

Reported prevalence of allergy and asthma in children from urban and rural Egypt

Walid A. Al-Qerem^{1,2}  · Jonathan Ling² · Ropert Pullen² · Kenneth McGarry²

Received: 17 March 2015 / Accepted: 5 October 2015
© Springer Science+Business Media Dordrecht 2015

Abstract Previous studies have shown an association between the urban environment and the risk of developing asthma and allergic rhinitis (AR) in children. This is the first longitudinal study to examine risk factors associated with asthma, eczema and AR in a comparison between Cairo, one of the world's most polluted cities, and a rural area, Shben El-Kom. Two groups of school children were selected. One group was from inner-city Cairo, and the other was from a low-polluted rural area, Shben El-Kom in the Nile Delta region. The children were studied four times, with testing taking place every 6 months over an 18-month period using the ISAAC questionnaire. Two generalized mixed logistic regressions showed that living in Cairo increased the risk of current wheeze, wheeze ever, asthma ever, current AR, AR ever, hay fever ever, current rash, rash ever and eczema ever. Other risk factors that effected asthma included maternal eczema, paternal asthma, maternal asthma and passive smoking. Exposure to farm animals decreased the odds of having asthma. Children living in urban Cairo had a higher risk of allergic conditions than those living in the rural area of Shben El-Kom. This was not fully explained by passive smoking, breastfeeding, parental allergy or exposure to animals.

Keywords Asthma · Allergy · Eczema · Rural environment · Urban environment

✉ Walid A. Al-Qerem
wadderus@gmail.com

¹ AlZaytoonah University, Amman, Jordan

² University of Sunderland, Sunderland, UK

Introduction

The worldwide prevalence of asthma and allergies has significantly increased in recent years (World Health Organisation Statistical Information 2013). Several environmental risk factors have been attributed to the sharp increase of these in both developed and developing countries. One major risk factor associated with the increase in asthma is increasing air pollution resulting from the rise in the number of motor vehicles (Brunekreef et al. 2009) and the presence of certain industrial processes (Wang and Chau 2013). While outdoor air pollution has received much focus, numerous other risk factors found within the home have been found to be associated with an increase in asthma and allergies. These include changing lifestyles and nutritional habits, breastfeeding and keeping pets (Aït-Khaled et al. 2009).

Studies have shown differences in the prevalence rates and severity between rural and urban environments. Important risk factors associated with urban versus rural lifestyle and environment include outdoor air pollution, diet, infections, stress, allergic exposure and parasitic infections (Priftis et al. 2009). Inner-city children appear to have more episodes of acute respiratory infection than children of rural areas, possibly due to overcrowding, indoor air pollution or poor nutrition (Priftis et al. 2009). Other works have shown the protective effect of farming activities and daily contact with livestock (Hugg et al. 2008), through prolonged and early exposure to allergens and pathogens including parasitic infections (Dagoye et al. 2003). However, previous studies performed in Egypt found no protective effect of parasitic infections against asthma (Alshishtawy et al. 1991).

Nutrition also plays an important role in the variation found between rural and urban areas. For example, an Egyptian study found that consumption of farm milk may protect against asthma (Morcos et al. 2011) and a recent ISAAC phase

III study (Ellwood et al. 2013) has confirmed that the consumption of fast food three or more times per week increased the risk of severe asthma, severe rhinoconjunctivitis and severe eczema. Although much work has evaluated changes in the prevalence of asthma and allergies worldwide, few have examined the rural/urban environmental effect in the same population on asthma, eczema and rhinitis.

The primary aim of this longitudinal study was to investigate if there are differences in allergic disease prevalence between schoolchildren in an urban area—Cairo—and in a rural area of Egypt—Shben El-Kom. The secondary outcome was to explore the relative importance of other known risk factors in relation to the observed prevalence.

Methods

Design

This longitudinal study examined the effect of rural versus urban environment and other risk factors on allergies and respiratory health in school children in Egypt. We enrolled school children aged from 7 to 12 years old from two locations. The first, exposed, group was drawn from the urban city of Cairo, and the second, comparison, group was from the rural area of Shben El-Kom. We used the ISAAC questionnaire (ISAAC 2012) and additional questions related to environmental factors. The questionnaire was completed four times, every 6 months. While there was an initial intent to consider ambient air pollution as a risk factor, doing so proved to be impossible with our two community designs.

