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The Southern Sweden Adolescent Allergy-Cohort: Prevalence of allergic diseases and cross-sectional associations with individual and social factors

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ABSTRACT

Objectives: Asthma and allergic diseases are the most frequent chronic diseases in childhood worldwide, and considered a burden for the affected children and their families. The diseases impose an economic burden on society if not diagnosed and treated properly and management of and these diseases are challenging for healthcare professionals. The aim of the present investigation was to assess the prevalence of allergic diseases in an unselected cohort of adolescents in southern Sweden. Additionally, associations with sociodemographic factors were investigated, as well as impact on daily life. **Methods:** This cross-sectional study was based on a cohort of $n = 1\,530$ school children, aged 13 to 14, from 13 municipalities in southern Sweden. Data were collected through web-based questionnaires. **Results:** Of all children 32% reported at least one allergic disease. 67% reported one allergic disease and 33% reported more than one. No allergy-related disease were reported by 68%. Current asthma was reported by 9.8% and current rhino-conjunctivitis was reported by 13%. The prevalence of food hypersensitivity was 12% and the prevalence of eczema was 11%. One to three wheezing attacks were reported from 55% and 40% reported more than four attacks of wheezing in the preceding year. The self-reported allergic diseases were diagnosed by a doctor in; 36% (food hypersensitivity) to 69% (rhinoconjunctivitis) of the cases. **Conclusions:** A high number of affected children were identified. Some children being undiagnosed and some not receiving satisfactory treatment. These results suggest that additional studies to evaluate treatment procedures in order to improve healthcare for allergic children are warranted.

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Introduction

Asthma and allergic diseases are the most common chronic diseases during childhood worldwide. European studies among adolescents show wide variations in the prevalence of rhinitis, rhinoconjunctivitis and current asthma (1–4). The national Swedish environmental health report (2013) and the Swedish children's environmental health survey (2011), reported national and regional prevalence of asthma and rhinitis in children aged 12 (5,6). The national prevalences among 12-year old children; asthma 9%, rhinoconjunctivitis 13%, asthma treatment 10% and 8% of children experience a significant impact on their daily life function. The reported results also exhibited clear regional differences that could depend on, for example, differences in climate and environment, as well as healthcare and parental

education level (6). Recent and more specific data on asthma and rhinoconjunctivitis among adolescents in southern Sweden are lacking. Allergic disease and asthma in childhood have been shown to be a burden not only for the affected children but also for their families and impose an economic burden on society (4,7,8). Many children with asthma might not have sufficient asthma control. In a Dutch study, it was shown that 55% of the children aged 4–11 years, treated with inhaled corticosteroids (ICS), had sub-optimal control (9). There is a need of further studies of children's wellness, with focus on asthma and allergic diseases.

The aim of the present cross-sectional investigation was to assess the prevalence of asthma and allergic diseases in an unselected cohort of adolescents aged 13–14 living in southern Sweden. Additionally, associations with

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sociodemographic and lifestyle factors were investigated, as well as impact on daily life.

Materials and methods

Participating schools

The investigated population is from southern Sweden (the counties of Blekinge, Kronoberg, Skåne and southern part of the county of Halland), with 52 municipalities in total. A stratified random sample of 13 municipalities was made in order to get representation of both smaller and larger municipalities. Counties by the sea as well as rural areas were also represented. Study information was sent by post to the headmasters and school nurses of 104 schools in the 13 selected local municipalities, and each headmaster was personally contacted by phone in order to elicit the school's participation in the study.

The living area was defined as: large city $\geq 250\,000$ inhabitants (1 city), city $\geq 50\,000$ inhabitants (6 cities) and rural $< 50\,000$ inhabitants (6 areas).

Informed consent

Among the schools where the headmaster agreed to participate, parents to children in 7th and 8th grade were provided with study information and a consent document to be returned to the investigators.

