the children. 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 includes a risk of misclassification of disease and exposure status resulting in statistical significance arising by chance. Information is based largely on reports of the guardians (72%) and siblings (14%) as only 0.5% of the questionnaires were completed by parents. The remaining 14% of questionnaires gave no indication of who had completed them. The low literacy rate of adults in some of the areas may have resulted in misinterpretation of some of the questions. This may have had an influence on the quality of the response; particularly those answers to questions like ''ever had eczema''. Mercer et al. (2004) have found that there is no word for ''eczema'' in Xhosa, while a North- Sotho word does exist. It is likely that perceptions of questions related to ES may differ between rural South African participants and their counterparts from developed countries. Therefore, even if the translation of the meanings of eczema symptoms and eczema itself may be perfect, people living in unhygienic conditions may be less likely to answer positively to such questions. Some misclassification of symptoms attributable to other diseases and conditions (e.g. scabies) that may be prevalent in this population is unavoidable, but because these other diseases and conditions are not likely to be dependent on the household characteristics studied here, the result of such non-differential misclassification is expected to be an underestimation of the extent of true effects on ES.

Fourth, no quantitative exposure assessment was conducted as part of the 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.

Fifth, 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 should separate the type of fuels used for cooking and heating into two separate questions. Exposure to smoke from polluting fuels during heating lasts longer than exposure during cooking. Notwithstanding the lack of the quantitative measurement of air pollution exposure levels and clinical measurements for eczema, the uniformity in the significance of crude and adjusted effects for ETS and fuel use implies a probable exposure–response relationship (Tables 2 and 3).

Sixth, other factors not recorded in this study that may contribute to ES and EE included: outdoor and indoor air pollution sources (e.g. mother's smoking status, location of household close to industry, transportation sources or waste fill sites, insecticide or fertilizer use, allergens such as pollen, dust, fungal spores from mildew and moulds); meteorological variables (precipitation, temperature, humidity); child's birth weight; length of breastfeeding; 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 substantial bias (differential or non-differential). Thus, the direction of bias on the calculated association measures is not easy to predict. The definition of a confounder is important to remember: it must be associated with both the exposure variable of interest and the health effect. 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.

Last, during the analysis, it was assumed that confounding is additive and not multiplicative. If

confounding is additive, then the confounding variable would generate the same additional risk of a health outcome in the exposed and the unexposed. However, if the health outcome is rare in the unexposed, it would follow that the confounder might account for a much larger proportion of health outcome in that group. Equally, if two exposures act multiplicatively, the proportional increase in health outcome rates due to confounding would be the same in the exposed and the unexposed. However, if the health outcome is more prevalent in the exposed group, the absolute increase would be larger in the exposed. This issue thus has important risk assessment and public health policy implications.

In order to improve health for the South African population through epidemiological studies, it is imperative that future studies attempt to minimize systematic and random errors, and subsequently strengthen their validity and accuracy. It is hoped that future analytic studies will attempt to validate and improve the understanding of how these identified potential risk and protective factors both increase and decrease the risk of eczema development amongst children. Such research is important. Of the 11 million South African households that still used polluting fuels (such as wood, animal dung, crop residues, coal or paraffin exclusively or in combination), during 2001, 41% used it for cooking and 48% used it for heating even when electricity was available (Statistics South Africa Census, 2001). The majority (70%) of the households surveyed used electricity for lighting. Living in an informal house was identified as a potential risk factor for EE. During 2001 nearly one third of these 11 million households could be categorized as informal. Exposure to ETS increased the likelihood of both ES and EE. During 2001, 42% of men (>15 years) and 11% of women (>15 years) smoked in South Africa (South Africa Demographic and Health Survey, 1999). Living in a rural area was also identified as a potential risk factor for ES. About 50% of the South African population lives in rural areas (Statistics South Africa Census, 2001).

