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Changes in the prevalence of asthma and respiratory symptoms in western Sweden between 2008 and 2016

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Abstract

Background: Asthma is a common chronic inflammatory disease of the airways, with a noticeable increase in prevalence during the second half of the 20th century. Recent studies assessing the prevalence trends among adults have been inconsistent. We investigated the changes in the prevalence of asthma, respiratory symptoms, and risk factors between 2008 and 2016 in western Sweden.

Methods: The West Sweden Asthma Study (WSAS) is a population-based study which started in 2008 (WSAS I) and then repeated in 2016 (WSAS II) in western Sweden. Randomly selected individuals aged 16–75 years (N = 18 087 in 2008 and N = 24 534 in 2016) completed a questionnaire regarding obstructive lung diseases, respiratory symptoms, potential risk factors, and also questions from the GA²LEN survey.

Results: The prevalence of reported ever asthma, physician-diagnosed asthma, use of asthma medication, and current asthma increased significantly from 9.6% to 11%, 8.3% to 10%, 8.6% to 9.8%, and 8.1% to 9.1%, respectively, between 2008 and 2016. There were also increases in the prevalence of respiratory symptoms during the same period. The greatest increase occurred in young adults aged 16–25 years. Female gender, allergic rhinitis, obesity, and family history of asthma remained the strongest risk factors for asthma in 2016 as it was in 2008.

Conclusion: There were moderate increases in asthma and respiratory symptoms in adults in western Sweden between 2008 and 2016, the greatest increase occurring in younger adults. The potential risk factors for asthma remained the same during the study period.

KEYWORDS

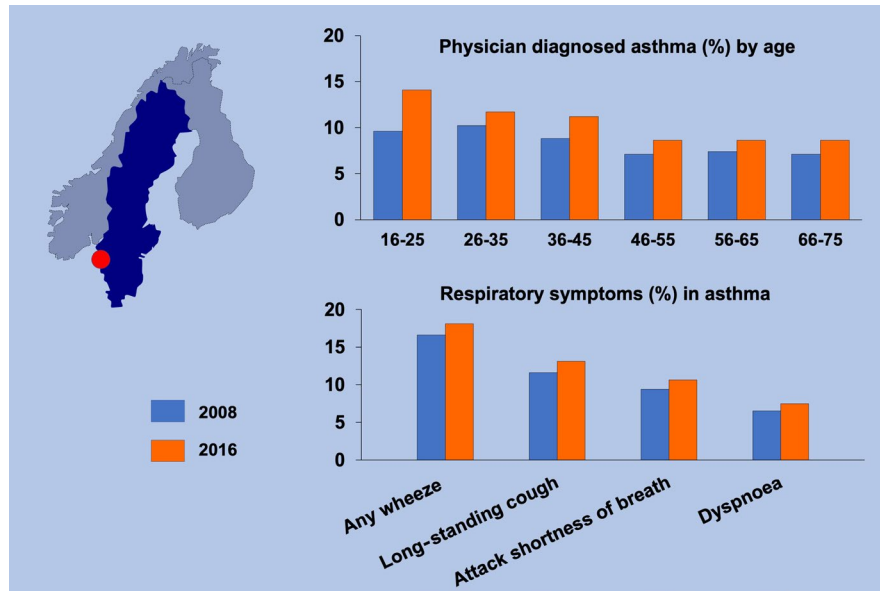
allergy diagnosis, asthma, epidemiology, rhinitis

1 | INTRODUCTION

Asthma and allergic diseases are the most common chronic diseases from early childhood to young adulthood.¹ Today, an estimated 300–400 million people have asthma worldwide.^{2,3} In contrast to many other respiratory diseases, asthma affects individuals of all ages. The incidence of asthma is highest among children and adolescents, whereas the prevalence is highest among teenagers and young adults.^{4,5}

Asthma creates a large burden on society including high societal costs.^{6–8} It can reduce quality of life of patients, increase the rate of morbidity and co-morbidity, and can be life-threatening.⁹ Worldwide about 250 000 deaths are attributed to asthma annually.^{10–12} Asthma is a heterogeneous disease expressing several clinical phenotypes^{10,13,14}; however, the traditional terms allergic asthma and nonallergic asthma are still commonly used.¹⁵

The prevalence of asthma increased considerably during the second half of the past century.^{1,10,16} Trends in prevalence from recent



GRAPHICAL ABSTRACT

We investigated the prevalence of asthma and respiratory symptoms in two large randomly selected cohorts in western Sweden between 2008 and 2016.

Asthma prevalence showed a moderate increase between 2008 and 2016.

The increase in asthma prevalence was seen irrespective of age but was most pronounced in younger age groups.

An increase in most respiratory symptoms was seen from 2008 to 2016. Allergic rhinitis was the most common symptom and showed the highest increase.

studies of adult populations have been fewer and less consistent compared with studies in children.¹⁷ While there are several cross-sectional studies in adult populations from the westernized world, the results of these studies are contrasting.¹⁸⁻²¹ This makes it difficult to conclude whether in fact asthma prevalence has changed in recent decades. In certain reviews where prevalence trends have been analyzed, there seems to be evidence of leveling off, although with the exception of increases observed among populations undergoing urbanization.^{22,23} In Northern Europe, the prevalence of asthma in adults has been estimated at around 10%.¹ Recent studies indicate either an increase²⁴⁻²⁶ or a leveling off, particularly in Sweden,²⁷⁻²⁹ according to the Swedish part of the GA²LEN,²⁷ and the first survey of West Sweden Asthma Study (WSAS).²⁹

The primary aim of this study was to investigate whether the prevalence of asthma and respiratory symptoms in adults has changed between 2008 and 2016 in western Sweden. The secondary aim was to estimate any change in the prevalence of asthma across different population demographics between 2008 and 2016 and to assess the stability or variability in risk factors for asthma during the same period.

2 | MATERIAL AND METHODS

2.1 | Study area

The WSAS is a population-representative survey of adults performed in the region of Västra Götaland, which is located in south-west Sweden. The western part of the county lies adjacent to the

North Sea. It borders Norway in northwest and neighboring six other regions from the north, along the eastern part to the south. The county is the second largest in Sweden in terms of population with more than 1.6 million inhabitants (September, 2017), living in both urban and rural areas. Gothenburg is the largest city in the region with a population of 557 000 (2016) living in the city and about a total of one million people including the greater Gothenburg area.