The questionnaires

The study used two web-based questionnaires, comprising 110 questions for children and 52 questions for parents. From *The International Study of Asthma and Allergies in Childhood* (ISAAC) questionnaire we used the questionnaire modules about asthma, eczema and rhinoconjunctivitis intended for children aged 13–14 (10–12). The ISAAC questionnaire was constructed as a tool for epidemiological research in asthma and allergic diseases. The translation from English to Swedish has followed the strict rules set up by a steering committee of ISAAC (12). In our study we also included questions regarding food hypersensitivity and contact allergy, used in previous epidemiological studies (13,14). The parental questionnaire contained questions regarding medication

and personal characteristics, home environment, parental smoking and physical exercise habits. School location was used as a proxy for the living area, since in Sweden, most children go to schools close to home. The questions were presented with fixed alternative answers, except questions in the parental questionnaire regarding medical treatment.

GINA and ARIA guidelines were used to determine severity of asthma and rhinoconjunctivitis (15,16).

The web-based survey was constructed and provided by Clinical Studies Sweden, Forum South, Skåne University Hospital.

Definitions

Current asthma, current rhinoconjunctivitis, current eczema and current food hypersensitivity were obtained from the questionnaire data using definitions listed in Table 1.

Procedure and study-population

Of the 104 invited schools, 51 agreed to participate (i.e. the headmaster agreed). Parental consent was obtained for 2 568 (46%) of the 5 622 eligible children attending participating schools. A total of 1530 children (60% of all with consent, 27% of all eligible) and parents answered the questionnaire. Children's answers numbered 1 333 (52% of all with consent, 24% of all eligible), of which 888 questionnaires were matched by parents answers and 445 were children's answers only (Figure 1). Ninety-eight percent of children answering were aged 13–14, with a mean 13.5 years and min-max 12–14 years of age.

From participating schools, a new random sample selection of schools was made for the clinical part of the study (phase II, *blood samples and epicutaneous testing*) with 200 participating children as a goal. These results will be presented separately.

Statistical analysis

All statistical analyses were conducted using IBM SPSS Statistics 22.0 for Windows (SPSS Inc., Chicago, IL, USA). Fisher's exact test and Chi square test were used for testing differences in binary and categorical sociodemographic

Table 1. Definitions, self-reported; asthma, rhinoconjunctivitis, eczema and food-hypersensitivity.

Variables	Definition
Self-reported current asthma	Was defined if the child answered yes on whistling and wheezing, during life and last year
Self-reported current rhino-conjunctivitis	Was defined if the child answered yes on rhinitis (sneezing, runny blocked nose without a cold) during life and last year and conjunctivitis (itchy and/or watery eyes) during life and last year
Self-reported current eczema	Was defined if the child answered yes on itching, rash/eczema during six months and last year.
Self-reported current food hypersensitivity	Was defined if the child answered yes on food reaction during life and last year.

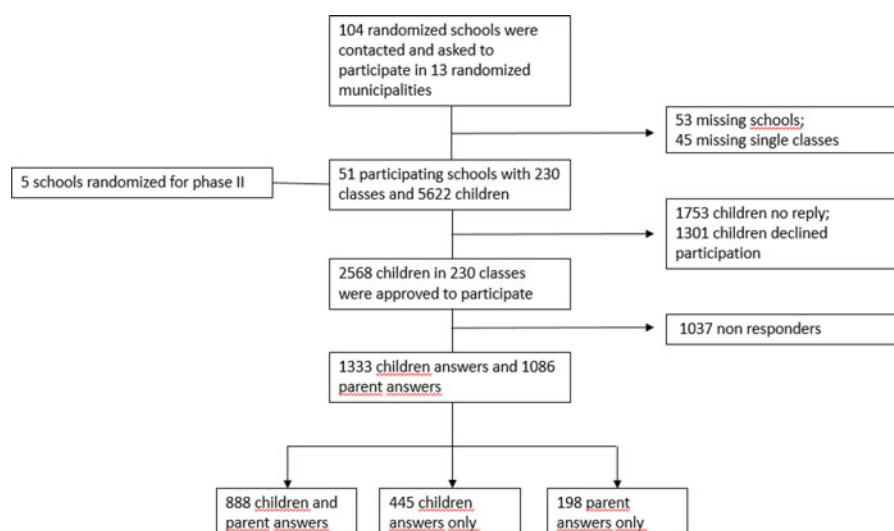


Figure 1. Flowchart of the study-population.

