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What factors are associated with the prevalence of atopic symptoms amongst adolescents in Greater Manchester?

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Introduction: Atopy commonly manifests itself as atopic diseases (ADs), namely asthma, eczema and hay fever. The prevalence of AD is rising worldwide, and it is widely accepted as a major public health issue, due to the significant burden of AD on health care systems. **Method:** Data were obtained from the youth survey of the European Urban Health Indicator System 2 project. The study participants were students aged 14–16 years from Greater Manchester. The main outcomes measured were the prevalence of atopic symptoms and the factors associated with the development of atopy. **Results:** Of the sample studied, 70% reported having had an AD during their lifetime. The lifetime prevalence of ever having asthma, eczema or hay fever was 33.4%, 28.1% and 49.0%, respectively. Gender, family affluence, body mass index, diet, smoking and worrying were all significantly associated with atopic symptoms. Smoking was the only variable to be significantly associated with all three ADs. Season of birth and pollution were not shown to be associated with atopic symptoms. **Conclusion:** This study demonstrates that the prevalence of AD in Greater Manchester was high amongst adolescents. Several environmental, demographic and social factors were found to be significantly associated with the development of atopic symptoms. This study provides a baseline for future studies to further investigate the factors that are associated with AD and allow for the implementation of preventative public health policy.

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Introduction

Atopy is defined as an immunological disorder determined by a complex combination of genetic and environmental factors.¹ Atopic individuals produce specific Immunoglobulin E (IgE) in response to exposure to environmental allergens.² Atopy commonly manifests itself as atopic diseases (ADs), namely asthma, eczema and hay fever.

The prevalence of AD is rising worldwide, and it is widely accepted as a major public health issue, due to the significant burden AD has on health care systems.³ Despite a wealth of research, the aetiology of AD remains poorly understood. Epidemiological studies form the

foundation of efforts to enhance knowledge of risk and protective factors as well as the changing prevalence of AD.⁴ Identifying such factors will determine future direction for research into causation, prevention and public health policy.

Significant geographical variations have been observed with respect to the prevalence of AD worldwide, with the highest prevalence rates for asthma in Western countries and the lowest in developing countries.⁵ Both eczema and hay fever have a more scattered worldwide distribution.

The UK has one of the highest prevalences of allergic disease in the world.⁶ The burden of AD in the UK is further put into perspective

when we consider that in 2001, 6% of all consultations in general practice were for AD, 65.1 million community prescriptions were administered in relation to AD and 70 000 AD-related hospital admissions were made.⁷

The geographical diversity of AD suggests that its aetiology involves genetic and environmental interactions. There is somewhat of a phenotypic plasticity with regards to the expression of allergy, and it is largely considered that not only the exposure but also the timing of the exposure to the environmental risk factors dictate the onset of atopic symptoms.⁸ A review of the literature suggests that the following factors may be related to the development of AD: genetics,^{1–3,8,9} gender,^{1,2} infection,^{1,2,9} smoking,^{1–3,10} exposure to allergens,^{2,3} diet,^{1–3,10} immune system development,⁹ pollution,^{1,3,8,10} stress,¹ maternal factors,¹ post-natal factors,¹ heavy metals,³ xenobiotics,³ season of birth (SOB),¹¹ pesticides³ and economic status.¹⁰ Questions regarding interaction between these factors and how allergies arise remain unanswered.

The 'hygiene hypothesis' was first proposed by Strachan who stated that infection in childhood from siblings or from the mother prenatally act as a protective factor for AD.¹² Children from large families have been shown to be less at risk of AD as they are likely to be exposed to more infections.¹² Over the past 20 years, many studies have presented findings to support this theory and have further suggested that Western lifestyle is largely causative.^{8,13} However, the hygiene hypothesis has been challenged, particularly as the prevalence of asthma in some Western countries has decreased in recent years.⁵ Therefore, this hypothesis cannot fully explain the aetiology of AD.