2.2 | Methods and study population

In 2008, the first cross-sectional survey (WSAS I) was carried out among those aged 16-75 years. A postal questionnaire was sent to 30 000 randomly selected individuals who were sampled from the Swedish population register. We could not trace 782 individuals; therefore, the questionnaire was sent to 29 218 subjects, of which 18 087 (62%) participated.²⁹ In 2016, using an identical approach as in the 2008 survey, we selected 50 000 new individuals (ie, nonoverlapping population from the 2008 survey) for a repeat survey (WSAS II). We included a randomly selected population aged 16-75 years living 100 km or less from Gothenburg. Of the 50 000 postal questionnaires sent out, 24 534 individuals participated, giving a response rate of 50%. For the purpose of the present paper, in order to have a comparable population between WSAS I and WSAS II, we excluded 2362 individuals from WSAS I who were living further than 100 km from Gothenburg as this was beyond the coverage of WSAS II, yielding a final study population of 15 725 subjects in 2008.

2.3 | The questionnaire

Identical questionnaires were used both in WSAS I and in WSAS II and comprised of two parts. The first part was modified from the questionnaire used in the Obstructive Lung Disease in Northern Sweden study.³⁰ This part of the questionnaire includes detailed questions on obstructive lung diseases including asthma, emphysema, bronchitis, and COPD. Questions related to risk factors of obstructive respiratory diseases such as family history of airway disease; smoking habit; respiratory symptoms; and environmental and occupational exposure to gas, dust, or fumes were also inquired. BMI was calculated from self-reported height and weight. The second part of the questionnaire was the Swedish version of the questionnaire used in the European-wide GA²LEN study,²⁷ which added further detailed questions about rhinitis and eczema.

2.4 | Ethics

The study was approved by the regional ethical board at the University of Gothenburg. WSAS I: 20080222, 034-08. WSAS II: 20160222, 052-16.

2.5 | Definitions

The outcomes were defined using the respective corresponding questions below.

2.5.1 | Asthma

Ever asthma: "Have you ever had asthma?" *Physician-diagnosed asthma:* "Have you ever been diagnosed as having asthma by your doctor?" *Use of asthma medication:* "Do you currently use asthma medicine (permanently or as needed)?"

Current asthma: Having physician-diagnosed asthma and at least one of following variables: asthma medication or attacks of shortness of breath or recurrent wheeze or wheeze during the last 12 months.

2.5.2 | Respiratory symptoms and allergic rhinitis

Attacks of shortness of breath: "Do you presently have, or have you had in the last 10 years, asthma symptoms and have you had these symptoms within the last 12 months?"

Any wheeze: "Have you had whistling or wheeze in the chest at any occasion in the last 12 months?"

Recurrent wheeze: "Do you usually have wheezing or whistling in your chest when breathing?"

Wheeze with breathlessness: "Have you had whistling or wheezing in the chest at any occasion during the last 12 months and have you been at all breathless when you had wheezing in the chest?"

Wheeze apart from cold: "Have you had whistling or wheezing in the chest at any occasion during the last 12 months and have you had this wheezing or whistling in your chest when you have not had a cold?"

Dyspnea: "Do you usually get breathless when you walk on level ground with people your own age?"

Breathlessness-dust: "Do you usually have breathlessness, wheeze or severe cough in dusty environments?"

Long-standing cough: "Have you had longstanding cough during the last year?"

Sputum production: "Do you usually have phlegm when coughing or do you have phlegm in the chest which is difficult to bring up?"

Chronic productive cough: "Sputum production for at least 3 months during two subsequent years?"

Allergic rhinitis: "Have you now, or have you ever had allergic rhinitis (hay-fever)?"

2.5.3 | Demographics and covariates

Gender: men or women.

Age groups (years): 16-25, >25-35, >35-45, >45-55, >55-65, >65-75.

Family history of asthma: "Have any of your parents or siblings asthma?"

Raised on a farm: "Did you live on a farm first five years of life?"

Present place of residence: in Gothenburg area or outside Gothenburg.

Smoker: Presently smoking and during the year of the study; *Ex-smoker:* Quitted smoking at least 12 months

preceding the study; *Nonsmokers*: Neither smoking nor ex-smoking.

Body mass index (BMI): Underweight: <18.5; Normal weight: 18.5-24.9; Overweight: 25-30; Obese:>30.

Occupational exposure to gas, dust, or fumes: "Have you been exposed to gas, dust or fumes at work?"

2.6 | Statistical analyses

All statistical analyses were performed using the IBM SPSS software (version 24.0; SPSS Inc, Chicago IL, USA). The Pearson chi-square test was used to test for differences in the outcomes between groups of categorical variables. A *P*-value of <0.05 was

regarded as statistically significant. Logistic regression was used to study the associations between the risk factors and the outcomes. All estimates of odds ratio are accompanied with their respective 95% confidence intervals. The risk factors were simultaneously adjusted for gender; family history of asthma; age; smoking habit; allergic rhinitis; exposure to gas, dust, or fumes at work; current living; living on a farm first 5 years of life; and BMI.

3 | RESULTS

3.1 | Participation

In 2016, 46% of the participants lived in the city of Gothenburg, which was also the case in 2008. More women (54%) than men (46%) participated in the study in 2016, and this was similar to that in 2008. Both in

TABLE 1 Gender comparison of the study population (%) from 2008 to 2016, including age, BMI, smoking habit, occupational exposure education, and residence