and lifestyle characteristics across groups with and without asthma and rhinoconjunctivitis. P-values below 0.05 were considered statistically significant.

Results

Of all children 32.5% (433 out of 1333) reported at least one allergic disease including asthma. In this group 67.2% (291) had one allergic disease and 32.8% (142) had more than one allergic diseases, [Figure 2](#). Self-reported current asthma was reported for 9.8% of the children (131 out of 1333) and current rhinoconjunctivitis was reported for 12.7% (170 out of 1333). The prevalence of current food hypersensitivity was 12.2% (163 out of 1333) and the prevalence of eczema was 10.8% (144 out of 1333). The proportions of girls in each disease group were 47% (asthma), 50% (rhinoconjunctivitis), 70% (food hypersensitivity) and 58% (eczema). Among

those with self-reported disease, doctor diagnosis were reported from; asthma 51%, rhinoconjunctivitis 69%, food hypersensitivity 36% and eczema 51%. No allergy-related disease was reported from 67.5% (900 out of 1333). [Figure 2](#) illustrates the overlapping of allergic diseases and also that 44–51% of the children in each disease are mono-symptomatic with no allergic comorbidity.

The main findings in the study population are presented in [Table 2](#). In both groups of current asthma and current rhinoconjunctivitis, children had a significantly higher prevalence of eczema (19.1% vs 9.0%) $p < .001$ and food allergy (23.5% vs 10.2%) $p < .001$, compared to children without current asthma and rhinoconjunctivitis. No statistical significance was found between the groups of current asthma and current rhinoconjunctivitis. Parental history of asthma, hay fever and/or eczema was significantly more common among children with current asthma or rhinoconjunctivitis ($p < 0.001$). Additionally, the results indicated that asthma was more common both among children without siblings and among children to smoking parents. However, these two associations did not reach statistical significance ($p = 0.07$ and $p = 0.11$, respectively). Both asthma and rhinoconjunctivitis were equally prevalent across different parental educational groups, living areas and housing types ($p > 0.30$ for all comparisons). Exposure to furry pets were reported from 47% to 53% (current asthma vs rhinoconjunctivitis), no statistical significance was found between these two groups and those with no reported disease. ([Table 2](#))

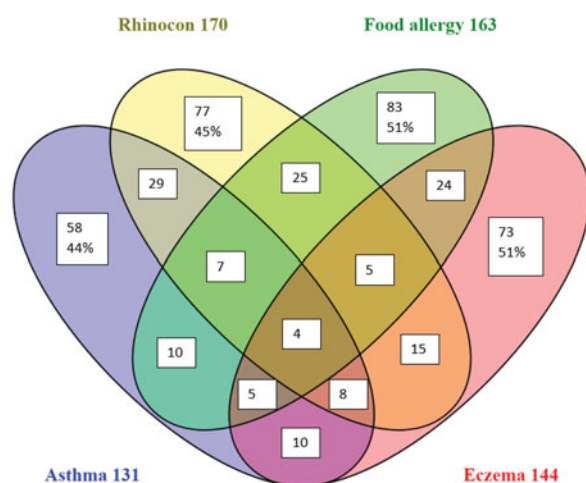


Figure 2. Current self-reported allergic diseases. Data from the child questionnaire (n = 1333).

