



The triad of current asthma, rhinitis and eczema is uncommon among adults: Prevalence, sensitization profiles, and risk factors

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ABSTRACT

Background: Coexistence of asthma, rhinitis, and eczema has been studied in children, but data are lacking in adults. As new treatments emerge, epidemiological data on the coexistence are needed.

Aims: To study the prevalence of concomitant asthma, rhinitis and eczema in the general adult population and among those sensitized to aeroallergens, and to study associations between background characteristics and risks of phenotypes of asthma, rhinitis, and eczema.

Methods: In the West Sweden Asthma Study, phenotypes and sensitization profiles of 1103 randomly selected adults (16–75 years) were assessed. The methods included measures of serum-IgE and structured interviews on asthma, rhinitis, eczema, their associated symptoms, and relevant risk factors.

Results: Among all participants and in those sensitized, 2% and 6% had concomitant asthma, rhinitis, and eczema, respectively, and the condition did not differ by age or sex. Corresponding figures for asthma and rhinitis, but not eczema, was 8% and 19%, respectively. Determinants of coexistence of the three conditions were family history of asthma/allergy, body mass index, and occupational exposure to gas, dust and fumes.

Allergic sensitization in those with asthma, rhinitis and eczema was found in 78%, in those with asthma and rhinitis but not eczema in 65%, in those with asthma and eczema but not rhinitis in 40%, while only 5% were sensitized among those having asthma only.

Conclusions: In the general adult population about 2% have concomitant asthma, rhinitis, and eczema. Of sensitized adults, about 6% has coexistence of the three conditions.

1. Introduction

Asthma, rhinitis and eczema are common chronic disorders that are associated with well-recognized impact on the quality of life of affected individuals. The prevalence of asthma and rhinitis has increased worldwide across all ages [1,2], as well as in the Nordic countries [3–9]. Two large population based studies in Sweden have demonstrated that

the prevalence of current asthma increased from 8% to 11% over the last 20 years and from 8% to 9% over the last 10 years up to 2016, with increase in prevalence being particularly high for allergic rhinitis [8,9]. Between 1991 and 2010, a study from Italy reported 3% and 9% increase in the prevalence of current asthma and allergic rhinitis among adults, respectively [10]. Among Swedish adolescents, lifetime and current prevalence of rhinitis increased by 11% and 7%, respectively, between

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2000 and 2008 [11]. During the last 30 years, the prevalence of atopic eczema has also increased among children, with prevalence in Western countries ranging from 9% in Switzerland [12] to 26% in Sweden, where a wider definition may have been used [13]. In adults, there are paucity of data on the prevalence of eczema and it is unclear whether the prevalence is increasing. However, some studies report that the prevalence in Northern Europe and USA is around 10% [14–16]. The European Community Respiratory Health Survey II (ECRHS II), which was performed in 11 European countries and the United States in 1998, found that the overall prevalence of participant-reported eczema in adults is 7% [17]. Another study performed in the USA, Canada, Japan, and major European countries that used strict criteria, including use of medication, reported the prevalence of atopic eczema in adults to be low and ranging from 1 to 4% [18].

Asthma, rhinitis and atopic eczema share several common pathophysiological mechanisms. During the course of the atopic march, children often first get atopic eczema and then develop asthma and rhinitis [19]. Whilst the coexistence of asthma, rhinitis and atopic eczema has mainly been evaluated in childhood and teenage studies [20, 21], data from adult populations are lacking. For instance, in the Swedish BAMSE birth cohort study the coexistence of the three conditions occurred less often in preschool children than among school children, increasing from less than 1% at the age of 4 years to 1% at the age of 8 and 12 years [20]. In a large US population-based study of adults, the prevalence of coexistence of eczema and asthma and/or hay fever was 3% [14]. Apart from this previous US study, to our knowledge, our previous report was the only other study that has evaluated the prevalence of coexistence of asthma, rhinitis and eczema in an adult population, showing that the prevalence of co-existence of the three conditions was around 2% [22]. However, in that study, the sensitization profiles of the participants was not taken into account. As novel treatment options for allergic diseases evolve, particularly the observed effects of IL-4/IL-13R α -chain antibody on both severe asthma and eczema, uncovering the extent of the coexistence of allergic diseases and their underlying allergic sensitization profiles may facilitate the identification of therapeutic potentials.