Locations

Cairo is the capital of Egypt and the largest city in Africa and the Arab world and the 11th largest urban area in the world with a population of 17,816,000 (World 2012). Cairo is ranked 21st in population density (The City Mayors Foundation 2007). The city is located around the Nile River and surrounded by large deserts. Shben El-Kom, the provincial capital of Monofeya Governorate, is located in the Delta region which is 95 km from Cairo inner city. Shben El-Kom is a rural town with most of its population working in farming and does not experience the heavy road traffic found in Cairo, although for both locations, there may be other (non-traffic) sources of pollution including indoor pollution through the use of inefficient fuels for cooking.

Participants

Participants were drawn from a randomly selected a predominantly middle class school in Shben El-Kom. In Cairo, we approached a school with a similar profile of children. The

schools approved access to the children and provided all the necessary support. Children were selected from both schools to form a homogeneous sample with comparable age, physical measurements and male/female ratio between the two locations. Ethical approval was granted by the lead investigator's university and the Ministry of Education.

Four school visits took place to collect data. In visit 1, 1397 children were recruited (705 from Cairo, 692 from Shben El-Kom); in visit 2 which took place 6 months after visit 1, additional children were enrolled (sample size 2198; 1100 from Cairo, 1098 from 117 Shben El-Kom). In visits 3 and 4, after 18 and 24 months from the first visit, 2183 subjects were re-evaluated (1087 from Cairo, 1096 from Shben El-Kom; see Table 1).

ISAAC written questionnaire

The ISAAC questionnaire was used to evaluate the prevalence and severity of allergic conditions in children. The questionnaires were completed by their parents and returned the next day. ISAAC questionnaire has a standardized core questionnaire (ISAAC 2012). The questionnaire has been tested and validated and is formulated to be suitable for international comparisons. The questionnaire evaluates the severity and prevalence of asthma, eczema and rhinitis. The Arabic form of the core ISAAC questionnaire which has been used and verified by ISAAC in the Arabic centres was used for data collection (Behbehani et al. 2000).

In addition to this, other environmental questions were included which related to possible risk factors for asthma and allergy. These additional questions were added to the core ISAAC questionnaire that dealt with probable risk factors such as the family's allergic condition history, house members' smoking habits, whether children were breastfed and the presence of animals (subdivided into three groups: birds, indoor pets such as cats and dogs and farm animals).

Statistical analyses

Descriptive analysis

Descriptive statistics for all of the variables were calculated, along with frequencies and proportions for categorical

Table 1 Number of children involved at each visit

Wave	Remained in	Added in	Dropped out	Total number
Visit 1	–	1397	–	1397
Visit 2	1393	805	4	2198
Visit 3	2183	–	15	2183
Visit 4	2183	–	–	2183

variables. Means and standard deviations were calculated for continuous variables. The associations between symptom prevalence and location were analysed using chi-square tests for categorical variables. Statistical significance was evaluated at $p < 0.05$. The factors measured categorically (presence or absence of the symptom) were having been breastfed, family atopy history (asthma/eczema), exposure to passive smoking, presence of other allergic condition and exposure to animals. The continuous measures of height, age, BMI and weight were expressed as means and standard deviations (SD).

Regression analyses

Crude odds ratios (OR) and 95 % confidence intervals (CI) of major symptoms were calculated for all the risk factors which included exposure to pets, birds and farm animals, parental smoking habits and atopy history, breastfeeding and location.

A two-level generalized mixed logistic regression model with random intercepts was performed for the last four visits using the mixed model command (GENLINMIXED) in SPSS. The regression was modeled by two levels with clustering by individual and by time as scale for repeated measures. Missing data were imputed by full-information maximum likelihood estimation.

The first model (model 1) included location (Cairo/Shben El-Kom), gender (male/female), passive smoking (yes/no), paternal and maternal asthma (asthma/no asthma) and eczema history (eczema/no eczema), breastfeeding habits (breastfed/not breastfed) and keeping pets (keeping pets/not keeping pets).

The second model (model 2) included all the variables from model 1 with the exception of location, but added contact with farm animals (contact with farm animals/no contact with farm animals) and birds (presence of birds/no presence of birds). Model 2 was performed to evaluate whether the presence of farm animals and birds, although strongly correlated with location, demonstrated similar associations with the outcomes.