	Men (%)			Women (%)			Total (%)		
	2008	2016	<i>P</i> -value	2008	2016	<i>P</i> -value	2008	2016	<i>P</i> -value
Participated (n)	7115	11 204		8610	13 330		15 725	24 534	<0.001
Age (y)									
16-25	13.1	9.6		14.1	10.6		13.6	10.1	
>25-35	17.9	13.1		18.7	15.0		17.9	14.1	
>35-45	18.3	15.2	<i>P</i> < 0.001 ^a	18.3	15.5	<i>P</i> < 0.001 ^a	18.2	15.4	<0.001 ^a
>45-55	17.4	18.4		17.4	19.3		17.6	18.9	
>55-65	18.9	20.0		18.9	18.8		19.8	19.3	
>65-75	12.6	23.8		12.6	20.9		12.9	22.2	
BMI									
<18.5	0.9	0.8		2.9	2.1		7.2	5.5	
18.5-24.9	45.3	40.7	<i>P</i> < 0.001 ^a	60.0	55.4	<i>P</i> < 0.001 ^a	53.4	48.7	<0.001 ^a
25-30	42.3	44.3		26.4	29.1		33.6	36.0	
>30	11.5	14.2		10.7	13.4		11.1	13.8	
Smoking habit									
Nonsmokers	59.1	62.7		57.8	63.0		58.4	62.9	
Ex-smokers	22.6	24.3	<i>P</i> < 0.001 ^a	22.2	23.3	<i>P</i> < 0.001 ^a	22.4	23.8	<0.001 ^a
Smokers	17.7	11.7		19.6	12.3		18.7	12.0	
Raised on a farm	13.0	11.7	<i>P</i> = 0.05	12.9	11.4	<i>P</i> < 0.001	13.0	11.5	<0.001
Occupational exposure	31.0	27.3	<i>P</i> < 0.001	13.6	10.6	<i>P</i> < 0.001	21.5	18.2	<0.001
Place of residence									
Gothenburg	54.6	44.6	<i>P</i> < 0.001	55.3	46.6	<i>P</i> < 0.001	55.0	45.7	<0.001
Education									
Primary school	1.0	1.0		1.1	0.9		1.0	0.9	
Secondary school	20.1	17.9		20.7	15.5		20.4	16.6	
High school	41.5	42.4	<i>P</i> < 0.001 ^a	34.6	34.9	<i>P</i> < 0.001 ^a	37.7	38.3	<0.001 ^a
University	37.4	38.7		43.7	48.8		40.8	44.2	

Note: Occupational exposure: dust, fumes, and gases.

Abbreviation: BMI, body mass index.

^aTest for trend.

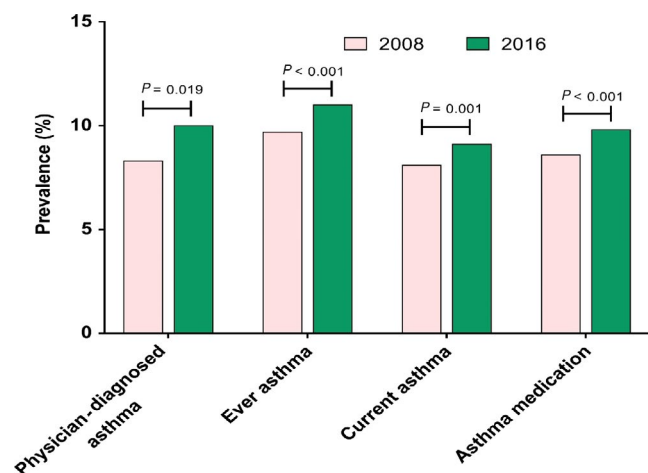


FIGURE 1 Prevalence of physician-diagnosed asthma, ever asthma, current asthma, and asthma medication in 2008 and 2016 [Color figure can be viewed at wileyonlinelibrary.com]

the 2008 and 2016 surveys, the response rate increased significantly with increasing age. In the 2008 survey, 40% of the participants reported having a university degree, which increased to 44% in 2016. The percentage of smokers decreased significantly from 19% in 2008 to 12% in 2016 ($P < 0.001$). This reduction was seen in all age groups. The middle-aged (46–55 years) population had the highest rates of smoking in 2008, compared with the younger population with the highest rates in 2016. Smoking was more common among women than men in both surveys (Table 1). Test for difference remained significant in Table 1 even after correction for multiple comparisons, except for “raised on a farm.”

3.2 | Prevalence of asthma and other respiratory symptoms in 2008 and 2016

The prevalence of ever asthma, physician-diagnosed asthma, current asthma, and use of asthma medication all statistically significantly

increased between 2008 and 2016. The greatest increase in prevalence was seen in physician-diagnosed asthma, which increased overall from 8.3% in 2008 to 10% in 2016 ($P = 0.019$), followed by ever asthma 9.6% to 11% ($P = 0.001$) and current asthma 8.1% to 9.1% ($P < 0.001$). The use of asthma medication also increased in the overall population between 2008 and 2016, from 8.6% to 9.8% ($P < 0.001$) (Figure 1). However, in the group with physician-diagnosed asthma use of asthma medication decreased from 2008 to 2016. The majority of respiratory symptoms increased in prevalence in the total population between the two study periods (Figure 2). Overall, allergic rhinitis was the most common respiratory symptom in both surveys, followed by any wheeze, attacks of shortness of breath, and dyspnea. (Figure 2) Despite a decrease in smoking between the two surveys, cough-related symptoms, while already high in 2008, increased even more in 2016. Long-standing cough, sputum production, and chronic productive cough had a prevalence of 13.0%, 15.5%, and 7.0%, respectively, in 2016 compared to 11.4%, 13.4%, and 6.1%, respectively, in 2008 (Figure 2).

3.3 | Changes in prevalence of asthma and other respiratory symptoms by demographic factors

The prevalence of physician-diagnosed asthma and current asthma was overall higher in women than in men in both 2008 and 2016. Among women, both physician-diagnosed asthma (9.1% to 10.9%, $P = 0.019$) and current asthma (9.2%–10.4%, $P = 0.005$) increased between 2008 and 2016 which was also true for the men, 7.4%–8.9%, $P < 0.001$ and 6.8%–7.6%, $P = 0.058$. In both genders, the most common symptoms were allergic rhinitis, shortness of breath, and any wheeze in 2008 and 2016. (Figure 2) However, the prevalence of these symptoms was higher among women than in men in both 2008 and 2016. For women, allergic rhinitis increased from 27.6% to 29.5% ($P < 0.001$) compared to men 26% to 27.6% ($P = 0.013$). Attacks of shortness of breath increased from 11.2% to 12.2% ($P = 0.017$) and 7.5%