The aims of the current study were therefore to [1]: describe the prevalence of asthma with and without rhinitis and eczema [2]; compare the prevalence of coexistence of these diseases in the general population and among those who are sensitized to specific aeroallergens; and [3] investigate the associations between various background characteristics and risk of both the coexistence of asthma, rhinitis, and eczema, and of clinical phenotypes of combinations of the conditions.

2. Methods

2.1. Study area and population

The design of the West Sweden Asthma Study (WSAS) has previously been described in detail elsewhere [23]. In brief, the Västra Götaland region of Sweden includes the city of Gothenburg with a population including suburbs of about 1 million, several other small towns and large rural areas, amounting to a total population of about 1.7 million. In 2008, a postal questionnaire on respiratory and allergic symptoms and diseases, smoking habits and occupation was mailed to 30 000 randomly selected subjects aged 16–75 years in the region [24]. Questions used in the questionnaire were adapted from the Swedish version of the Global Allergy and Asthma (GA²LEN) questionnaire [5] and the OLIN-questionnaire [25], which is used particularly in Nordic countries but also other countries [6–9,24,26,27]. Of those who could be traced, 62% (n = 18 087) responded [23]. A non-response study verified that the participants were representative of the population of the study area [28]. Of those who responded to the survey, 2000 randomly selected subjects were invited to clinical examinations, and 1172 (59%) subjects participated in 2009–2012. The study set-up and participation is

described in Fig. 1. Ethical approval was obtained from the Ethics Committee at the University of Gothenburg.

2.2. Clinical data

The clinical examinations included an extensive structured interview, with detailed questions about respiratory and allergic symptoms and diseases and potential determinants of disease, anthropometric measurements, together with various clinical examinations, including blood sample for measurement of serum Immunoglobulin E (IgE) [23]. Of the 1172 who participated in the clinical examinations, data on serum IgE were available for 1103 subjects (52.9% women). The presence of serum specific IgE to a mixture of common airborne allergens was first assessed using an ImmunoCAP®Phadiatop (Thermo Fisher Scientific) test. Specific IgE to birch, timothy, mugwort, cat, dog, horse, *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, and *Cladosporium herbarum* was then measured among all those with a positive Phadiatop test. A positive serum specific IgE was defined as ≥ 0.35 kU/l.

2.3. Definition of study variables

2.3.1. Study outcomes

Current asthma was defined as affirmative answers to either of the two following questions: “Have you ever had asthma?” or “Have you ever been diagnosed as having asthma by a physician?” in combination with a report of either use of asthma medication, recurrent wheeze or attacks of shortness of breath during the last 12 months. *Current rhinitis* was defined based on affirmative answers to either of the following questions: “Do you have sneezing, runny nose, or nasal block without having a cold?” or “During the last 12 months, have you used medicines for hay fever or other problems of rhinitis, such as runny nose or nasal blocking without having a cold?”. *Current eczema*, referring mainly to atopic eczema, was defined by affirmative answers to both of the following questions: “Have you ever had an itchy rash which was coming and going for at least six months?” and “Have you had this itchy rash in the last 12 months?”. Based on the above definitions for current asthma, rhinitis, and eczema, we derived four study outcomes [1]: asthma only, without concomitant rhinitis and eczema [2]; asthma and rhinitis only, but without eczema [3]; asthma and eczema only, but without rhinitis; and [4] asthma and rhinitis and eczema: coexistence of all three diseases.

2.3.2. Background characteristics

Family history of asthma or allergy: “Has any of your parents or siblings ever had asthma” or “Has any of your parents or siblings ever had allergic eye or nose problems (hay fever)”.

Body mass index (BMI) was calculated as follows: weight (kg)/(height (m))². BMI categories were then derived as follows: <25, 25–29.9, and ≥ 30 kg/m².

Smoking: Smoking status was categorized into three groups: smokers include those who reported smoking the year preceding the study; ex-smokers those who reported having quit smoking at least one year before the study; and non-smokers those who reported neither smoking nor ex-smoking.

Occupational exposure to gas, dust and fumes (GDF): “Have you been heavily exposed to dust, gases or fumes at work?”

Degree of urbanization was dichotomized into towns with >10 000 inhabitants and towns/villages with ≤ 10 000 inhabitants.

Educational level was divided into three categories: less than high school, high school, and tertiary level (i.e. university or other corresponding post high school level).

Raised on a farm: “Did your family live on a farm during your first five years of life?”