All statistical tests were carried out using SPSS v17 (SPSS Inc., Chicago, IL).

Results

Response rates were high in both locations as shown on Table 2

Physical measurements

T tests showed there were no significant differences between the two locations in BMI and age among all children or for boys and girls separately (all $p>0.05$) (see Table 2).

Chi-square tests showed no significant associations between location and reported health problems, medication

Table 2 Physical measurements of children studied (means $\pm$ SD) in visits 1 and 4

Variable	Visit 1				Visit 4							
	Boys		Girls		All children		Boys		Girls		All children	
	Shben El-Kom N=367	Cairo N=364	Shben El-Kom N=497	Cairo N=599	Boys N=731	Girls N=666	Shben El-Kom N=599	Cairo N=567	Shben El-Kom N=497	Cairo N=520	Boys N=1166	Girls N=1017
Age (years)	8.85±1.2	8.92±1.04	8.68±1.24	8.68±1.06	8.89±1.12	8.68±1.15	10.15±1.21	10.15±1.10	10.0±1.25	9.94±1.08	10.15±1.15	10±1.17
Ht (cm)	129.69±0.58	129.32±9.66	129.11±7.4	128.63±9	129.64±10.13	128.86±8.25	136.65±9.77	134.46±10.04	136.20±8.30	133.61±9.52	135.59±9.96	134.88±9.03
Wt (kg)	29.69±7.72	29.90±7.11	28.91±5.83	29.61±7	29.79±7.42	29.27±6.46	35.28±7.58	34.40±7.29	34.92±6.76	33.99±7.52	34.85±7.45	34.44±7.17
BMI	17.35±2.84	17.68±2.97	17.23±2.59	17.75±3.38	17.52±2.91	17.5±3.03	18.75±2.71	18.93±3.01	18.74±2.76	18.92±3.13	18.84±2.86	18.83±2.96

intake, paternal and maternal eczema and asthma and pets (Table 3). There were significant associations with breastfeeding, smoking mother, smoking father, smoking member of the household and the presence of animals, birds and farm animals. For boys, associations were found between location and breastfeeding, all animals, birds and farm animals. For girls, all animals, farm animals, birds and general smoking were significantly associated with location.

Change in symptoms with time

Prevalence rates for all symptoms were higher in Cairo, as was the increase in the rates within a year from visit 2 to visit 4 in Cairo (see Table 4). This pattern was also found for asthma, hay fever, allergic rhinitis (AR) and eczema.

Risk factors associated with children's symptoms

A two-level logistic regression model with intercept was used to analyse the risk factors associated with children's symptoms (see Table 5). The children had comparable mean ages and BMIs between the two locations; the other investigated risk/confounding factors were also included in the regression.

The results of the two-level logistic regression model 1 showed that living in Cairo was associated with current wheeze, asthma ever, current AR, AR ever, current rash and eczema ever. Boys reported significantly less wheeze ever and asthma ever.

Father eczema was significantly associated with current wheeze, wheeze ever, asthma, rash ever and eczema ever. Mother eczema was associated with current wheeze, wheeze ever, asthma ever, current rash, rash ever and eczema ever. Father asthma and mother asthma were significantly associated with current wheeze ever, current AR, AR ever, current rash, rash ever and eczema ever.. Breastfeeding was significantly associated with a decrease in reporting of current wheeze, wheeze ever, AR ever and current AR.

Having a cat or a dog pet at home was associated with current AR, AR ever and rash ever. Smoker at home was associated with current wheeze, wheeze ever, asthma ever and AR ever. Ex-smoker at home was associated with current wheeze, wheeze, asthma ever, current AR, AR ever, current rash, rash ever and eczema ever.

The results of the two-level logistic regression model 2 showed that exposure to farm animals was significantly associated with a decrease in the reporting of current wheeze, wheeze, asthma, current AR, AR, hay fever, current rash, rash and eczema. Birds were negatively correlated with wheeze and AR.