Impact on daily life

Among 131 children who reported current asthma, 74% reported wheezing symptoms during or after exercise, 72 (55%) children reported one to three attacks of wheezing

Table 2. Study population and basic characteristics. Data were obtained from the sampling of child questionnaire (n = 1333); gender, age, school location and symptoms and social factors from the parental questionnaire (n = 888).

	All Number of valid answers	Self-reported current asthma	Self-reported current rhinoconjunctivitis	No self-reported current asthma or rhinoconjunctivitis	P-value Self-reported current asthma vs no self-reported asthma or rhinoconjunctivitis	P-value Self-reported current rhinoconjunctivitis vs no self-reported rhinoconjunctivitis or asthma
N (%)	1333	131 (9.8)	170 (12.7)	930 (69.7)		
<i>Gender of the child</i>						
Female	674 (50.5)	61 (46.5)	85 (50.0)	469 (50.4)	0.4	0.9
Male	659 (49.4)	70 (53.4)	85 (50.0)	461 (49.5)		
<i>School location</i>						
Large city	323 (24.2)	30 (22.9)	37 (21.7)	214 (23.0)	0.76	0.59
City	646 (48.5)	67 (51.1)	89 (52.3)	448 (48.1)		
Countryside	364 (27.3)	34 (25.9)	44 (25.8)	268 (28.8)		
<i>Child-reported eczema</i>						
Yes	144 (10.8)	25 (19.1)	34 (20.0)	84 (9.0)	<0.001	<0.001
No	818 (61.3)	106 (80.9)	136 (78.8)	846 (91.0)		
<i>Child-reported food-allergy</i>						
Yes	163 (12.2)	26 (19.8)	40 (23.5)	95 (10.2)	0.001	<0.001
No	1158 (86.9)	105 (80.1)	130 (76.5)	835 (89.8)		
Parental questionnaire n = 888	n = 888	n = 84	n = 110	n = 632		
<i>Children born in Sweden</i>						
Yes	852 (96.0)	83 (98.8)	106 (96.3)	605 (95.8)	0.35	1.0
No	35 (3.9)	1 (1.1)	4 (3.6)	26 (4.1)		
<i>Both parents born in Sweden</i>						
Yes	735 (82.9)	69 (82.1)	94 (85.4)	523 (82.7)	0.86	0.50
No	151 (17.0)	15 (17.8)	16 (14.5)	109 (17.2)		
<i>Accommodation type</i>						
House	744 (85.4)	70 (85.3)	92 (86.7)	542 (87.1)	0.65	0.92
Apartment	127 (14.6)	12 (14.6)	14 (13.2)	80 (12.8)		
<i>Furry pets</i>						
Yes	480 (55.1)	44 (53.6)	51 (47.6)	337 (54.2)	0.91	0.20
No	390 (44.8)	38 (46.3)	56 (52.3)	284 (45.7)		
<i>Smoking in the family. 18 missing answers</i>						
Yes	106 (12.1)	14 (17.0)	12 (11.2)	71 (11.3)	0.11	0.97
No	764 (87.8)	68 (82.9)	95 (88.7)	552 (88.6)		
<i>Parents' highest education</i>						
Compulsory school	26 (3.1)	0 (0)	1 (1.1)	15 (2.3)	0.21	0.27
High School	300 (36.6)	28 (37.3)	33 (35.5)	255 (40.0)		
University	492 (60.1)	47 (62.7)	59 (63.4)	366 (57.5)		
<i>Number of siblings 12 missing</i>						
0	73 (8.2)	13 (15.6)	7 (6.4)	50 (8.0)	0.07	0.15
1	476 (54.3)	41 (49.3)	69 (63.8)	336 (53.8)		
≥ 2	327 (37.3)	29 (34.9)	32 (29.6)	238 (38.1)		
<i>Parental history of asthma/hay fever/eczema</i>						
Both	88 (9.9)	12 (14.2)	19 (17.2)	47 (7.4)	0.001	<0.001
One	338 (38.1)	42 (50.0)	55 (50.0)	230 (36.3)		
None	462 (52.0)	30 (35.7)	36 (32.7)	355 (56.1)		

and 52 (39.7%) reported more than four attacks of wheezing in the preceding year and over 40% also reported other symptoms related to asthma (Table 3). Among the 52 children with four or more attacks of wheezing preceding year, 23 (44%) also had affected sleep, 48 (92%) reported symptoms during exercise, 21 (40%) reported coughing during the night and 20 (38%) children had current rhinoconjunctivitis.