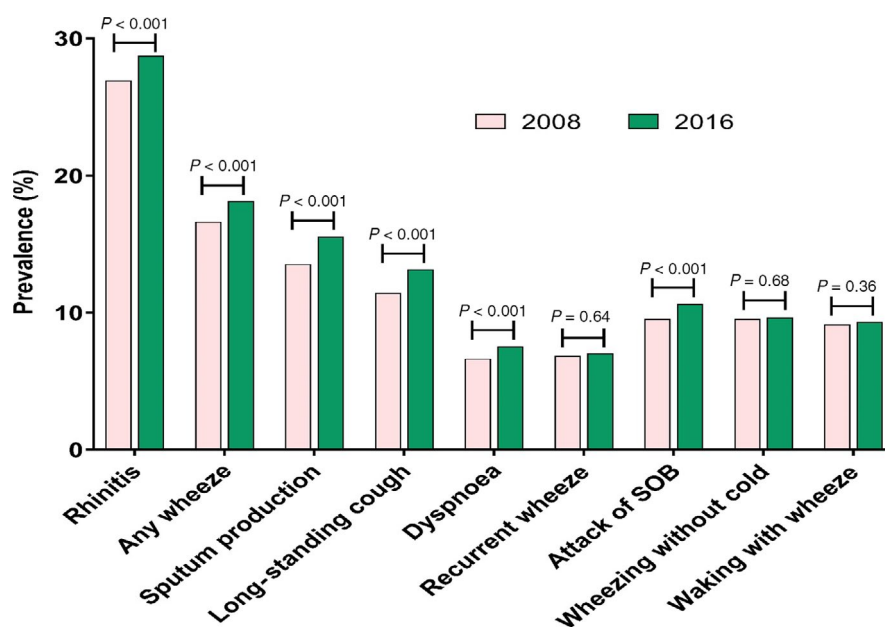


FIGURE 2 Prevalence (%) of respiratory symptoms in 2008 and 2016. SOB: Shortness of breath [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 2 Prevalence (%) of ever asthma, current asthma, and asthma medication by gender, age, BMI, and place of residence in 2008 and 2016

	Physician-diagnosed asthma (%)			Ever asthma (%)			Current asthma (%)			Asthma medication (%)		
	2008	2016	P-value	2008	2016	P-value	2008	2016	P-value	2008	2016	P-value
Gender												
Male	7.4	8.9	<0.001	8.7	9.8	0.002	6.8	7.6	0.058	6.8	7.8	0.015
Female	9.1	10.9	<0.001	10.5	12	0.002	9.2	10.4	0.005	10.1	11.6	<0.001
Age												
16-25	9.6	14.1	<0.001	11.1	15.3	<0.001	9.3	11.5	0.014	9.4	10.8	0.095
>25-35	10.2	11.7	0.052	12.0	13	0.261	9.0	9.1	0.850	8.9	8.7	0.798
>35-45	8.8	11.2	0.001	10.7	12	0.096	8.9	10.2	0.077	8.5	9.7	0.079
>45-55	7.1	8.6	0.017	8.3	10.4	0.001	7.4	8.8	0.040	8.1	9.4	0.052
>55-65	7.4	8.6	0.046	8.4	9.6	0.058	7.1	8.8	0.009	8.3	10.5	0.001
>65-75	7.1	8.6	0.026	7.5	8.8	0.067	7.1	7.8	0.361	8.7	10	0.075
BMI												
18.5	7.4	7.0	0.880	8.7	7.6	0.667	7.0	6.2	0.752	7.0	9.3	0.322
18.5-24.9	7.6	9.2	<0.001	8.7	10.1	<0.001	7.0	7.9	0.026	7.4	8.3	0.018
25-29.9	8.0	9.8	<0.001	9.6	10.9	0.014	8.3	9.2	0.082	8.8	10.0	0.019
>30	12.2	13.5	0.105	14.0	14.9	0.394	12.7	13.5	0.425	13.8	14.9	0.348
Family history												
Yes	18.2	22.6	<0.001	21.4	25.4	<0.001	18.3	21.3	0.003	17.7	20.4	0.007
No	6.1	7.1	0.001	7.0	7.7	0.015	5.9	6.3	0.149	6.4	7.2	0.007
Smoking												
Smoker	8.5	10.5	0.007	9.8	11.5	0.039	8.7	10.6	0.013	9.4	11.9	0.002
Ex-smoker	9.5	10.0	0.429	10.7	11.1	0.632	9.5	9.5	0.971	9.8	10.9	0.095
Nonsmoker	7.8	9.9	<0.001	9.1	10.9	<0.001	7.4	8.7	0.001	7.9	9.0	0.001
Occupational exposure												
Yes	10.3	13.2	<0.001	11.9	14.9	<0.001	10.6	12.9	0.001	11.1	13.9	0.001
No	7.7	9.3	<0.001	8.9	10.2	<0.001	7.3	8.3	0.003	7.8	8.9	<0.001
Place of residence												
Gothenburg	8.4	10.0	<0.001	9.9	10.9	0.018	8.4	8.9	0.193	8.7	9.4	0.071
Outside Gothenburg	8.2	10.0	<0.001	9.3	11.0	<0.001	7.8	9.2	0.001	8.6	10.7	<0.001

Note: Family history: family history of asthma; Occupational exposure: gas, dust, or fumes.
Abbreviation: BMI, body mass index.

to 8.6% ($P = 0.004$), respectively, for women and men. Any wheeze increased from 17.6% to 19.3% ($P = 0.001$) in women and from 15.3% to 16.8% ($P = 0.006$) in men. Bronchitis symptoms were more common in the first survey and increased more in men than in women in the second survey (Tables 2 and 3). While those in the age group >25-35 years had the highest prevalence of physician-diagnosed asthma in 2008, the prevalence was overall highest in the youngest age group 16-25 years in 2016 (Figures 3 and 4). The increase in the prevalence of most of the respiratory symptom between 2008 and 2016 was also highest in the youngest age group (16-25 years).

The prevalence of current asthma was higher in smokers compared to nonsmokers in both surveys. Current asthma increased from 8.7% to 10.6% ($P = 0.012$) among smokers and from 7.4% to

8.7% ($P = 0.001$) among nonsmokers. Similar difference between smokers and nonsmokers was also seen in the prevalence of physician-diagnosed asthma between 2008 and 2016, increasing from 8.5% to 10.5%, ($P < 0.001$) among smokers and from 7.8% to 9.9%, ($P < 0.001$) among nonsmokers.