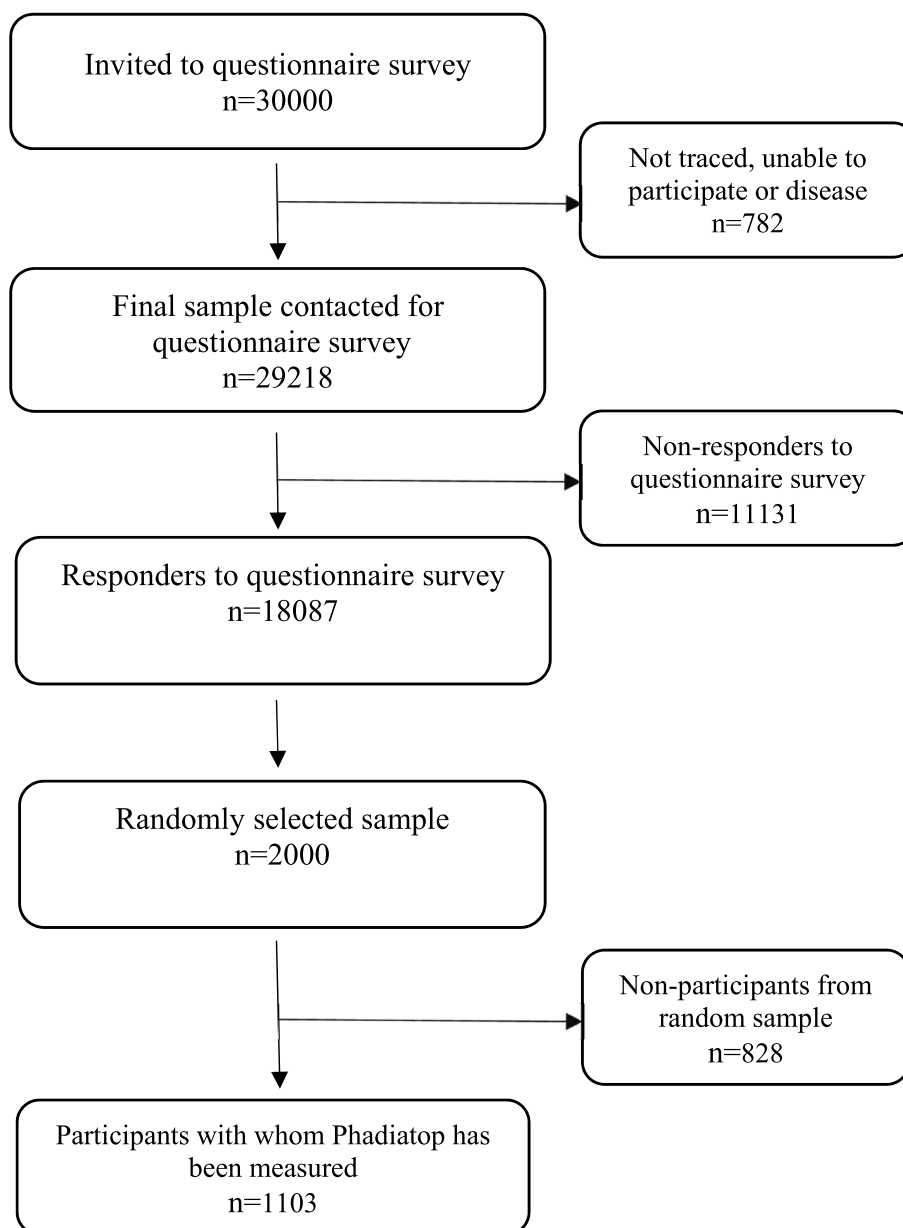


Fig. 1. Flowchart of the study population. The study was based on a questionnaire survey from which a random sample was selected.

2.4. Statistical analyses

The Pearson's Chi-square test was used to evaluate differences in proportions between categories of the categorical variables. Multinomial logistic regression was used to investigate the associations between the background characteristics of the participants and the study outcomes, with those not having either of the three outcomes (i.e. no asthma, rhinitis, and eczema) being used as the reference category in the model. Given small numbers for some of the outcomes (e.g., only five persons had asthma and eczema without concomitant rhinitis) and hence the models became inestimable, we only calculated unadjusted associations in which each background characteristic was studied in relation to the outcomes. The estimated odds ratios (OR) are accompanied by their respective 95% confidence intervals (CI). All analyses were carried out using Stata version 15.