Seven children reported no attacks of wheezing but symptoms during exercise and when having a cold. Answers regarding their children's treatment of asthma were obtained from 41 parents. Of those treated with any kind of inhaled corticosteroids (ICS), 53.7% of the children reported more than four wheezing attacks in the preceding year, and 82.9% reported symptoms during or after exercise (Table 3).

Of the children with self-reported current rhinoconjunctivitis ($n = 170$) 52.4% reported symptoms more than four weeks a year and 47.7% reported symptoms more than four days a week. Symptoms during pollen season were reported from 51.8% while 28% reported affected daily activity (Table 4).

Furthermore the severity of rhinoconjunctivitis, according to ARIA guidelines, is referred to symptoms more than four weeks a year and symptoms more than four days a week. In this study, 76 children (45%) reported severe level, of which 35% reported affected sleep and school performance and 54% reported affected daily activity.

Allergy to pollen, reported by 122 children, was the most common allergy among the children with self-reported current rhinoconjunctivitis ($n = 170$); 25 children reported allergy to mites, 30 children reported allergy to cats, and 23 children reported allergy to dogs. Most of the children have their symptoms during the Swedish pollen season, from April until August (most important pollen during this time are; birch, grass and mugwort) (Figure 3). Self-reported rhinoconjunctivitis during the pollen season was reported by ($n = 107$), and 10% of them experienced worse symptoms than the year before.

Discussion

This cross-sectional study, introduces the first population-based cohort of adolescents in southern Sweden. The majority (67.5%) of all children with allergy reported only one allergic disease. The prevalence proportions for asthma (10%) and rhinoconjunctivitis (13%) were in accordance with other European population-based studies as well as the Swedish children's environmental health survey (1,5,17). The national environmental health survey among 12 year old children

in Sweden 2013 reported somewhat lower prevalences of asthma, 6% vs 10% and for rhinitis 9% vs 13%. But our definition is if the child answered yes to respectively disease during previous year and during life, this is not the case in national survey. In an unselected birth-cohort study from the neighbor country Denmark, the prevalence of rhinoconjunctivitis (14 year old) was much higher (32.8%) than in our study, whereas the prevalence of asthma was similar (13%) (17). In the Isle of Wight birth cohort the figures for rhinoconjunctivitis and asthma were 35.8% and 17.9% respectively, at 18 years (18).

Nearly half of the children with current asthma had affected breathing in four or more attacks of wheezing during the last year, more than 70% also reported symptoms during or after exercise, and 52% reported rhinoconjunctivitis symptoms more than four week per year. These self-reported data indicate that a large group of children with current asthma and rhinoconjunctivitis are affected more severely than expected. With consistent therapy most children with asthma should be free from symptoms (as for example nocturnal awakening, activity or exercise restrictions) according to GINA guidelines (16). Affected daily activity was reported for 28% of those with rhinoconjunctivitis. Optimal treatment for supporting children with rhinoconjunctivitis could be achieved using the ARIA guidelines (18).

Eczema and food allergy were in our study more common among children with self-reported current asthma or current rhinoconjunctivitis than among those with no reported disease. (Table 2 and Figure 2). Current food allergy were reported by 12% of the children. This is much lower than the prevalence presented in the OLIN-study from the most northern part of Sweden, with a prevalence of food hypersensitivity of 26% at age 12. Their study also shows that this number is reduced by half after food-challenge.