Overall, current smokers had high prevalence of respiratory symptoms compared to nonsmokers in both surveys. The highest increase in respiratory symptoms among current smokers was seen in bronchitis-related symptoms. Among current smokers, the prevalence of ever bronchitis increased from 6.3% to 8.4% ($P = 0.002$), sputum production from 22.8% to 29.2%, ($P < 0.001$), long-standing cough from 18.1% to 21.5% ($P = 0.001$), and attacks of shortness of breath from 13.1% to 15.6% $P = 0.005$ between 2008 and 2016.

TABLE 3 Prevalence (in %) of respiratory symptoms typically found in asthma by gender, age, BMI, and place of residence in 2008 and 2016

	SOB 12m			Any wheeze			Recurrent wheeze			Long-standing cough		
	2008	2016	P-value	2008	2016	P-value	2008	2016	P-value	2008	2016	P-value
Gender												
Male	7.5	8.6	0.004	15.3	16.8	<0.001	6.8	7.1	0.517	10.2	12.0	<0.001
Female	11.2	12.2	0.017	17.6	19.3	0.010	6.9	6.9	0.966	12.4	14.0	<0.001
Age (y)												
16-25	9.3	12.2	0.001	15.8	19.0	0.003	5.1	6.7	0.015	13.5	15.1	0.009
>25-35	9.8	10.3	0.515	16.8	17.6	0.424	5.2	4.9	0.576	11.0	13.1	0.007
>35-45	9.8	10.9	0.129	16.2	17.4	0.189	6.2	5.4	0.188	11.1	12.1	0.178
>45-55	9.2	10.4	0.086	17.3	16.7	0.499	7.9	6.7	0.038	11.0	11.9	0.221
>55-65	9.3	10.6	0.540	17.0	19.3	0.007	7.9	8.3	0.582	11.5	14.5	<0.001
>65-75	9.6	9.9	0.634	16.8	18.9	0.002	8.5	8.5	0.994	10.9	12.7	0.719
BMI												
<18.5	6.7	10.7	0.049	14.4	15.2	0.826	5.4	6.2	0.738	15.8	10.8	0.062
18.5-24.9	8.1	8.8	0.077	14.3	14.1	0.771	4.5	4.3	0.525	10.9	11.4	0.280
25-29.9	9.7	10.6	0.085	16.9	19.1	0.002	7.2	7.4	0.683	11.1	13.4	<0.001
>30	15.1	17.0	0.088	27.0	30.5	0.010	15.6	14.9	0.557	15.9	18.6	0.018
Family history												
Yes	19.3	21.3	0.042	27.6	29.5	0.012	13.1	12.9	0.799	16.7	20.1	<0.001
No	7.1	7.8	0.036	14.1	15.1	0.012	5.2	5.4	0.571	10.4	11.3	0.017
Smoking												
Current	13.1	15.6	0.006	30.2	35.2	<0.001	14.4	17.4	0.002	18.1	21.5	0.001
Ex-smoker	10.4	11.4	0.162	16.8	19.2	0.003	6.7	7.7	0.055	9.5	12.4	<0.001
Nonsmoker	7.9	9.3	<0.001	12.3	14.5	<0.001	4.4	4.7	0.282	10.3	11.8	0.001
Occupational exposure												
Yes	13.6	16.4	0.001	23.7	26.8	0.002	12.0	12.9	0.266	15.5	19.1	0.001
No	8.1	9.2	0.001	14.6	16.1	0.001	5.1	5.5	0.108	10.5	11.7	<0.001
Place of residence												
Gothenburg	9.9	10.4	0.287	17.3	17.9	0.252	7.2	7.0	0.483	12.1	13.8	0.001
Outside Gothenburg	10.7	10.0	<0.001	15.9	18.3	<0.001	6.2	6.9	0.039	11.0	12.5	0.002

Note: Family history: family history of asthma; Occupational exposure: gas, dust, or fumes; SOB 12m: attacks of shortness of breath last 12 mo. Abbreviation: BMI, body mass index.

3.4 | Risk factors for asthma and respiratory symptoms in 2008 and 2016

The adjusted risk factor estimates for current asthma in 2016 were allergic rhinitis OR: 4.86 (95% CI: 4.41-5.35), family history of asthma OR: 3.15 (95% CI: 2.85-3.49), female sex OR: 1.37 (95% CI: 1.24-1.51), and obesity (BMI > 30) OR: 2.70 (95% CI: 1.73-4.39) (Table 4). Smoking was associated with an increased risk of current asthma and physician-diagnosed asthma, but the association between smoking and asthma was less pronounced in 2016 than in 2008. Although allergic rhinitis is a common risk factor for developing asthma, the impact of rhinitis as a risk factor for current asthma and physician-diagnosed asthma decreased in the overall population between 2008 and 2016. Family history of asthma tended to be a

stronger risk factor for asthma in 2016 than in 2008. Being overweight increased the risk for current asthma and physician-diagnosed asthma (Tables 4 and 5).

4 | DISCUSSION

In this population-representative sample of western Sweden, we report that the prevalence of ever, physician-diagnosed, and current asthma, including use of asthma medication, is still increasing. The highest increase in the prevalence was among young adults and overall higher among women than men. Furthermore, respiratory symptoms typical for asthma also increased in prevalence between 2008 and 2016, especially allergic rhinitis, which continues to be

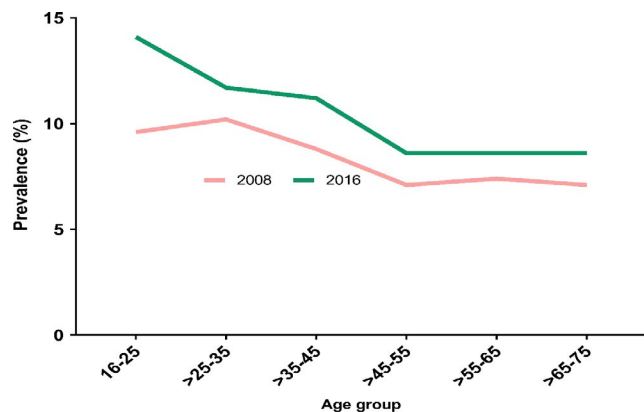


FIGURE 3 Prevalence (%) of physician-diagnosed asthma by age group in 2008 and 2016 [Color figure can be viewed at wileyonlinelibrary.com]

high and significantly increased between the two surveys. Female gender, rhinitis, obesity, and family history of asthma remained strong risk factors for asthma. Overall, smoking is steadily decreasing in western Sweden.