It has been widely speculated that both maternal and childhood diet can impact on the development of AD.^{3,10} Consumption of trans fats is associated with an increased prevalence of AD, whereas fruit and vegetable consumption is thought to have a protective effect.¹⁰ Maternal diets that are high in fruits, vegetables and fish oils are associated with a reduced risk of early childhood asthma.¹⁴ Studies have demonstrated significant associations between a high body mass index (BMI) and asthmatic symptoms.^{15–18} The links between BMI and other ADs are less clear. A study found that BMI was not associated with hayfever.¹⁹ However, there may be an association between eczema and high BMI.²⁰ With the changing prevalence of AD worldwide, increased knowledge regarding the association between food, BMI and AD is required.

The SOB hypothesis suggests that individuals born when certain allergen levels are elevated and are highly exposed to those allergens in the first month of life are at greater risk of developing AD.¹¹ Studies of the SOB hypothesis are generally contradictory; however, the most recurrent finding is that children born in autumn are more likely to develop asthma. This correlates with exposure to high levels of house dust mite during this season.^{11,21,22} More robust evidence in this area may allow health professionals to give specific allergen avoidance advice to children born in months when allergen levels are high.

Exposure to both indoor and outdoor pollution has been suggested to be associated with AD.^{1,3,10} Pollutants are thought to increase the risk of allergy in two ways: by altering the potency of allergen exposure and by altering the development of the immune system in early life.³

It has been suggested that people who smoke have higher IgE concentrations in their blood and therefore are more likely to become sensitized to allergens and develop AD.² In particular, the relationship between smoking and asthma has been heavily studied due to its association with bronchial hyperreactivity.² It is widely accepted that exposure to cigarette smoke is related to the development of asthma.³

The aims of this study are to investigate the prevalence of AD amongst adolescents and investigate the factors that were associated with the development of AD amongst adolescents in Greater Manchester (GM).

Methods

The methodology for the youth survey, including the sampling strategy, can be found in 'Collecting standardised urban health indicator data at an individual level for school-aged children living in urban areas (UAs): methods from EURO-URHIS 2'.²³ The main outcome measures relating to AD for this study were the prevalence of AD and the factors that are associated with the prevalence of AD. Twelve-month prevalence of atopy was measured in reference to self-reported symptoms of asthma, eczema and hay fever 'in the last 12 months', namely wheezing, rhinitis and an itchy rash. The lifetime prevalence was measured in reference to 'ever' having a diagnosis of asthma, eczema or hay fever. To determine the factors associated with the development of atopy, associations between dependent variables (symptoms of asthma, eczema and hay fever in the last 12 months) and independent variables were measured. The variables included gender, SOB, family affluence (calculated according to the Family Affluence Scale, WHO Europe—http://www.euro.who.int/__data/assets/pdf_file/0005/53852/E91416.pdf), self-reported BMI, diet, smoking status, whether they worry a lot and exposure to pollution.

All data were analysed using SPSS version 16. Prevalence rates were calculated by dividing the number of positive responses to survey questions (numerator) by the total number of survey participants (denominator). Associations between the prevalence of AD and individual variables were established with cross tabulations using Pearson's Chi Squared Test.

Results

The response rate to the EURO-URHIS 2 youth survey was 86.3% ($n = 4017$). A total of 3466 adolescents completed the EURO-URHIS 2 youth survey across the 10 UAs of GM. Out of the total sample, 46.6% were male and 53.4% were female. The ages of the sample ranged between 14 and 16 years (mean age was 14.97 years). More detailed demographics of the sample are reported in table 1.

The reported lifetime prevalence of ever having asthma, eczema or hay fever was 32.4%, 27.6% and 47.5%, respectively. Overall, 70.0% of respondents reported having one or more ADs in their lifetime. Of these, 37.1% reported only having one AD, 25.6% reported having two ADs and 7.4% reported having all three ADs in their lifetime; 18.6% reported wheezing, 31.0% reported rhinitis and 11.8% reported an itchy rash in the last 12 months. Overall, 46.6% of the sample reported suffering from at least one or more ADs in the last 12 months. Of these, 32.5% reported only having one AD, 12.0% reported having two ADs and 2.1% reported having all three ADs over the past 12 months.

Figure 1 compares the lifetime prevalence of AD and the 12-month prevalence of atopic symptoms. There was a significant difference between the number of adolescents reporting wheezing, an itchy rash and rhinitis in the last 12 months compared with adolescents reporting asthma (χ^2 , $P < 0.001$), eczema (χ^2 , $P < 0.001$) and hay fever (χ^2 , $P < 0.001$) in their lifetime.