The Swedish BAMSE study reported an increased comorbidity and at age 12. 7.5% were affected by at least two allergic diseases, which is comparable to the results in our study (7.7%). Asthma did (in our study) not occur in isolation as often as eczema, food-allergy or rhinitis, a finding that was also seen in the BAMSE cohort (19). Eczema, asthma and rhinitis develop dynamically throughout childhood, and allergic comorbidity seems in many studies to be common. These findings indicate that allergy-related diseases should be neither seen nor studied as isolated entities (19). It is important to identify patients with rhinitis and rhinoconjunctivitis because of the substantial impact on quality of life, while rhinitis as a risk factor might also precede symptoms of asthma. (20–22, 23). The associations of comorbidity in our study highlight the importance of identifying risk factors in

Table 3. Self-reported current asthma and parental reported treatment in association with the number of wheezing attacks and other symptoms. Data from the child questionnaire (n = 1333, symptoms) and the parental questionnaire (n = 888, treatment).

Self-reported current asthma	All n = 131 (%)	Any treatment and or combination drugs n = 41 (%)
No wheezing attack	7 (5.3)	0
1–3 wheezing attacks	72 (55.0)	19 (46.3)
≥4 wheezing attacks	52 (39.7)	22 (53.7)
Affected sleep	45 (34.4)	14 (34.1)
Breathing problems and difficult to talk	23 (17.6)	12 (29.3)
Symptoms during or after exercise	97 (74.0)	34 (82.9)
Cough during night	39 (29.8)	11 (26.8)
When having a cold	82 (62.6)	25 (60.9)
Self-reported current rhinoconjunctivitis	50 (38.2)	19 (46.3)
Self-reported current eczema	25 (19.1)	27 (65.9)
Doctors diagnosis of asthma	67 (51.1)	31 (75.6)

Table 4. Self-reported current rhino-conjunctivitis and parental reported treatment, in association with the number of symptoms. Data from the child questionnaire (n = 1333, symptoms) and the parental questionnaire (n = 888, treatment).

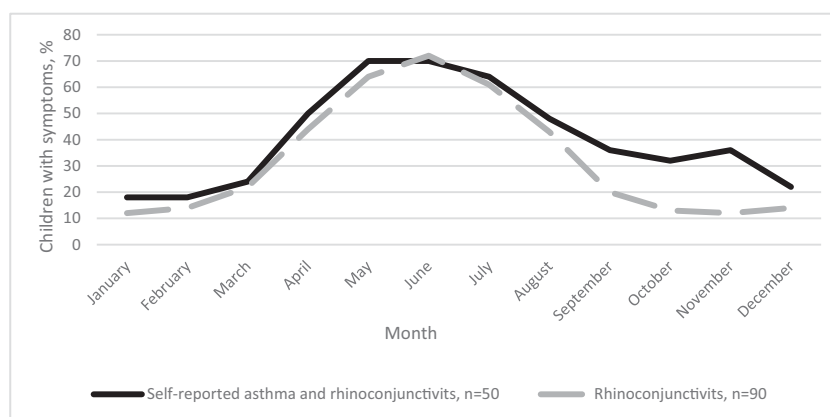
Self-reported current rhinoconjunctivitis	All n = 170	Treatment with steroids and/or antileukotriene n = 51 (%)	Only Antihistamine n = 34(%)
Affected sleep	36 (21.2)	15 (29.4)	7 (20.6)
Affected daily activity	48 (28.2)	23 (45.1)	7 (20.6)
Affected school performance	34 (20.0)	16 (31.4)	4 (11.7)
Affected physical activity	44 (25.9)	15 (29.4)	7 (20.5)
Troublesome symptoms during pollen season	88 (51.8)	38 (74.5)	16 (47.1)
Symptoms more than 4 weeks a year	89 (52.4)	38 (74.5)	17 (50.0)
Symptoms more than 4 days a week	81 (47.7)	36 (70.6)	15 (44.1)
Self-reported current asthma	50 (29.4)	16 (31.3)	6 (17.7)
Self-reported current eczema	34 (20.0)	16 (31.3)	6 (17.7)
Doctors diagnosis of rhinoconjunctivitis	93 (54.7)	41 (80.4)	17 (50.0)