Discussion

Children in Cairo had a higher prevalence of allergic conditions and reported more severe symptoms and higher morbidity than children from Shben El-Kom; this may be due to risk factors associated with the urban/rural environment including

Table 3 Prevalence rates (in %) of other variables in children who participated in all visits at visit 4

Variables	Cairo			Shben El-Kom		
	Boys N=364	Girls N=341	All N=705	Boys N=367	Girls N=325	All N=692
Father asthma	9.2	5.6	7.4	6.0	4.4	5.2
Mother asthma	4.2	5.9*	5.0	3.3	2.8	3.1
Father eczema	7.8	6.2	7.0	4.4	5.9	5.1
Mother eczema	8.6	6.2	7.4	6.0	4.4	5.2
Breast fed	78.3**	84.6	81.4**	89.3**	87.9	86.3**
Animals	20.6**	22.2**	21.3**	76.4**	78.2**	77.3**
Smoking mother	2.5	1.2	1.9*	0.8	1.2	0.6*
Smoking father	51.7	52.7	52.1*	57.0	55.1	56.1*
General smoking	51.7	53.0*	52.3*	56.7	55.1*	56.0*
Health problem	6.7	7.4	7.0	7.9	7.5	7.7
Medication	5.3	6.8	6.0	6.6	5.9	6.3
Pets	17.8	18.0	17.9	16.2	17.8	16.9
Farm animals	0**	0**	0**	37.5**	48.9**	42.9**
Birds	2.8**	5.3**	4.0**	53.2**	44.5**	49.1**

Significant association between location and risk factors, * $p < 0.05$, ** $p < 0.01$

outdoor air pollution, or diet, infections, stress, exposure to allergens in the home and parasitic infections.

Prevalence of asthma, AR and eczema in Egypt and the region

The present study found that the overall prevalence rate of asthma in both locations ranged between 6.8 and 7.5 % in all four visits. These findings are similar to an ISAAC-based survey conducted with children in different cities and villages in Egypt (Zedan et al. 2008) with reporting an overall prevalence rate for asthma of 7.7 %. However, while Zedan et al. (2008) found the prevalence in boys was higher than that in girls, this study showed that the prevalence of asthma was higher among girls. This could be due to different geographical, social and environmental factors in these localities. In addition, it has been documented that boys and girls react differently to different risk factors, for example, girls are more susceptible to air pollution (Liu and Zhang 2009). Although the participants in Zedan et al. had a similar mean age with the present study, the age range in their study was 5–16 years while in the present study, the range was 7–12 years which could lead to a different male-female prevalence ratio because the prevalence of asthma in girls increases after puberty (Yao et al. 2011).

When comparing the prevalence rate of asthma in this study with ISAAC phase I findings of other countries (ISAAC 2012), the overall rates in Egypt could be considered relatively low. This could be due to genetic factors (von Mutius 2009): a study conducted in Israel revealed that Arabs had lower prevalence of asthma in comparison with the Jewish population (von Mutius 2009).

Risk factors

Sex

The odds of reporting wheeze and asthma were higher in girls than boys. This is consistent with other studies (Chereches-Panta et al. 2011), although many others reported that boys were more likely to wheeze or have asthma (Moorman et al. 2011). This could be attributed to other risk factors for allergies that may have an association with sex and lead to an increase in allergies in girls, because girls are more susceptible to the affects of air pollution than boys (Liu and Zhang 2009). In addition, age of puberty plays a big role in the development of asthma and allergies (Yao et al. 2011). Oestrogens are pro-inflammatory and can increase the immune response to allergens while male testosterone hormones have an anti-inflammatory effect (Osman 2003). Ghaly et al. (2008) found that for Egyptian boys, the mean age of the start of puberty was 11.86 (SD=1.45) years and 10.46 (SD=1.36) years for girls and occurred in girls as early as 7 years, which is lower

Table 4 Changes occurred in symptom prevalence rates (in %) in a year between visit 2 and visit 4

Change in symptoms	Cairo			Shben El-Kom		
	Boys	Girls	All	Boys	Girls	All
Wheeze	1.4	2.1	1.7	0.8	0.4	0.8
Asthma	1	0.9	0.9	0.5	0.6	0.6
AR	1.7	1.4	1.6	0.5	0.4	0.5
Hay fever	0.8	1.3	1.1	0.5	0.4	0.5
Eczema	0.9	0.8	0.9	0.2	0.6	0.4

than that reported in Europe and Asia which may have had a bearing on the results of the present study.