3. Results

3.1. Basic characteristics

Of the 1103 participants, women constituted 53% and were generally younger than men (mean age 46.2 vs 49.2 years) were (Table 1). Compared to men, the proportion of current smokers was greater in women (13% vs 19%) ($p = 0.058$). Whereas the proportion of those with BMI less than 25 kg/m² was greater in women (45%) than in men (29%), men (55%) were much more overweight than women (38%), but the proportion of obese people was similar in both genders. Men were considerably more often exposed to gas, dust, or fumes at work than women (36% vs 15%, $p < 0.001$). Educational level was overall higher among women than men, with 52% of women having attended tertiary education compared to 40% of men ($p < 0.001$). Although women more commonly had a family history of asthma and/or allergy than men did (41% vs 32%), specific sensitization demonstrated with positive Phadiatop test was more common among men (36%) than among women (24%) ($p < 0.001$) (Table 1). The prevalence among the participants of

Table 1
Background characteristics of the study population.

| Background characteristic | Men N = 520 n (%) | Women N = 583 n (%) | All N = 1103 n (%) | P-value |
|------------------------------------------|-------------------------|---------------------------|--------------------------|---------|
| Age, years | | | | <0.001 |
| ≤35 | 122 (23.5) | 162 (27.8) | 284 (25.7) | |
| 36-55 | 178 (34.2) | 247 (42.4) | 425 (38.5) | |
| ≥56 | 220 (42.3) | 174 (29.8) | 394 (35.7) | |
| Smoking | | | | 0.058 |
| Non-smokers | 302 (58.1) | 322 (55.2) | 624 (56.6) | |
| Ex-smokers | 147 (28.3) | 146 (25.0) | 293 (26.6) | |
| Current smokers | 69 (13.3) | 112 (19.2) | 181 (16.4) | |
| Body mass index (BMI), kg/m ² | | | | <0.001 |
| <25 | 152 (29.2) | 260 (44.6) | 412 (37.3) | |
| 25–29.9 | 284 (54.6) | 223 (38.2) | 507 (46.0) | |
| ≥30 | 84 (16.1) | 100 (17.1) | 184 (16.7) | |
| Exposure to dust/fumes at work | | | | <0.001 |
| No | 329 (63.3) | 491 (84.2) | 820 (74.4) | |
| Yes | 188 (36.1) | 87 (14.9) | 275 (24.9) | |
| Raised on a farm | | | | 0.779 |
| No | 447 (86.0) | 505 (86.6) | 952 (86.3) | |
| Yes | 70 (13.5) | 73 (12.5) | 143 (13.0) | |
| Degree of urbanization | | | | 0.108 |
| >10 000 inhabitants | 390 (75.0) | 461 (79.1) | 851 (77.2) | |
| ≤10 000 inhabitants | 130 (25.0) | 122 (20.9) | 252 (22.8) | |
| Highest education attained | | | | <0.001 |
| Less than high school | 105 (20.2) | 106 (18.2) | 211 (19.1) | |
| High school | 206 (39.6) | 173 (29.7) | 379 (34.4) | |
| Tertiary education | 207 (39.8) | 303 (52.0) | 510 (46.2) | |
| Family history of asthma or allergy | | | | 0.004 |
| Yes | 169 (32.5) | 239 (41.0) | 408 (37.0) | |
| Positive Phadiatop | | | | <0.001 |
| Yes | 187 (36.0) | 143 (24.5) | 330 (29.9) | |

P-values from chi-square tests comparing characteristics between men and women. For smoking status, exposure to dust/fumes at work, raised on a farm and highest education attained information was not available for all participants.

current asthma, rhinitis, and eczema was 13%, 53%, and 14%, respectively.

3.2. Asthma with and without rhinitis and eczema

About 2% of the study population and 6% among the sensitized subjects had coexistence of the three conditions: asthma, rhinitis, and eczema (Fig. 2). Only 2% of subjects in the study population, and 0.3% of sensitized subjects, had asthma only without rhinitis and eczema. The most common co-morbid phenotype was coexistence of asthma and rhinitis without eczema, 9% in the study population, but 19% among the sensitized subjects (Fig. 2). Among subjects with asthma, 83% also had rhinitis, while 22% had eczema. Among sensitized asthmatics, the corresponding numbers were 95% and 27%. The relative proportion of asthma in relation to the two other conditions was: asthma with no rhinitis or eczema 13%; asthma with rhinitis but no eczema 65%; asthma with eczema but no rhinitis 3%; asthma with rhinitis and eczema 19%.

Overall, there was no significant difference between men and women (Fig. 2), however, in sensitized participants there was a tendency that women had higher coexistence of asthma, rhinitis and eczema than men (Fig. 2). When stratified by age, overall and by gender, the different patterns of coexistence among the three conditions did not differ by age, overall and between men and women, both in the entire study sample (Supplementary Table 1) and among sensitized subjects (Supplementary Table 2).