order to reduce the burden of disease in allergic patients. Other studies have found that many school-aged children with doctor-diagnosed asthma and atopic diseases are both under-diagnosed and under-treated (21,23–26). Early diagnosis and better control are recommended from the European partnership of airways to prevent the consequences of allergies and asthma as chronic diseases (27).

Implications

Patients and parents knowledge of allergic diseases has been proven to be of importance in the management of

allergic disorders (21,28,29). These diseases place a huge burden on high indirect costs to health care and society therefore it is important to make the public aware of the problems (8). It is known that the knowledge of asthma and rhinitis in the society is limited and many parents/children might only contact the local pharmacy for over the counter drugs (OTC) (8,30). The organization and availability of healthcare are important for disease control (27,31). In Sweden, most children see physicians in primary healthcare and may never attend a specialist clinic if not experiencing severe symptoms. These

**Figure 3.** Seasonal variations in symptoms among children with current asthma and/or rhinoconjunctivitis. Data from the child questionnaire (n = 1333).

factors could contribute to the fact that in our study only 51% reported a doctor's diagnosis despite pronounced symptoms. These findings are in line with previous studies (2,31). For society, having a health service able to identify and treat all adolescents with atopic diseases. This was realized in Finland where the Finnish Allergy Program was launched in 2007, a 10-year program in order to reduce burden of allergies both at the individual and societal levels. Networking of allergy experts with primary care doctors and nurses as well with pharmacists is found to be important for effective implementation (32).

Our findings of undiagnosed and under-treated asthma and rhinoconjunctivitis in children necessitate measures to be taken to improve the management of these diseases. Management may include the use of national guidelines such as *The Swedish National Guidelines for Asthma* (33).

Strength and limitations

The strength of this study was its population-based design, with a broad range of survey questions covering not only symptoms from atopic diseases but also sociodemographic and family factors, as well as the co-existence of other allergies and impact on daily life. Validated ISAAC questions were used to ensure our study results are comparable with other investigations (11). We have also obtained/collected data from both children and parents, which further strengthens the results. It also indicate the importance of allowing the child to answer questions about wellbeing since there are discrepancies between children's and parents' reports (34). The low response rate, mostly due to lack of availability of computer resources and technical problems at the participating schools, was a study limitation. Analysis of missing data did however not reveal significant differences between schools with high and low response rates. In a public health survey in 2011 (results reported in Swedish) for the same geographic area and in the same age as in our study, 9 650 school children (response rate 85%) reported one-year prevalence of asthma, 11% and rhinoconjunctivitis 24% (5). The prevalence figures in our study are somewhat lower probably due to use of another questionnaire and more comprehensive questions without any personal contact with the children. The rather low parental response rate, which means less information about the children's medication was another study limitation that hampered our abilities to study associations between specific treatments and persistent symptoms. However even with this limitation, the results clearly indicate that the affected children of this population are not receiving satisfactory treatment.

Conclusions

A high number of affected children were identified as being undiagnosed as well as not receiving satisfactory treatment.

Abbreviations

ISAAC	The International Study of Asthma and Allergies in Childhood
ICS	Inhaled corticosteroids
ARIA guidelines	Allergic Rhinitis and its impact on Asthma
GINA guidelines	Global Initiative for Asthma Guidelines and Resources
ALMA guide	Active Life with Asthma
OTC	over the counter

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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Ethics

The study was approved by the regional ethical board in Lund, Sweden, 2011/753.

Availability of data and materials

Data cannot be shared without additional approval from the regional board and legal authorities at Lund University.

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