Asthma

No statistically significant associations were seen between wheezing in the last 12 months and self-reported BMI, SOB, worrying and pollution.

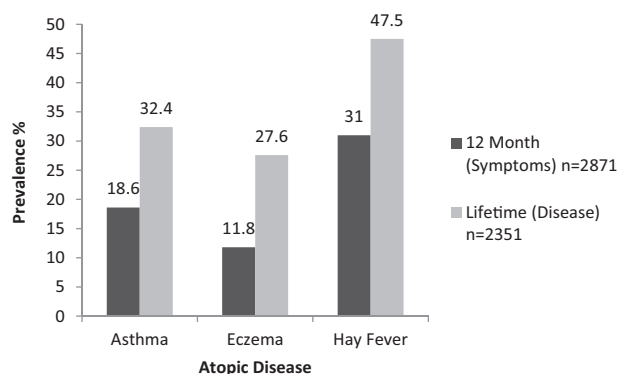
There were significant associations between adolescents reporting asthmatic symptoms in the last 12 months and gender, family affluence, school performance, diet and smoking status. Table 2 outlines the significant associations.

Eczema

No statistically significant associations were seen between symptoms of eczema and the following in the previous 12 months: SOB; family

Table 1 Population demographics and prevalence rates of symptoms and diagnosis of asthma, hay fever and eczema

Variable	N(%)	Asthma ever, N(%)	Wheezing in past 12 months, N(%)	Eczema ever, N(%)	Itchy rash in the past 12 months, N(%)	Hay fever ever, N(%)	Rhinitis in the past 12 months, N(%)
Total	3466	1123(32.4)	645(18.6)	956(27.6)	408 (11.8)	1646(47.5)	1075(31.0)
Missing data	0(0)	71(2)	79(2.3)	82(2.4)	88(2.5)	82(2.4)	53(1.5)
Gender							
Male	1615(46.6)	485(30.8)	258(16.4)	360(22.9)	153(9.8)	730(46.6)	478(30.1)
Female	1851(53.4)	638(35.1)	387(21.3)	596(32.6)	255(14.1)	916(50.4)	597(32.7)
Missing data	0(0)	71(2)	79(2.3)	65(1.9)	88(2.5)	82(2.4)	53(1.5)
SOB							
Winter	811(23.4)	262(33.0)	147(18.5)	233(29.1)	91(11.5)	391(49.3)	239(29.8)
Spring	880(25.4)	298(34.6)	163(19.0)	225(26.1)	106(12.4)	434(50.4)	280(32.6)
Summer	853(24.6)	268(32.0)	158(19.0)	246(29.6)	95(11.5)	388(46.6)	268(31.8)
Autumn	909(26.2)	291(32.7)	174 (19.6)	251(28.0)	114(12.7)	425(48.1)	286(32.0)
Missing data	13(0.4)	84(2.4)	91(2.6)	78(2.3)	101(2.9)	95(2.7)	66(1.9)
Family Affluence Scale							
Low	282(8.1)	101(36.8)	69(25)	78(28.5)	41(15.0)	132(48.0)	93(33.5)
Middle	1216(35.1)	411(34.5)	247(20.8)	317(26.6)	132(11.2)	552(46.6)	390(32.4)
High	1839(53.1)	576(31.9)	310(17.2)	536(29.6)	224(14.3)	905(50.3)	561(31.0)
Missing data	129(3.7)	195(5.6)	203(5.9)	190(5.5)	215(6.2)	209(6)	177(5.1)
Self-reported BMI							
Under/normal Weight	1854(53.5)	598(32.8)	34 (19.1)	524(28.9)	225(12.4)	887(48.8)	596(32.6)
Overweight	292(8.4)	103(36.4)	58(20.6)	89(31.1)	50(21.5)	145(51.8)	90(31.4)
Obese	86(2.5)	35(41.2)	18 (21.4)	25(29.1)	17 (21.0)	38(44.7)	27 (31.4)
Missing data	1234(35.6)	1273(36.7)	1281(37.0)	1278(36.9)	1286(37.1)	1285(37.1)	1267(36.6)
Eating fruit							
Rarely or never	1035(29.9)	378 (37.2)	230(22.7)	282(27.8)	133(13.2)	480 (47.6)	367(36.1)
Often	2043(58.3)	731(31.1)	402(17.1)	663(28.1)	271(11.5)	1155(49.2)	700(29.6)
Missing data	45(1.3)	96(2.8)	106(3.1)	92(2.7)	113(3.3)	109(3.1)	81(2.3)
Eating chips							
Rarely/never	434(31.7)	434(31.7)	230(16.4)	403(29.4)	175(12.9)	666(48.5)	400(29.0)
Often	669(33.8)	669(50.9)	403(20.4)	537(27.1)	230(11.9)	958(48.7)	666(33.5)
Missing data	45(1.3)	114(3.3)	122(3.5)	109(3.1)	129(3.7)	126 (3.6)	97(2.8)
Smoking							
Yes	1328(38.3)	507(39.0)	322(24.9)	274 (24.2)	189(14.7)	640(49.4)	492(37.7)
No	2118(61.1)	605(29.1)	316(15.24)	679 (30.2)	216(10.4)	999(48.3)	579(27.7)
Missing data	20(0.6)	90(2.7)	98(2.8)	84(2.4)	108(3.1)	100(2.9)	73(2.1)
Worrying							
Worries	2285(65.9)	781(34.9)	442(19.8)	274(24.2)	316(14.1)	1135(50.6)	768 (51.8)
Worries rarely	1163(33.6)	338(29.7)	201(17.7)	679(43.3)	89(7.9)	504(44.9)	302(26.4)
Missing data	18(0.5)	89(2.6)	96(2.8)	83(2.4)	106(3.1)	100(2.9)	71(2.0)
Pollution							
Near	2356(68.0)	768(33.3)	441(19.2)	648(28.0)	288(12.5)	1134(49.3)	747(32.1)
Far	975(28.1)	314(32.8)	117(18.5)	663(28.1)	105(11.0)	450 (47.4)	292(30.5)
Missing data	135(3.9)	98(2.8)	208(6.1)	195(5.6)	218(6.3)	214(6.2)	183(5.3)