Given the fact that only 5% of the national research budget is spent on health-related research in South Africa, compared with 30% in developed countries (Chimere-Dan et al., 2001), it is important that analytical studies do more than merely document the impact of known risk factors. Instead, such studies should provide a basis for designing technical or socio-behavioral interventions to minimize exposure to ETS and indoor pollution due to the combustion of polluting fuels. It is hoped that future studies will scrutinize these results in more detail, to inform and influence policy decisions, and form a basis for a health-promotion intervention in the community.

Conflict of interest

This survey was part of a bigger project, commissioned by Anglo Platinum and managed by SE Solutions (Pty) Ltd. The School of Health Systems and Public Health from the University of Pretoria conducted this survey by following the International Study of Asthma and Allergies in Childhood (ISAAC) protocol. All data from this study are the property of Anglo American Platinum Corporation, ISAAC and the University of Pretoria.

Ethical approval

Approval was granted by the University of Pretoria Ethics Committee and the Ministry of Education, Limpopo Province. Consent was sought from each participant's parent or guardian in the study individually before the questionnaire was completed. The data collectors were instructed to keep all information confidential. Anonymity was maintained and the names of the respondents were not recorded.

Acknowledgements

The authors thank everybody who completed questionnaires, the school principals and the Education Department of the Limpopo Province for giving permission to conduct this study, the students who conducted the interviews for the questionnaires, the data capturers and Annemieke van Middelkoop for her assistance during the data processing stages.

References

Anderson, H.R., Poloniecki, J.D., Strachan, D.P., Beasley, R., Björkstén, B., Asher, M.I., For the ISAAC phase 1 study group, 2001. Immunization and symptoms of atopic disease in children: results from the international study of asthma and allergies in childhood. American Journal of Public Health 91, 1126–1129.

Asher, M.I., Keil, U., Anderson, H.R., Beasley, R., Crane, J., Martinez, F., Mitchell, E.A., Pearce, N., Sibbald, B., Stewart, A.W., Strachan, D., Weiland, S.K., Williams, H.C., 1995. International study of asthma and allergies in childhood (ISAAC): rationale and methods. European Respiratory Journal 8, 83–91.

Asher, M.I., Anderson, H.R., Stewart, A.W., Crane, J., 1998. Worldwide variations in prevalence of asthma symptoms: the international study of asthma and allergies in childhood (ISAAC). European Respiratory Journal 12, 315–335.

Asher, M.I., Montefort, S., Björkstén, B., Lai, C.K.W., Strachan, D.P., Weiland, S.K., Williams, H., The ISAAC phase three study group, 2006. Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC phases one and three repeat multicountry cross-sectional surveys. Lancet 368, 733–743.

Björkstén, B., Dumitrascu, D., Foucard, T., Khetsuriani, N., Khaitov, R., Leja, M., Lis, G., Pekkanen, J., Priftanji, A., Riikjärv, M.A., 1998. Prevalence of childhood asthma, rhinitis and eczema in Scandinavia and Eastern Europe. European Respiratory Journal 12, 432–437.

Bruce, N., Perez-Padilla, R., Albalak, R., 2000. Indoor air pollution in developing countries: a major environmental and public health challenge. Bulletin of the World Health Organization 78, 1078–1092.

Chimere-Dan, G., Makubalo, L.E., Ntuli, N.H., Netshidzivhani, P., Mahlasela, L., Johnson, C., 2001. Essential National Health Research in South Africa. The Council on Health Research for Development. Available at: 〈http://www.doh.gov.za/docs/reports/2001/enhr〉. Last accessed on 5 March 2007.

Cohet, C., Cheng, S., MacDonald, C., Baker, M., Foliaki, S., Huntington, N., Douwes, J., Pearce, N., 2004. Infections, medication use, and prevalence of symptoms of asthma, rhinitis, and eczema in childhood. Jounal of Epidemiology and Community Health 58, 852–857.

Ellwood, P., Asher, M.I., Björkstén, B., Burr, M., Pearce, N., Robertson, C.F., The ISAAC phase one study group, 2001. Diet and asthma, allergic rhinoconjunctivitis and atopic eczema symptom prevalence: an ecological analysis of the international study of asthma and allergies in childhood (ISAAC) data. European Respiratory Journal 17, 436–443.