The lack of a standardized questionnaire across studies and different cohort selection and changing diagnostic habits make it difficult to compare the time change in asthma between places. However, in westernized countries the International Study of Asthma and Allergies in Childhood (ISAAC) study protocol has enabled comparison of asthma in children and adolescents.^{31,32} Studies using ISAAC protocol suggest that asthma prevalence among children has plateaued since 1990.²² Among adults, there are far less studies of representative samples from the general population, which complicates evaluation and comparison of prevalence changes in asthma over time between places. Nevertheless, some international studies using similar methods in repeated surveys of general population samples have been conducted, providing some data to evaluate changes in asthma prevalence over time. In Australia, physician-diagnosed asthma increased from 7.5% in 1990 to 12.2% in 2003.²⁰ An Italian study repeated in 1991-1993, 1998-2000, and 2007-2010 showed prevalence of physician-diagnosed asthma 4.3%-4.6%-6.6%, respectively.²¹ In the Scandinavian and Nordic countries, there are a few

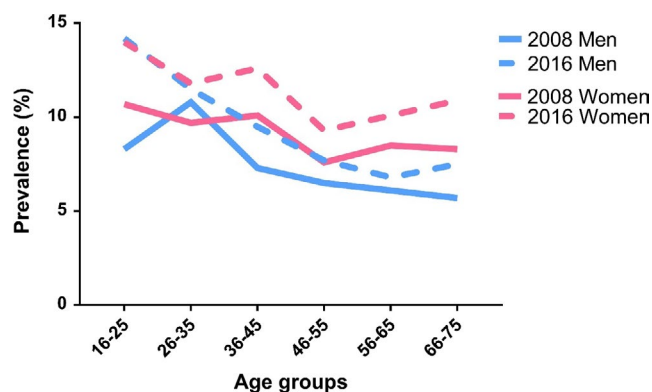


FIGURE 4 Prevalence (%) of physician-diagnosed asthma compared by age groups, gender, and study year [Colorfigure can be viewed at wileyonlinelibrary.com]

repeated studies on asthma and respiratory symptoms. One study from Stockholm showed an increase in physician-diagnosed asthma from 7.6% to 9.4% between 1996 and 2007.²⁸ A Danish study suggested an increase in current asthma from 1.2% in the late 70s to 7.7% in early 2000.³³ A Finnish study showed an increase in physician-diagnosed asthma from 6.5% in 1996 to 10% in 2006.²⁴ A Norwegian study found increased crude prevalence of ever asthma from 3.4% to 9.3% between 1972 and 1999.¹⁶ The most recent repeated cross-sectional study from Northern Sweden comparing randomly selected cohorts in 1996, 2008, and 2016 showed an increased prevalence of asthma from 8.4% in 1996 to 10.9% in 2016.³⁴

The increase in current asthma and physician-diagnosed asthma is in line with recent population-based studies in the Nordic countries.^{24,26,34} Although an increase in the asthma prevalence was seen in the studies mentioned above, symptoms typical of asthma have decreased, suggesting increasing amount of patients with physician-diagnosed asthma may have milder disease. However, improved asthma control with inhaled corticosteroid may also explain stabilization of symptoms.³⁵ Although our data support the increased use of asthma medication in the overall population, we do not have data that fully explain the reason for this increase. One could speculate that the increased use of asthma medication is due to a parallel rise or increased observance of other obstructive lung conditions, such as chronic obstructive lung disease (COPD). COPD and asthma are commonly treated with similar medications, and in clinical setting, patients often refer corticosteroids and bronchodilators to asthma medications.

In Sweden, access to health care, number of practicing physicians, and respiratory doctors have remained stable over the years. Due to the well-developed health system, most patients with asthma are diagnosed and managed by general practitioners. The increase in asthma prevalence is less likely explained by enhanced access to health care. Increased awareness of asthma leading to change in diagnostic praxis however could explain some of the increase. The increase in asthma prevalence among young adults may partly be explained by the parallel increase in the prevalence of allergic rhinitis in these age groups. The increase in allergic rhinitis was less prominent in the older age groups between 2008 and 2016. In the overall cohort, allergic asthma did however not increase in contrast to the result from a recent study in Northern Sweden.³⁴ In the overall study population, we found a significant increase in the prevalence of allergic rhinitis, any wheeze, shortness of breath, and long-standing cough. These symptoms are commonly found in asthma patients, which could indicate that asthma is underdiagnosed in the studied population.

The risk factors for asthma and respiratory symptoms were similar in 2008 and 2016, without any substantial differences in the impact of demographic factors on the respiratory conditions during the 8-year period of the surveys. However, a few points are worth mentioning. Female gender was a risk factor for asthma in 2008 and 2016.²⁹ Similar to our results, several epidemiological studies have shown that female gender is a risk factor for developing asthma. Although the mechanism is not

TABLE 4 Risk factors in 2008 and 2016 for current asthma and physician-diagnosed asthma by multiple logistic regression analysis