**Figure 1** Comparison between the lifetime prevalence of AD and the 12-month prevalence of atopic symptoms amongst adolescents in GM

affluence; school performance; eating fruit; eating chips and pollution.

There were significant associations between adolescents reporting symptoms of eczema and the following in the previous 12 months:

gender; self-reported BMI; smoking status and worrying. Table 2 outlines the significant associations.

Hay fever

No statistically significant associations were seen between adolescents reporting symptoms of hay fever and the following in the previous 12 months: gender; SOB; self-reported BMI and pollution.

There were significant associations between adolescents reporting symptoms of hay fever and the following in the previous 12 months: school performance; diet (specifically eating fruit and chips regularly); family affluence; smoking status and worrying. Table 2 outlines the significant associations.

Discussion

Seventy percent of adolescents in GM had suffered from an AD during their lifetime and 46.6% had suffered from atopic symptoms in the last 12 months. The variables that were significantly associated with ADs are summarized in table 3 ($P \leq 0.05$).

The lifetime co-prevalence of asthma, eczema and hay fever in the study was 7.4%, and the 12-month co-prevalence of all three was 2.1%. This illustrates the significant co-morbidity of asthma, eczema

Table 2 Significant associations between variables and adolescents reporting asthmatic, eczema and hay fever symptoms in the last 12 months