Passive smoking

Because of cultural customs in Egypt, the reported rate of maternal smoking was very low and ranged from 2 % in Cairo to 1 % in Shben El-Kom. It is also common to find grandparents and other adult family members living with the families in the same house. For these reasons, we chose to use a smoking member of the household in the regression model instead of smoking fathers and smoking mothers. Results showed that the presence of a smoking/former smoking member in the household was associated with having allergies. These findings are in accordance with previous studies (Zedan et al. 2008; Burke et al. 2012) which showed an association between childhood asthma and wheezing and parental smoking habits.

Breastfeeding

Breastfeeding was negatively correlated with wheezing, asthma and AR. These results confirm previous studies that found protective effects of breastfeeding against AR (Mimouni Bloch et al. 2002) and wheezing (Tidswell and Langley-Evans 2011). The effect of breastfeeding is associated with mother's IgE levels (Wright et al. 1999), breastfeeding exclusiveness and the introduction of solid food and other milk formula at different ages (Kull et al. 2010). The protective effect of breastfeeding could be induced by the presence of IgA, cytokines and prebiotics in breast milk (Kull et al. 2010).

Presence of pets and other animals

The presence of indoor pets (cats/dogs) was associated with allergy symptoms; however, the presence of farm animals had a negative correlation. This confirms previous work that found that growing up among farm animals has a negative correlation with allergy (Morcos et al. 2011). The possible protective effects of exposure to farm animals against allergy could be

Table 5 Factors associated with studied symptoms

Variables	Current wheeze OR (95 % CI)	Wheeze ever OR (95 % CI)	Asthma ever OR (95 % CI)	Current AR OR (95 % CI)	AR ever OR (95 % CI)	Current rash OR (95 % CI)	Rash ever OR (95 % CI)	Eczema ever OR (95 % CI)
Intercept	0.05 (0.03–0.08)**	0.06 (0.04–0.09)**	0.03 (0.02–0.05)**	0.17 (0.12–0.24)**	0.26 (0.19–0.36)**	0.05 (0.03–0.08)**	0.09 (0.06–0.13)**	0.04 (0.02–0.07)**
Cairo	1.45 (1.03–2.04)*	1.31 (0.97–1.76)	1.48 (1.05–2.10)*	1.27 (1.01–1.62)*	1.31 (1.06–1.64)*	1.51 (1.10–2.08)**	1.25 (0.97–1.61)	1.46 (1.04–2.05)*
Male	0.83 (0.59–1.16)	0.72 (0.54–0.96)*	0.68 (0.49–0.95)*	1.04 (0.82–1.31)	1.04 (0.84–1.29)	1.01 (0.75–1.38)	1.12 (0.87–1.44)	1.03 (0.74–1.44)
Father eczema	2.24 (1.25–4.03)*	2.48 (1.48–4.14)**	2.42 (1.40–4.18)**	0.85 (0.51–1.41)	0.95 (0.59–1.51)	1.47 (0.86–2.52)	2.36 (1.55–3.58)**	3.02 (1.82–5.0)**
Mother eczema	2.98 (1.78–5.00)**	3.63 (2.30–5.73)**	3.74 (2.28–6.12)**	0.98 (0.59–1.63)	1.06 (0.67–1.69)	2.38 (1.40–4.04)**	1.92 (1.20–3.07)*	2.79 (1.61–4.84)**
Father asthma	2.51 (1.49–4.23)**	4.49 (2.88–7.00)**	3.61 (2.22–5.87)**	1.72 (1.11–2.67)*	1.59 (1.05–2.41)*	2.76 (1.71–4.46)*	2.21 (1.43–3.41)**	1.94 (1.12–3.36)*
Mother asthma	2.84 (1.59–5.07)**	4.08 (2.39–6.96)**	3.11 (1.77–5.47)**	2.32 (1.51–3.57)**	2.23 (1.47–3.38)**	1.25 (0.67–2.33)	1.59 (0.96–2.65)	1.06 (0.54–2.06)
Breast feeding	0.67 (0.45–0.99)*	0.71 (0.51–1.01)	0.88 (0.58–1.35)	0.73 (0.55–0.95)*	0.50 (0.39–0.64)**	1.02 (0.68–1.53)	1.11 (0.79–1.56)	1.01 (0.65–1.57)
Pets	0.93 (0.61–1.42)	1.13 (0.79–1.61)	1.28 (0.86–1.91)	1.70 (1.30–2.23)**	1.71 (1.33–2.20)**	1.21 (0.84–1.74)	1.57 (1.18–2.10)	1.22 (0.83–1.79)
Smoker at home	2 (1.41–2.83)**	2.33 (1.72–3.17)**	2.35 (1.65–3.34)**	1.08 (0.86–1.37)	1.38 (1.11–1.71)*	1.13 (0.83–1.54)	0.99 (0.78–1.28)	1.03 (0.74–1.44)
Ex-smoker at home	6.27 (2.51–15.65)**	6.25 (2.46–14.87)**	6.67 (2.50–17.8)**	3.37 (1.61–7.06)**	3.31 (1.58–7.00)**	6.86 (3.22–14.59)**	5.45 (2.63–11.3)**	10 (4.49–22.44)**