3.3. Allergic sensitization in asthma with and without rhinitis and eczema

Twenty eight percent of the study sample was sensitized to at least one aeroallergen. The most common sensitizing group of allergens was pollens (22%), followed by furry animals (12%), and mites (11%) (Table 2). Only three subjects (0.3%) were sensitized to *Cladosporium*

herbarum, and all three had coexistence of asthma, rhinitis and eczema (Table 2). Those having only asthma, but not rhinitis or eczema, had the least frequency of sensitization to any aeroallergen (5%), while those with the three conditions had the highest frequency of sensitization (78%), followed by those with asthma and rhinitis but not eczema (65%), and followed by those with asthma and eczema but not rhinitis (40%), although it should be noted that the number of subjects in the group was only five. Whilst those with coexistence of the three conditions had the highest frequency of sensitization to pollens and mites, those with coexistence of asthma and rhinitis but not eczema had the highest frequency of sensitization to furry animals.

3.4. Associations between background characteristics and outcomes

Although small numbers inhibited estimation of adjusted results, based on unadjusted results, there were indications of associations between each of the background characteristics and the outcomes, although these were mostly statistically non-significant. The instances with statistical significant findings were: increased risk between family history of asthma/allergy and coexistence of all three conditions and also between coexistence of asthma and rhinitis without eczema; increased risk between BMI ≥ 30 kg/m² and coexistence of the three conditions and also between coexistence of asthma and rhinitis without eczema; and increased risk between occupational exposure to GDF and coexistence of all three conditions (Table 3).

4. Discussion

This population-based study among adults based on clinical examinations including measurement of serum IgE found the prevalence of the coexistence or triad of current asthma, rhinitis and eczema to be 2%, while the prevalence among sensitized subjects was 6%. The most common phenotype was the coexistence of asthma and rhinitis without eczema, while the coexistence of asthma and eczema without concomitant rhinitis was the least common phenotype. Those having only asthma without concomitant rhinitis and eczema were least likely to be sensitized to aeroallergens, while those with the three conditions were most likely to be sensitized to aeroallergens.

The prevalence of asthma and eczema increases from early childhood to adolescence-age, after which the prevalence of eczema declines and then plateaus after reaching adulthood [29]. For asthma, the prevalence increases until young adulthood, and then decreases subsequently with increasing age during adulthood, but also contradicting data have been reported [30,31]. Rhinitis, on the other hand, starts to become common during preschool-age followed by a continuous increase during teenage and young adulthood [32]. During young adulthood and up to middle-age, rhinitis acts as a risk factor for developing asthma [6,33,34]. Whilst most studies among adults have primarily reported the association between asthma and rhinitis and vice versa, studies evaluating the distribution of the coexistence of asthma, rhinitis, and eczema are lacking. Hence, we found no previous studies in adults to compare our findings with.

However, such studies are much more common in children. In a large study based on 12 birth cohorts from eight countries, the prevalence of coexistence of asthma, rhinitis and eczema was less than 1% and stable from age 4 to age 8 years, while it was almost 2% among sensitized children [21]. In the Swedish BAMSE study, the prevalence of coexistence of asthma and rhinitis and/or atopic eczema increased by age, and at age 12 years the prevalence was 7.5%; furthermore, among those with asthma, 67% also had rhinitis [19], which remained similar (64%) by age 16 [35].

A prospective Danish cohort study carried out in the city of Odense found that about 9% of participants had coexistence of asthma, rhinitis, and eczema at least once during the 15 years of follow-up that started at age 14 years [16]. Whilst the current prevalence of coexistence of asthma, rhinitis, and eczema at age 29 years was not reported in that