Ellwood, P., Asher, M.I., Beasley, R., Clayton, T.O., Stewart, A.W., The ISAAC steering committee, 2005. The international study of asthma and allergies in childhood (ISAAC): phase three rationale and methods. International Journal of Tuberculosis and Lung Disease 9 (1), 10–16.

Goh, D.Y.T., Chew, F.T., Quek, S.C., Lee, B.W., 1996. Prevalence and severity of asthma, rhinitis, and eczema in Singapore schoolchildren. Archives of Disease in Childhood 74, 131–135.

Hassan, M.R., Kabir, A.R., Mahmud, A.M., Rahman, F., Hossain, M.A., Bennoor, K.S., Amin, M.R., Rahman, M.M., 2002. Self-reported asthma symptoms in children and adults of Bangladesh: findings of the national asthma prevalence study. International Journal of Epidemiology 31 (2), 488–489.

Heinrich, J., Wichmann, H.E., 2004. Traffic related pollutants in Europe and their effect on allergic disease. Current Opinion in Allergy and Clinical Immunology 4, 341–348.

International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee, 1998a. International Study of Asthma and Allergies in Childhood (ISAAC) Methodology. Available at: 〈http://isaac.auckland.ac.nz/index.html〉. Last accessed on 5 March 2007.

ISAAC steering committee, 1998b. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema: ISAAC. Lancet 351, 1225–1232.

Johansson, S.G., Bieber, T., Dahl, R., Friedmann, P.S., Lanier, B.Q., Lockey, R.F., Motala, C., Ortega Martell, J.A., Platts-Mills, T.A., Ring, J., Thien, F., Van Cauwenberge, P., Williams, H.C., 2004. Revised nomenclature for allergy for global use: report of the nomenclature review committee of the world allergy organization, October 2003. Journal of Allergy and Clinical Immunology 113, 832–836.

Larsson, P-Å., Lidén, S., 1980. Prevalence of skin diseases among adolescents 12–16 years of age. Acta Dermato-venereologica (Stockholm) 60, 415–423.

Meding, B., Swanbeck, G., 1990. Predictive factors for hand eczema. Contact Dermatitis 23, 154–161.

Mercer, M.J., Joubert, G., Ehrlich, R.I., Nelson, H., Poyser, M.A., Puterman, A., Weinberg, E.G., 2004. Socioeconomic status and prevalence of allergic rhinitis and atopic eczema symptoms in young adolescents. Pediatric Allergy and Immunology 15 (3), 234–241.

Mitchell, E.A., Stewart, A.W., On behalf of the ISAAC phase one study group, 2001. The ecological relationship of tobacco smoking to the prevalence of symptoms of asthma and other atopic diseases in children: The International Study of Asthma and Allergies in Childhood (ISAAC). European Journal of Epidemiology 17, 667–673.

Mortz, C., Lauritsen, J., Bindslev-Jensen, C., Andersen, K., 2001. Prevalence of atopic dermatitis, asthma, allergic rhinitis, and hand and contact dermatitis in adolescents. The odense adolescence cohort study on atopic diseases and dermatitis. British Journal of Dermatology 144, 523–532.

Nigerian Demographic and Health Survey, 2003. Available at: 〈http://www.measuredhs.com〉. Last accessed on 5 March 2007.

Polokwane Municipal Level Analysis, Polokwane City, Available at: 〈http://www.polokwane.org.za/legisl_docs/reports/docs/final_baseline.doc〉. Last accessed on 5 March 2007.

Reid, P., Lewis-Jones, M.S., 1995. Sleep difficulties and their management in preschoolers with atopic eczema. Clinical and Experimental Dermatology 20, 38–41.

Schultz-Larsen, F., 1993. The epidemiology of atopic dermatitis. In: Burr, M.L. (Ed.), Epidemiology of Clinical Allergy. Karger, Basel, pp. 9–28.