Significant association between reported conditions and symptoms and risk factors, * $p < 0.05$, ** $p < 0.01$

explained by the exposure in early life to pathogens that leads to adequate developing of T regularity cells (Bufford and Gern 2005). These results further confirm that exposure to different animals at different ages leads to different effects on atopy (Ege et al. 2007). An environment that has detectable allergen levels and a low level of certain endotoxins could lead to animal allergen sensitization (Gereda et al. 2001).

Family allergy history

Paternal asthma or eczema increased the odds of reporting allergies and asthma in children. These results support previous studies which suggested the role of genes in allergic conditions (Simon 2000).

Changes over time

There were differences in the amount of increase in reporting of ever having a symptom between the two locations in the last three visits. Children from Cairo reported greater increases in wheezing, asthma and eczema symptoms. This could be attributed to the continuous adverse effect of the larger number of risk factors associated with the urban/rural environment discussed previously.

Limitations

There were several difficulties and limitations faced during this study. Previous work has also shown a relationship between air pollution and allergic symptoms (Robinson 2011). However, contradictory findings have been reported when evaluating the causative effect of air pollution on asthma. For example, in two systematic reviews performed by Anderson and colleagues, one (Anderson et al. 2013a) found no association between the prevalence of asthma and air pollution concentrations while the other found an association between air pollution and asthma incidence (Anderson et al. 2013b). Anderson et al. attributed these opposing findings to chance, confounding and exposure misclassification. For example, several confounding factors may not have been included in these studies like birthweight. Moreover, relying on place of residence to measure air pollution exposure could be misleading because other factors, such as occupation, time spent outdoors or type of transport used, could play a more significant role in exposure to air pollution. In addition, air pollution may increase exacerbations forcing patients to seek medical assistance (Gowers et al. 2012).

Indoor air pollution through the use of inefficient fuels for cooking is known to cause chronic obstructive pulmonary disease and acute respiratory infections in childhood (Bruce et al. 2000); however, participants were not asked which cooking fuel was used in the home. Indoor sources of air pollution could have been high in the rural area and possibly

even higher than the traffic-driven pollution in Cairo. Future work should therefore include questions related to potential pollutants within the home, in particular related to the fuel used for cooking.

One concern was the response bias: there was a possibility that those who took part may have been more likely to have (or have had) respiratory disease. However, the high response rate (in the largest sample size in visit 2, the response rate was 96.4 % in Cairo and 93.8 % in Shben El-Kom) reduces the likelihood of response bias between subjects or locations. Moreover, when comparing between the two locations, the individuals that did not participate in the survey will be likely to have similar characteristics in both groups. The large sample size in this study and the similarity in the outcomes found in the five visits, in addition to the confirmation of previous studies that reported similar findings, minimize the possibility of simple chance being responsible for the significant differences between the two locations and other possible risk factors found in this study.

A further limitation was that the information gathered relied on the recall of parents when completing the questionnaires, particularly when they had to answer questions about events from several years earlier including breastfeeding habits and previous symptoms. In addition, this study reported the diagnosis of a third party for both parents and children's allergic conditions. Blood samples and skin prick tests could have given us a more accurate diagnosis and thus would have helped us to determine the prevalence rates of the studied conditions and the risk factors associated with them more accurately, although we were unable to obtain the required approvals necessary to perform these tests.

Another difficulty was the lack of having information about other potential risk factors, including, for example, birthweight, indoor air pollution from fuel used for cooking, deprivation or parents' education (Yao et al. 2011). However, to tease out different risk factors, we performed a hierarchical test of three levels: multiple measures (level 1), nested within the person (level 2) and nested within locations (level 3). This mixed model gave estimates of the contribution of the clustering variable (i.e. location or person) to the outcome and the full picture of how the clustering at the location and person levels also influences the outcome which makes this test ideal for this study. Therefore, we are as confident as we can be that the urban/rural differences in the prevalence of allergy and asthma found in this study are likely to be independent of socioeconomic status.