Variable	Asthma	Eczema	Hay fever
Gender	P < 0.001	P < 0.001	P = 0.106
Male	16.4%	9.8%	30.1%
Female	21.3%	14.1%	32.7%
Family affluence	P = 0.002	P = 0.217	P = 0.007
Low	25.0%	15.0%	33.5%
Intermediate	20.8%	11.2%	32.4%
High	17.2%	14.3%	31.0%
School performance	P < 0.001	P = 0.526	P = 0.006
Bad performance	23.8%	12.9%	35.4%
Good performance	17.4%	12.0%	30.3%
Diet—Fruit	P < 0.001	P = 0.168	P = 0.001
Eat fruit regularly	17.1%	11.5%	29.6%
Don't eat fruit regularly	22.7%	13.2%	36.1%
Diet—Chips	P = 0.001	P = 0.289	P = 0.006
Eat chips regularly	20.4%	11.9%	33.5%
Don't eat chips regularly	16.4%	12.9%	29.0%
Smoking	P < 0.001	P < 0.001	P < 0.001
Ever smoked	24.9%	14.7%	37.7%
Never smoked	15.2%	10.4%	27.7%
Self-reported BMI	P = 0.731	P = 0.007	P = 0.892
Worrying	P = 0.154	P < 0.001	P < 0.001
Worried a lot	19.8%	14.1%	51.8%
Worried rarely	17.7%	7.9%	26.4%
Pollution	P = 0.67	P = 0.234	P = 0.369
Near	19.2%	12.5%	32.1%
Far	18.5%	11.0%	30.5%
SOB	P = 0.96	P = 0.802	P = 0.639
Winter	18.5%	11.5%	29.8%
Spring	19.0%	12.4%	32.6%
Summer	19.0%	11.5%	31.8%
Autumn	19.6%	12.7%	32.0%

Table 3 Variables significantly associated with asthma, eczema and hay fever

Asthma	Eczema	Hay fever
• Gender	• Gender	• Diet
• Family affluence	• Self-reported BMI	• Smoking
• Diet	• Smoking	• Worrying
• Smoking	• Worrying	• School performance
• School performance		• Family affluence

and hay fever and highlights the burden of AD on adolescent populations. The EURO-URHIS 2 study found a significant difference between the lifetime prevalence and the 12-month prevalence of AD, as fewer atopic symptoms were reported in the last 12 months. This may be due to the fact that adolescents whose AD was well controlled by medication were unlikely to report symptoms.

This study shows a significant association between gender and symptoms of eczema and asthma, with more girls reporting symptoms than boys. No association was found between gender and hay fever. Previous studies have suggested that atopy is more common in boys until puberty when this pattern reverses and AD becomes more common in girls.^{24–28} Certain studies have suggested that gender differences in the prevalence of atopy may be a result of socio-cultural differences in symptom perception between males and females.²⁸ A study on gender differences and symptom perception stated that women were 50% more likely to report physical symptoms.²⁹

The SOB hypothesis suggests that the month a child is born in can affect their future development of atopy. The EURO-URHIS 2 study showed no association between SOB and the development of AD. Studies undertaken around the world have all suggested a significant link between SOB and AD.^{11,21,30,31} However, the sample sizes in

these studies were all small. Austin *et al.*²⁷ found no association between month of birth and atopic symptoms. Furthermore, a review article on the association between birth month and AD concluded that literature was inconsistent.²⁴

Family affluence was significantly associated with symptoms of asthma. Adolescents from low family affluence reported more symptoms of wheezing. Results in the literature were inconsistent with regards to socioeconomic status and asthma. Some studies showed no relationship,^{32,33} others showed a positive relationship¹⁰ and others a negative one.³⁴ Children from a lower socio-economic background were more likely to be exposed to pollution, which may result in them developing more asthmatic symptoms.³⁵

Eczema was the only AD significantly associated with self-reported BMI, with overweight adolescents reported more symptoms of eczema. Results from EURO-URHIS 2 were in keeping with another study,³⁶ which showed eczema, but not hay fever, to be associated with high BMI. However, results from EURO-URHIS 2 contradict the well-established relationship regarding asthma and BMI.^{18,36} This could be because the EURO-URHIS 2 study analysis was based on self-reported measurements. Around 35% of EURO-URHIS 2 respondents did not answer the questions regarding their weight and height, which indicates that the results may not be representative. However, the relationship with BMI and asthma has been challenged by several studies which show no association.^{37,38}

A significant association between eating chips and fruit was seen for both asthma and hay fever. Adolescents who ate fruit regularly reported fewer symptoms of asthma and hay fever while those who ate chips regularly reported more symptoms. Fruit's protective effect is thought to be because of anti-oxidant content and the effects on intestinal microflora.³⁹ The consumption of trans fatty acids increases the risk of AD.¹⁰ The change in diets over the last century and the increased availability of fatty foods emphasizes the importance of understanding the role that diet has in the development of AD.