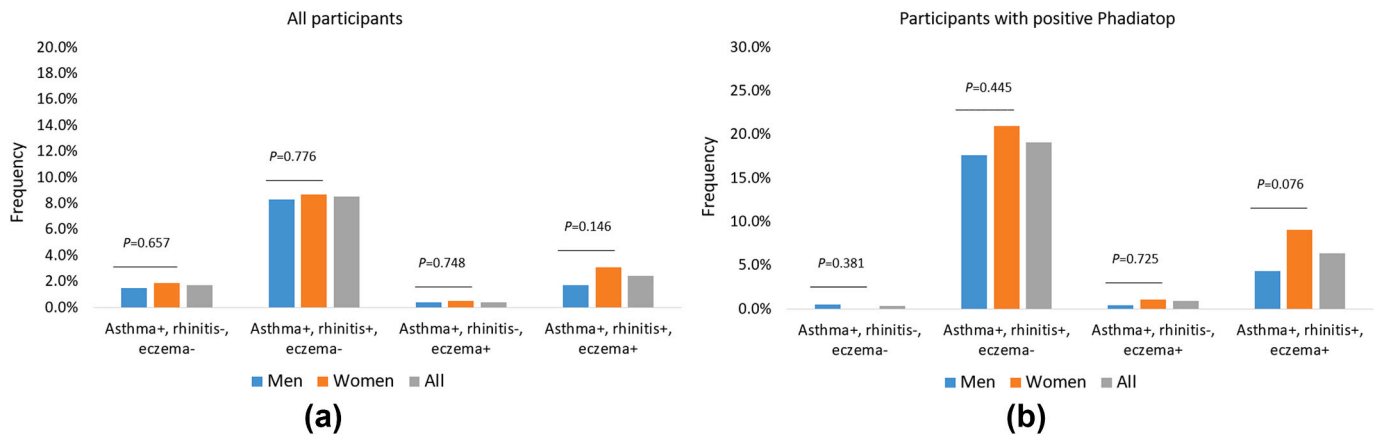


Fig. 2. Prevalence of outcomes by gender among participants and among those with positive Phadiatop.

study, 73% of those with asthma were sensitized to at least one aeroallergen, which compares closely to the 78% in young adults aged <35 years found in our study. In our study, as many as 83% of those with asthma had rhinitis, and this number was even higher (95%) among sensitized individuals. Our results show that asthma without rhinitis is not common (16%) among adults, and this is particularly true for those with asthma who are sensitized to aeroallergens (4%). Similarly, in the Danish study, only about 20% of those with asthma did not have rhinitis [16]. In a previous large survey among adults performed in the USA, while 10% reported that they had eczema, only 3% reported coexistence of eczema with asthma and/or rhinitis [14].

In our study, among those with coexistence of asthma, rhinitis, and eczema, 70% were sensitized to any pollen, with sensitization to birch being the dominating pollen allergen (63%), followed by timothy grass (48%), while 33% were sensitized to any mite, and 30% to any furry animal. We have found no study that has evaluated the sensitization profiles of adults with coexistence of asthma, rhinitis and eczema, therefore comparison of our findings to previous studies on the topic is not possible. However, the sensitization profiles of those with symptoms of asthma or rhinitis in the referred Danish study [16] found that sensitization to birch, grass and mites were most common. In an Australian birth cohort study, sensitization to mites was most common, and those with asthma had become sensitized to at least one allergen by the age of 24 years, a majority of whom had developed comorbidity with rhinitis [32]. In the BAMSE cohort at age 16 as well as the EGEA study among adults, the proportion of sensitized individuals increased with the number of allergic diseases [35], a similar phenomenon that can be inferred from our results.

Many studies have investigated the associations between allergic diseases and allergic sensitizers, including examination of the age and sex differences in these associations. Similar to results on adults from Northern Sweden [36], we have in the current study shown that asthma and rhinitis are both strongly associated with allergic sensitization [21], but we have found no clear association between eczema and allergic sensitization [15,21]. These previous observations are in line with results of the current analyses, which showed that the association between sensitization to aeroallergens and eczema in adults is unclear [17,37]. In the current study, while 22% of subjects with asthma also had eczema in the whole study population, it was 27% among sensitized individuals.

Less studies have included analyses of exposures and other independent variables that may be associated with disease coexistence. Some studies have shown that female sex is associated with coexistence of asthma and rhinitis or eczema [14,16]. Whilst gender and age were not significantly associated with disease coexistence in our study, occupational exposure to gas, dust and fumes was associated with increased risk of coexistence of the three conditions, as was high BMI, and particularly family history of asthma and allergy. In the referred US study, increasing age was associated with risk of coexistence of asthma and eczema [14].