Finally, this study collected information on whether a member of a household was a smoker as a proxy for environmental tobacco smoke exposure. This may not be an accurate method as specific smoking habits were not examined; hence, individual differences may have caused residual confounding. However, the general awareness of passive smoking hazards

is low in Egypt and it is very unusual for people to avoid smoking at home or around children.

Conclusion

Living in an urban area, ownership of pets and passive smoking each statistically increased the probability of having asthma and allergy. The most influential risk factors for asthma were parental allergy and passive smoking. These findings represent one of the first longitudinal studies to examine the prevalence rates of asthma, eczema and AR in Egyptian children and the associated risk factors of these conditions in urban and rural environments. These findings could be used to aid the development of prophylactic policies in Egypt and other developing countries including promoting breastfeeding and reducing outdoor air pollution.

References

- Ait-Khaled N, Pearce N, Anderson HR, Ellwood P, Montefort S, Shah J (2009) ISAAC Phase Three Study Group. *Allergy* 64(1):123–148
- Alshishtawy MM, Abdella AM, Gelber LE, Chapman MD (1991) Asthma in Tanta, Egypt: serologic analysis of total and specific IgE antibody levels and their relationship to parasite infection. *Int Arch Allergy Immunol* 96:348–354
- Anderson HR, Favarato G, Atkinson RW (2013a) Long-term exposure to outdoor air pollution and the prevalence of asthma: meta-analysis of multi-community prevalence studies. *Air Qual Atmos Health* 6(1):57–68
- Anderson HR, Favarato G, Atkinson RW (2013b) Long-term exposure to air pollution and the incidence of asthma: meta-analysis of cohort studies. *Air Qual Atmos Health* 6(1):47–56
- Behbehani NA, Abal A, Syabbalo NC, Abd Azeem A, Shareef E, Al-Momen J (2000) Prevalence of asthma, allergic rhinitis, and eczema in 13- to 14-year-old children in Kuwait: an ISAAC study. *Ann Allergy Asthma Immunol* 85(1):58–63
- Bruce N, Perez-Padilla R, Albalak R (2000) Indoor air pollution in developing countries: a major environmental and public health challenge. *Bull World Health Organ* 78(9):1078–1092
- Brunekreef B, Stewart AW, Anderson HR, Lai CK, Strachan DP, Pearce N (2009) Self-reported truck traffic on the street of residence and symptoms of asthma and allergic disease: a global relationship in ISAAC phase 3. *Environ Health Perspect* 117(11):1791–1798
- Bufford J, Gern JE (2005) The hygiene hypothesis revisited. *Immunol Allergy Clin N Am* 25(2):247–262
- Burke H, Leonardi-Bee J, Hashim A, Pine-Abata H, Chen Y, Cook DG et al (2012) Prenatal and passive smoke exposure and incidence of asthma and wheeze: systematic review and meta-analysis. *Pediatrics* 129(4):735–744
- Cherches-Panta P, Dumitrescu D, Marshall M, Mirestean I, Muresan M, Iacob D et al (2011) Epidemiological survey 6 years apart: increased prevalence of asthma and other allergic diseases in schoolchildren aged 13–14 years in Cluj-Napoca, Romania (based on Isaac questionnaire). *Maedica (Buchar)* 6(1):10–16
- Dagoye D, Bekele Z, Woldemichael K, Nida H, Yimam M, Hall A et al (2003) Wheezing, allergy, and parasite infection in children in urban and rural Ethiopia. *Am J Respir Crit Care Med* 167(10):1369–1373