	Current asthma		Physician-diagnosed asthma	
	2008	2016	2008	2016
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Gender				
Male	1	1	1	1
Female	1.39 (1.22-1.59)	1.49 (1.35-1.65)	1.29 (1.13-1.46)	1.28 (1.16-1.40)
Age (y)				
16-25	1	1	1	1
>25-35	0.85 (0.69-1.06)	0.72 (0.60-0.87)	0.93 (0.76-1.15)	0.77 (0.65-0.92)
>35-45	0.85 (0.68-1.06)	0.81 (0.68-0.97)	0.80 (0.64-0.99)	0.72 (0.61-0.85)
>45-55	0.69 (0.54-0.87)	0.69 (0.58-0.83)	0.66 (0.52-0.83)	0.54 (0.45-0.64)
>55-65	0.75 (0.60-0.95)	0.78 (0.65-0.94)	0.77 (0.61-0.96)	0.60 (0.51-0.72)
>65-75	0.92 (0.71-1.19)	0.84 (0.70-1.00)	0.96 (0.75-1.23)	0.73 (0.62-0.87)
BMI				
<18.5	1	1	1	1
18.5-24.9	1.21 (0.75-1.96)	1.37 (0.87-2.16)	1.26 (0.79-2.01)	1.51 (0.98-2.31)
25-29.9	1.56 (0.96-2.55)	1.88 (1.18-2.97)	1.39 (0.86-2.25)	1.89 (1.22-2.91)
>30	2.31 (1.40-3.82)	2.60 (1.63-4.13)	2.09 (1.28-3.41)	2.50 (1.61-3.88)
Family history of asthma				
No	1	1	1	1
Yes	2.66 (2.33-3.05)	3.13 (2.83-3.47)	2.60 (2.27-2.97)	2.96 (2.68-3.27)
Smoking				
Nonsmokers	1	1	1	1
Ex-smoker	1.35 (1.16-1.57)	1.05 (0.93-1.18)	1.29 (1.11-1.50)	1.01 (0.90-1.13)
Smokers	1.17 (1.00-1.39)	1.17 (1.02-1.36)	1.10 (0.93-1.29)	1.02 (0.89-1.18)
Rhinitis				
No	1	1	1	1
Yes	5.69 (5.00-6.48)	4.76 (4.32-5.24)	5.02 (4.43-5.70)	4.34 (3.96-4.76)
Raised on a farm				
Yes	1	1	1	1
No	1.49 (0.71-3.10)	1.32 (0.83-2.08)	1.62 (0.75-3.51)	1.19 (0.77-1.83)
Place of residence				
Gothenburg	1	1	1	1
Outside Gothenburg	1.04 (0.91-1.18)	0.38 (0.12-1.21)	0.97 (0.86-1.11)	0.45 (0.14-1.41)
Exposure at work				
No	1	1	1	1
Yes	1.39 (1.20-1.61)	1.58 (1.15-2.19)	1.30 (1.12-1.50)	1.39 (1.24-1.55)

Note: Exposure at work: dust, fumes, and gas.

Abbreviation: BMI, body mass index.

well understood, there have been speculated that the higher prevalence of asthma in women is related to smaller airway caliber size³⁶ or possible hormonal differences.³⁷ A family history of asthma is a strong risk factor for developing asthma, which indicates a genetic predisposition.³⁸⁻⁴⁰ Environmental factors, such as work-related exposure to dust, tobacco smoke, and air pollution, are other risk factors.⁴¹

The hygiene hypothesis was first formulated in the end of 1980s.⁴² In particular, declining family size, improvements in household amenities, and higher standards of personal cleanliness have reduced the opportunity for cross infection.⁴³ The hygiene hypothesis finds support in the immunological basis of atopic diseases which results in increased T helper type 2 (Th2) differentiation of naive T cells, with production of IL-4, IL-5, and IL-13 cytokines, as opposed to the

TABLE 5 Risk factors in 2008 and 2016, for attacks of shortness of breath (SOB), recurrent wheeze, and long-standing cough by multiple logistic regression

	Attacks of SOB		Recurrent wheeze		Long-standing cough	
	2008	2016	2008	2016	2008	2016
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Gender						
Male	1	1	1	1	1	1
Female	1.67 (1.47-1.89)	1.61 (1.46-1.76)	1.09 (0.94-1.25)	1.10 (0.98-1.22)	1.30 (1.17-1.45)	1.29 (1.19-1.40)
Age						
16-25	1	1	1	1	1	1
>25-35	0.90 (0.73-1.11)	0.76 (0.64-0.91)	0.88 (0.67-1.16)	0.63 (0.49-0.80)	0.7 (0.62-0.88)	0.80 (0.68-0.93)
>35-45	0.92 (0.74-1.13)	0.82 (0.69-0.98)	1.04 (0.80-1.36)	0.71 (0.56-0.90)	0.71 (0.59-0.85)	0.74 (0.63-0.86)
>45-55	0.79 (0.63-0.99)	0.76 (0.64-0.90)	1.29 (0.99-1.67)	0.83 (0.67-1.03)	0.74 (0.61-0.88)	0.70 (0.60-0.81)
>55-65	0.93 (0.75-1.16)	0.82(0.69-0.97)	1.38 (1.06-1.79)	1.02 (0.82-1.25)	0.80 (0.67-0.96)	0.90 (0.77-1.04)
>65-75	1.24 (0.98-1.57)	0.92 (0.78-1.09)	1.79 (1.35-2.37)	1.27 (1.03-1.56)	0.88 (0.72-1.08)	0.86 (0.74-0.95)
BMI						
<18.5	1	1	1	1	1	1
18.5-24.9	1.46 (0.90-2.37)	0.84 (0.59-1.22)	0.82 (0.48-1.41)	0.73 (0.46-1.16)	0.74(0.53-1.03)	1.21 (0.85-1.71)
25-29.9	1.87 (1.15-3.05)	1.15 (0.80-1.65)	1.23 (0.72-2.12)	1.27 (0.80-2.02)	0.80 (0.57-1.12)	1.53 (1.08-2.18)
>30	2.78 (1.68-4.59)	1.79 (1.24-2.60)	2.79 (1.61-4.82)	2.55 (1.60-4.05)	1.14 (0.80-1.62)	2.10 (1.47-3.01)
Family history						
No	1	1	1	1	1	1
Yes	2.35 (2.07-2.67)	2.51 (2.28-2.77)	2.42 (2.08-2.81)	2.36 (2.09-2.66)	1.47 (1.29-1.66)	1.70 (1.55-1.86)
Smoking						
Nonsmokers	1	1	1	1	1	1
Ex-smokers	1.31 (1.13-1.52)	1.16 (1.04-1.30)	1.24 (1.03-1.48)	1.35(1.18-1.54)	0.87 (0.75-1.00)	0.98 (0.89-1.08)
Smokers	1.78 (1.51-2.02)	1.73 (1.53-1.96)	3.52(3.01-4.11)	4.06 (3.57-4.63)	1.84 (1.63-2.08)	1.87 (1.68-2.09)
Rhinitis						
No	1	1	1	1	1	1
Yes	4.50 (3.99-5.07)	3.94 (3.60-4.31)	2.48 (2.16-2.85)	2.41 (2.16-2.69)	1.79 (1.61-1.99)	1.90 (1.75-2.06)
Raised on a farm						
Yes	1	1	1	1	1	1
No	1.52 (0.75-3.03)	2.27 (1.42-3.60)	1.61 (0.76-3.39)	1.57 (0.95-2.60)	1.18 (0.66-2.18)	1.29 (0.90-1.86)