A particularly interesting finding from our study relates to the association between obesity and concomitant coexistence of asthma and rhinitis both with and without eczema. Whereas the association between obesity and asthma is clearly established both in children [38,39] and in adults [22,34], the association between obesity and rhinitis, as well as eczema, is less clear. Generally, the different studies in atopic diseases have shown somewhat contradicting results on the role of obesity in these diseases [40]. Our findings now extend current understanding

Table 2

Frequency of sensitization to aeroallergens by study outcomes.

| Aeroallergen | Frequency n = 1103 n (%) | Asthma+, rhinitis-, eczema- (n = 19) n (%) | Asthma+, rhinitis+, eczema- (n = 94) n (%) | Asthma+, rhinitis-, eczema+ (n = 5) n (%) | Asthma+, rhinitis+, eczema+ (n = 27) n (%) | P-value for difference across outcomes |
|---------------------------------------|--------------------------------|--------------------------------------------------|--------------------------------------------------|-------------------------------------------------|--------------------------------------------------|----------------------------------------------|
| Birch | 165 (15.0) | 1 (5.3) | 40 (42.5) | 1 (20.0) | 17 (63.0) | 0.001 |
| Timothy grass | 185 (16.8) | 0 (0.0) | 39 (41.5) | 0 (0.0) | 13 (48.1) | 0.001 |
| Mugwort | 62 (5.6) | 0 (0.0) | 19 (20.2) | 0 (0.0) | 5 (18.5) | 0.125 |
| Any pollen | 244 (22.1) | 1 (5.3) | 53 (56.4) | 1 (20.0) | 19 (70.4) | <0.001 |
| Cat dander | 113 (10.2) | 0 (0.0) | 42 (44.7) | 0 (0.0) | 7 (25.9) | <0.001 |
| Dog dander | 90 (8.2) | 0 (0.0) | 38 (40.4) | 0 (0.0) | 7 (25.9) | 0.002 |
| Horse dander | 48 (4.3) | 0 (0.0) | 21 (22.3) | 0 (0.0) | 6 (22.2) | 0.087 |
| Any furry animal | 134 (12.1) | 0 (0.0) | 44 (46.8) | 0 (0.0) | 8 (29.6) | <0.001 |
| <i>Dermatophagoides pteronyssinus</i> | 114 (10.3) | 0 (0.0) | 24 (25.5) | 1 (20.0) | 9 (33.3) | 0.056 |
| <i>Dermatophagoides farina</i> | 113 (10.2) | 1 (5.3) | 23 (24.5) | 1 (20.0) | 8 (29.6) | 0.240 |
| Any mite | 121 (11.0) | 1 (5.3) | 24 (25.5) | 1 (20.0) | 9 (33.3) | 0.165 |
| <i>Cladosporium herbarum</i> | 3 (0.3) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 3 (11.1) | 0.004 |
| Any aeroallergen | 314 (28.5) | 1 (5.3) | 61 (64.9) | 2 (40.0) | 21 (77.8) | <0.001 |

Table 3

Relation of demographics and environmental exposures to study outcomes: odds ratio (OR); 95% confidence interval (95% CI)^a. Significant associations are marked in bold.

| | No asthma, rhinitis, or eczema n = 958 OR (95% CI) ^b | Asthma+, rhinitis-, eczema- n = 19 OR (95% CI) ^b | Asthma+, rhinitis+, eczema- n = 94 OR (95% CI) ^b | Asthma+, rhinitis-, eczema + n = 5 OR (95% CI) ^b | Asthma+, rhinitis+, eczema + n = 27 OR (95% CI) ^b |
|-------------------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------------------------------------------|--------------------------------------------------------------------|
| Gender | | | | | |
| Men | Reference | 1 | 1 | 1 | 1 |
| Women | | 1.26 (0.50–3.16) | 1.09 (0.71–1.66) | 1.37 (0.23–8.26) | 1.83 (0.81–4.12) |
| Age, years | | | | | |
| ≤35 | Reference | 1 | 1 | Too small numbers | 1 |
| 36–55 | | 1.18 (0.34–4.07) | 1.04 (0.62–1.74) | | 0.81 (0.34–1.90) |
| ≥56 | | 1.39 (0.41–4.65) | 0.75 (0.43–1.30) | | 0.35 (0.12–1.03) |
| Smoking status | | | | | |
| Non-smoker | Reference | 1 | 1 | Too small numbers | 1 |
| Ex-smoker | | 0.56 (0.18–1.71) | 0.93 (0.56–1.56) | | 0.98 (0.40–2.44) |
| Current smoker | | Too small numbers | 1.13 (0.64–2.02) | | 1.16 (0.41–3.24) |
| BMI, kg/m ² | | | | | |
| <25 | Reference | 1 | 1 | 1 | 1 |
| 25–29.9 | | 0.83 (0.33–2.11) | 1.26 (0.76–2.09) | 1.66 (0.15–18.39) | 1.42 (0.55–3.65) |
| ≥30 | | 0.29 (0.03–2.21) | 2.41 (1.36–4.27) | 5.01 (0.45–55.64) | 2.86 (1.02–8.03) |
| Occupation exposure to dust/fumes | | | | | |
| No | Reference | 1 | 1 | 1 | 1 |
| Yes | | 0.59 (0.17–2.05) | 1.20 (0.75–1.94) | 4.73 (0.78–28.48) | 3.68 (1.68–8.07) |
| Raised on a farm | | | | | |
| No | Reference | 1 | 1 | 1 | 1 |
| Yes | | 0.36 (0.05–2.69) | 0.94 (0.50–1.77) | 1.60 (0.18–14.48) | 0.25 (0.03–1.83) |
| Degree urbanization | | | | | |
| >10 000 inhabitants | Reference | 1 | 1 | 1 | 1 |
| ≤10 000 inhabitants | | 1.18 (0.42–3.30) | 0.84 (0.49–1.41) | 0.82 (0.09–7.41) | 0.57 (0.20–1.67) |
| Highest education attained | | | | | |
| Less than high school | Reference | 1 | 1 | Too small numbers | 1 |
| High school | | 0.18 (0.04–0.92) | 1.22 (0.64–2.30) | | 0.83 (0.29–2.37) |
| Tertiary | | 0.77 (0.28–2.10) | 1.25 (0.68–2.31) | | 0.84 (0.31–2.26) |
| Family history of asthma or allergy | | | | | |
| No | Reference | 1 | 1 | 1 | 1 |
| Yes | | 0.88 (0.33–2.34) | 2.37 (1.54–3.63) | 0.48 (0.05–4.29) | 5.46 (2.28–13.05) |