Results from the EURO-URHIS 2 study found that adolescents who have smoked reported more symptoms of AD. These findings were in keeping with current literature's consensus that people who smoke had higher levels of IgE in their blood and therefore were more likely to develop atopic symptoms. Studies support EURO-URHIS 2 findings.^{40,41}

A significant association exists between worrying and symptoms of hay fever and eczema, with adolescents who worry more reporting more symptoms. It is believed that stress can disrupt physiological pathways and this leads to an increased risk of AD.⁴² However results from the EURO-URHIS 2 study found no association between worrying and asthma.¹ The terms 'stress' and 'worry' can be interpreted differently. The EURO-URHIS 2 survey did not focus directly on stress and instead used the notion of worrying as a proxy measure for stress. This may have limited the results.

No association was found between atopic symptoms and distance from the nearest main road. It is speculated that increased exposure to traffic-related air pollution may be a factor which has caused a rise in AD.³

Study strengths

The major strength of this study lay with the large sample size covering a range of adolescents from different socio-economic backgrounds. The relevance of the EURO-URHIS 2 study was enhanced by the fact that respondents had answered survey questions themselves. Therefore, the obtained results were a direct indication of prevalence and the associated factors of AD.

This study also collected information on exposure to risk factors, which may affect the development of atopic symptoms in the last 12 months. The use of 12-month prevalence of symptoms was a more accurate measurement of disease compared with diagnostic labelling, which was used in many other studies of this nature and was subject

to recall bias.^{28,40} However, it was acknowledged that the analysis may be limited by not including adolescents whose symptoms have been well controlled in the past year.

Study limitations

The cross-sectional survey design of the EURO-URHIS 2 study limited the results, as they only represent a snapshot in time. Population characteristics are changing continuously; therefore, the EURO-URHIS 2 results may not be representative of the current situation. The nature of this study design means that at most the study has only identified associations rather than the direction of cause and effect. Not all factors that have been acknowledged in literature to be related to the development of AD could be analysed in this study due to the limitations of the questions included in the EURO-URHIS 2 survey.

The results from this study were not objective measurements and this may be a source of bias. Nevertheless the questions from the EURO-URHIS 2 youth survey were based on validated research instruments.

The methodology stated at least 400 adolescents should be sampled in each UA; however, because of problems with gathering data, only 4 out of 10 of the UAs that make up GM met this goal and this could be a cause of bias.

Conclusion

It can be concluded that the prevalence of AD amongst adolescents was high when compared with worldwide figures. Findings from the ISAAC study⁵ revealed worldwide prevalence rates of asthma ranging from 3 to 34% (UK's prevalence at 34%), hay fever ranging from 4 to 40% (UK's prevalence at 16%) and eczema ranging from 1 to 18% (UK's prevalence at 16%). The estimated direct healthcare costs for the UK are over £1 billion per year, with treatments accounting for 11% of prescribing costs.⁷ This demonstrates the potential burden of AD on healthcare in GM and other UAs.

Gender, family affluence, school performance, self-reported BMI, diet, smoking and worrying have been shown to be associated with AD. These results provide a baseline for future studies to further investigate the factors that are associated with AD. Better knowledge of such factors should allow for the implementation of targeted public health policy against AD.

Continued urbanization and lifestyle changes mean that trends in the prevalence of atopic symptoms should be monitored, and more research into the factors associated with AD, taking into account genetic and environmental interplay, should take place. To alleviate some of the burden on healthcare, it is important for awareness raising and targeted public health policies, including anti-smoking campaigns amongst adolescents to be implemented.

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Key points

- The prevalence of atopic disease (AD) amongst adolescents in Greater Manchester is high when compared with worldwide figures.

- Gender, family affluence, school performance, self-reported BMI, diet, smoking and worrying are all associated with at least one AD.
- Smoking is the only factor associated with asthma, eczema and hay fever.
- These results provide a baseline for future studies to further investigate these factors, so that better knowledge will allow the implementation of targeted public health policy against AD.

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