- Ege M, Frei R, Bieli C, Schram-Bijkerk D, Waser M, Benz M (2007) Not all farming environments protect against the development of asthma and wheeze in children. *J Allergy Clin Immunol* 119(5):140–147
- Ellwood P, Asher MI, García-Marcos L, Williams H, Keil U, Robertson C et al (2013) Do fast foods cause asthma, rhinoconjunctivitis and eczema? Global findings from the International Study of Asthma and Allergies in Childhood (ISAAC) phase three. *Thorax* 68(4):351–360
- Gereda JE, Klinnert MD, Price MR, Leung DY, Liu AH (2001) Metropolitan home living conditions associated with indoor endotoxin levels. *J Allergy Clin Immunol* 107(5):790–796
- Ghaly I, Hussein FH, Abdelghaffar S, Anwar G, Seirvogel RM et al (2008) Optimal age of sexual maturation in Egyptian children. *East Mediterr Health J* 14(6):1391–1399
- Gowers AM, Cullinan P, Ayres JG, Anderson HR, Strachan DP, Holgate ST et al (2012) Does outdoor air pollution induce new cases of asthma? *Respirology* 17(6):887–898
- Hugg TT, Jaakkola MS, Ruotsalainen R, Pushkarev V, Jaakkola JJ (2008) Population-based cross-sectional study in Finnish and Russian children. *Environ Health* 7:28
- International Study of Asthma and Allergies in Childhood (ISAAC) (2012) The story of ISAAC, <http://isaac.auckland.ac.nz/story/Ch5/Centres.pdf>. Accessed on 25/2/2013.
- Kull I, Melen E, Alm J, Hallberg J, Svartengren M, van Hage M et al (2010) Breast-feeding in relation to asthma, lung function, and sensitization in young schoolchildren. *J Allergy Clin Immunol* 125(5):1013–1019
- Liu L, Zhang J (2009) Ambient air pollution and children's lung function in China. Review article. *Environ Int* 35(1):178–186
- Mimouni Bloch A, Mimouni D, Mimouni M, Gdalevich M (2002) Does breastfeeding protect against AR during childhood? A meta-analysis of prospective studies. *Acta Paediatr* 91(3):275–279
- Moorman JE, Zahran H, Truman BI, Molla MT (2011) Current asthma prevalence—United States, 2006–2008. *MMWR Surveill Summ* 60(01):84–86
- Morcos MM, Morcos WM, Ibrahim MA, Shaheen MA (2011) Environmental exposure to endotoxin in rural and urban Egyptian school children and its relation to asthma and atopy. *Minerva Pediatr* 63(1):19–26
- Osman M (2003) Therapeutic implications of sex differences in asthma and atopy. *Arch Dis Child* 88:587–590
- Priftis KN, Mantzouranis EC, Anthracopoulos MB (2009) Asthma symptoms and airway narrowing in children growing up in an urban versus rural environment. *J Asthma* 46(3):244–251
- Robinson CL (2011) Effect of urbanisation on asthma, allergy and airways inflammation in a developing country setting. *Thorax* 66(12):1051–1057
- Simon H (2000) CRC desk reference for allergy and asthma. CRC press, Florida
- The City Mayors Foundation (2007) The largest cities in the world by land area, population and density. <http://www.citymayors.com/statistics/largest-cities-density-125.html>. Accessed on 14/1/2013.
- Tidswell E, Langley-Evans S (2011) The health benefits of breastfeeding on the risk of children developing allergic asthma. *J Hum Nutr Diet* 24(3):307
- von Mutius E (2009) Gene by environment interaction in asthma. *J Allergy Clin Immunol* 123(1):3–11
- Wang KY, Chau TT (2013) An association between air pollution and daily outpatient visits for respiratory disease in a heavy industry area. *PLoS ONE* 8(10):e75220
- World Atlas (2012) Largest cities of the world by metro population <http://www.worldatlas.com/city pops.htm#UZcxR7XVDzx>. (Accessed 11/3/2013)
- World Health Organisation Statistical Information System (2013) Asthma by country. http://www.NationMaster.com/graph/mor_ast-mortality-asthma. Accessed on 10/4/2013.
- Wright AL, Sherrill D, Holberg CJ, Halonen M, Martinez FD (1999) Breast-feeding, maternal IgE, and total serum IgE in childhood. *J Allergy Clin Immunol* 104(3 Pt 1):589–594
- Yao TC, Ou LS, Yeh KW, Lee WI, Chen LC, Huang JL (2011) Associations of age, gender, and BMI with prevalence of allergic diseases in children: PATCH study. *J Asthma* 48(5):503–510
- Zedan M, Settin A, Farag M, Ezz-Elregal M, Osman E, Fouda A (2008) Prevalence of bronchial asthma among Egyptian school. *Egypt J Bronchology* 3(2):124–130