^a Based on multinomial logistic regression; those not having any of the disease conditions were used as the reference category in the model.

^b Only unadjusted results are presented given the small number of some of the outcomes, which made the adjusted models not to converge.

demonstrating that obesity is associated not only with asthma, but is a strong risk factor for the coexistence of asthma, rhinitis, and eczema. We found no previous studies that have demonstrated similar findings that we can compare our results to.

One of the strengths of our study is that it provides novel, perhaps the most contemporary data in adults, on the prevalence of different phenotypes of coexistence of asthma, rhinitis, and eczema, but in a general population contexts and among subjects who are sensitized to common aeroallergens measured by specific IgE. Furthermore, the study reflects well the general population in the studied area, that is, the adult population of western Sweden, which was verified by a detailed study of non-response [28]. However, those who participated at this clinical part of the study had in the preceding questionnaire survey reported a marginally higher prevalence of asthma and symptoms common to asthma, which might have slightly influenced the representativeness of the results [41]. The diagnosis of asthma has a high specificity, misclassification is thus low, while some under-diagnosis of asthma cannot be ruled out. Due to small numbers in some phenotypes of the disease coexistence, we were unable to undertake meaningful analysis of associations between the background factors and coexistence of the diseases. However, in the cases where we have sufficient power for analyses, we observed novel findings, particularly with regards to the associations of occupational exposure to dust, gas and fumes, and to the association of obesity with disease coexistence phenotypes, which also showed some differentials in the associations.

We conclude that about 2% of adults have concomitant coexistence of asthma, rhinitis, and eczema in a general population-representative sample in western Sweden, and the proportion of allergic sensitization is high among them. In individuals sensitized to common aeroallergens,

the coexistence of the three conditions amounted to a prevalence of about 6%. As progress is being made with the development of new treatment opportunities for chronic obstructive airway diseases and allergies, in particular the development of monoclonal antibody targeting the IL4/IL13 pathway, which is indicated for treatment of both severe asthma and atopic eczema, the current epidemiological data on the coexistence of these disease conditions is readily valuable. Although our study design does not allow drawing conclusions about the severity of the evaluated diseases, it provides epidemiological data in a general population, which may lead to better understanding about the coexistence of these conditions. Therefore, further studies are needed across different contexts in order to confirm the current observations and to contribute to better understanding of the phenotypic coexistence of asthma, rhinitis, and eczema in adults.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.rmed.2020.106250>.

Authors contributions

BIN, BL and TP designed the study. BIN analysed the data. BIN, TP and BL drafted the manuscript. TP, EPR, LE, MP, MA, RM, HB, HK, PI, MR, BL, BIN contributed to the design of the WSAS study, data interpretation and writing of the manuscript. All authors reviewed and approved the manuscript.

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