(Continues)

TABLE 5 (Continued)

	Attacks of SOB		Recurrent wheeze		Long-standing cough	
	2008	2016	2008	2016	2008	2016
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Place of residence						
Outside Gothenburg	1	1	1	1	1	1
Gothenburg	1.12 (0.99-1.26)	0.97 (0.22-4.30)	1.25 (1.08-1.43)	0.64 (0.17-2.32)	1.06 (0.97-1.19)	1.23 (0.35-4.25)
Occupational exposure						
No	1	1	1	1	1	1
Yes	1.71 (1.50-1.96)	1.87 (1.68-2.08)	2.07 (1.79-2.40)	1.98 (1.76-2.23)	1.52 (1.35-1.71)	1.67 (1.52-1.83)

Th1 differentiation.⁴⁴ Several studies have further shown that children growing up in farming environments, who therefore have been exposed to a variety of microflora, are protected against the development of allergic diseases.⁴⁵ This is true for allergic rhinitis,^{46,47} but also for asthma as shown in some studies.⁴⁸⁻⁵⁰ In the present study, fewer people were raised on farms in the 2016 cohort compared to the 2008 cohort, and one can speculate if the increase in asthma prevalence is partly due to less individuals growing up on farms.

Body weight continues to increase globally. In 2016, more than 1.9 billion adults aged 18 years and older were overweight, and of these, over 650 million adults were obese.⁵¹ While obesity and asthma are common conditions, a specific association of obesity with asthma was described in 1999.⁵² Both specific inflammatory causes and mechanical causes have been shown to play a role in asthma and obesity.^{53,54} In our study, being obese almost doubled the risk for current asthma.

Smoking habit has decrease continually in the Swedish population since the new smoking law was implemented in 2005. In the 2016 WSAS study, smoking had less impact on both current asthma and physician-diagnosed asthma compared to 2008. In contrast, ex-smokers showed an increased risk of shortness of breath, any wheeze, and long-standing cough in 2016 compared to 2008. A possible reason for the increasing risk in ex-smokers could be explained by smokers with more symptoms decide to quit the habit, while individuals with less symptoms continue.

Allergic sensitization is a strong risk factor for developing asthma. The prevalence of allergic sensitization has increased markedly in Sweden over last two decades.⁵⁵⁻⁵⁷ Although the GA²LEN questionnaire contains detailed questions regarding symptoms of allergic rhinitis, one could argue that lack of information about the nature of allergens gives a less accurate description of allergic asthma in epidemiological studies. In the present study, answering "yes" to questions about allergic rhinitis was used as a proxy for defining allergic asthma. An associated symptom of allergy (hay fever) is frequently used in population studies when clinical allergy tests are not available, and has been shown to be

a good marker of atopy in several studies.^{34,58,59} Although data collection for objective allergen investigation is ongoing in WSAS II, the corresponding measurement performed in a randomly selected population from WSAS I showed that among subjects aged 20-46 years, 81% of those reporting symptoms of allergic rhinitis also had elevated specific IgE and skin prick test,⁵⁶ which implies that reporting allergic rhinitis was a good marker for allergic sensitization. The present study showed a high risk of having asthma among those with rhinitis, although the impact of rhinitis was less in 2016 than in 2008. Similar observation was also found in an Italian study.²¹ In contrast to our study, other studies from Sweden and Nordic countries showed that the prevalence of allergic asthma increased more compared to nonallergic asthma.^{24,34}

WSAS is a large longitudinal population study, randomly selected and representative of the population of Western Sweden. Epidemiological studies of asthma are highly dependent on repeated studies with validated questionnaire. The questionnaire used in our study is well validated and used in several other studies around the world.⁶⁰⁻⁶² Even though the two surveys described in this paper were performed 8 years apart, the same questionnaires were utilized and the same age groups and similar demographics were recruited in the two surveys, thus allowing direct comparisons to be made between the two survey years. The sample size and the 8-year gap between the surveys provided sufficient time to observe any important changes within the population. The survey response rate was higher in the 2008 survey than in the 2016 survey. It is unclear why there was a decrease in response over the 8-year period, but this is a similar phenomenon across different contexts in which the general response rates to population surveys are continuously on the decrease nowadays. To mitigate the tendency of low response, we offered participants the opportunity to participate in the survey by completing the survey using paper copy or electronically through a dedicated survey website for the project. We also followed up nonresponders by conducting a nonresponder study, which indicated no substantial differences between participants and nonparticipants to the survey. By weighting the survey sample to adjust for the response rate, the

weighted and unweighted prevalence rates were similar, giving us confidence that there is no major respondent-related bias.

5 | CONCLUSION

In this large repeated population study, we have shown that the prevalence of asthma and respiratory symptoms in western Sweden moderately increased between 2008 and 2016. The highest prevalence of asthma was seen in youngest adults. The simultaneous increase in respiratory symptoms may suggest that asthma is under-diagnosed in this population.

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CONFLICTS OF INTEREST

Dr Lundbäck reports grants from AstraZeneca, personal fees from GSK, personal fees from AstraZeneca, and personal fees from Novartis, outside the submitted work.

AUTHOR CONTRIBUTIONS

EB drafted the manuscript and performed the statistical analyses. LE participated in the design of the study, collection of data, assisted in the statistical analyses, and revised the manuscript. BN assisted in the statistical analyses and revised the manuscript. AB, RM, and MR revised the manuscript. BL participated in the design of the study and revised the manuscript. All authors read and approved the final manuscript.

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