South Africa Demographic and Health Survey. Medical Research Council, Macro International, Department of Health. Pretoria: South Africa. Department of Health. 1999. Available at: 〈http://www.doh.gov.za/facts/1998/sadhs98〉. Last accessed on 5 March 2007.

Statistics South Africa Census, 2001. Census in brief. Pretoria: Statistics South Africa. 2003 Available at: 〈http://www.statssa.gov.za〉. Last accessed on 5 March 2007.

Stewart, A.W., Mitchell, E.A., Pearce, N., Strachan, D.P., Weiland, S.K., On behalf of the ISAAC steering committee, 2001. The relationship of per capita gross national product to the prevalence of symptoms of asthma and other atopic diseases in children (ISAAC). International Journal of Epidemiology 30, 173–179.

Strachan, D.P., Sibbald, B., Weiland, S.K., Ait-Khaled, N., Anabwani, G., Anderson, H.R., Asher, M.I., Beasley, R.,

Bjorksten, B., Burr, M., Clayton, T., Crane, J., Ellwood, P., Keil, U., Lai, C., Mallol, J., Martinez, F., Mitchell, E., Montefort, S., Pearce, N., Robertson, C., Shah, J., Stewart, A., von Mutius, E., Williams, H., 1997. Worldwide variations in the prevalence of symptoms of allergic rhinoconjunctivitis in children: the international study of asthma and allergies in childhood (ISAAC). Pediatric Allergy and Immunology 8, 161–176.

Svartengren, M., Wickman, M., 2001. Atopy-related diseases. Allergy 56 (4), 267–269.

Todd, G., Saxe, N., Milne, J., Tolosana, S., Williams, H., 2004. Prevalence of atopic dermatitis in Xhosa children living in rural, Peri-Urban and Urban areas. Current Allergy and Clinical Immunology 17, 140.

Uehara, M., Saito, Y., 1987. Occurrence of infantile atopic dermatitis in a different season. Hifu Rinshou 29, 37–39.

Weiland, S.K., Björkstén, B., Brunekreef, B., Cookson, W.O., von Mutius, E., Strachan, D.P., The international study of asthma and allergies in childhod phase II study group, 2004a. Phase II of the international study of asthma and allergies in childhood (ISAAC II): rationale and methods. European Respiratory Journal 24, 406–412.

Weiland, S.K., Husing, A., Strachan, D.P., Rzehak, P., Pearce, N., The ISAAC phase one study group, 2004b. Climate and the prevalence of symptoms of asthma, allergic rhinitis, and atopic eczema in children. Occupational and Environmental Medicine 61, 609–615.

Williams, H., Robertson, C., Stewart, A., Aït-Khaled, N., Anabwani, G., Anderson, H.R., Asher, M.I., Beasley, R., Björkstén, B., Burr, M., Clayton, T., Crane, J., Ellwood, P., Keil, U., Lai, C., Mallol, J., Martinez, F., Mitchell, E., Montefort, S., Pearce, N., Shah, J., Sibbald, B., Strachan, D., von Mutius, E., Weiland, S., 1999. Worldwide variations in the prevalence of symptoms of atopic eczema in the international study of asthma and allergies in childhood. Journal of Allergy and Clinical Immunology 103, 125–138.

Zar, H.J., Ehrlich, R.I., Weinberg, E.G., 2004. The prevalence of asthma, allergic rhinitis and atopic eczema (ISAAC phase 3 study) in adolescents in Cape Town and comparison with ISAAC 1. Current Allergy and Clinical Immunology 17, 140.

Zhao, T.B., Wang, H.J., Chen, Y.Z., Xiao, M.L., Duo, L.K., Liu, G., Lau, Y.L., Karlberg, J., 2000. Prevalence of childhood asthma, allergic rhinitis and eczema in Urumqi and Beijing. Journal of Paediatrics and Child Health 36, 128–133.