Chronic rhinosinusitis in a birth cohort: symptom trajectories and early-life risk factors up to young adulthood

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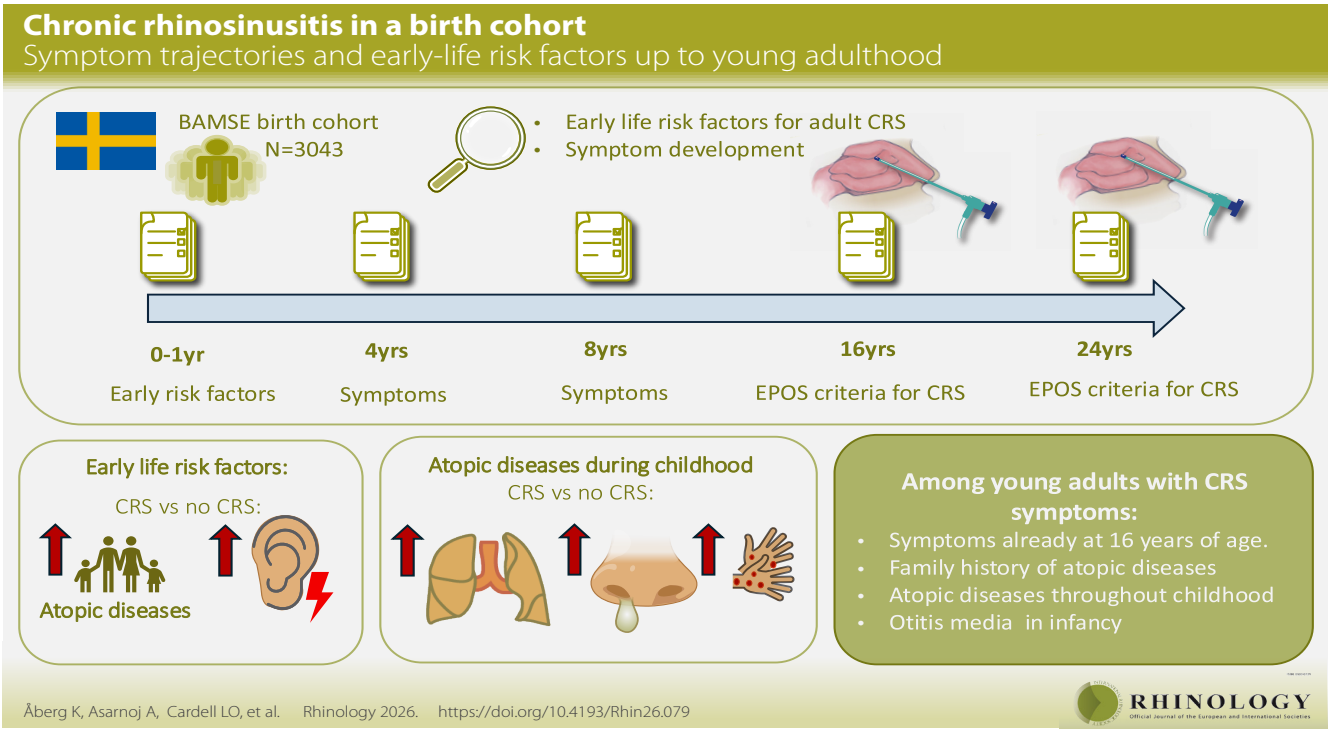

Abstract

Background: Chronic rhinosinusitis (CRS) is common worldwide in adults, but development of CRS has rarely been studied longitudinally in birth-cohorts. The aim was to investigate development of upper airway symptoms from childhood to young adulthood and to identify early risk factors for CRS at 24 years, in a population-based birth cohort.

Method: 3037 subjects from the BAMSE (Barn/children Allergy Milieu Stockholm Epidemiology) cohort had complete questionnaire answers on CRS at the 24-year-follow-up. Subjects fulfilling European Position Paper on Rhinosinusitis (EPOS) criteria of CRS at 16 and/or 24 years (n=141) were invited to a clinical examination with nasal endoscopy and interviews. Among these, 68 had clinically verified CRS symptoms. Symptoms and clinical status were compared with questionnaire-based answers on symptoms and potential risk factors for CRS, in early childhood.

Results: Among subjects with CRS symptoms at 24 years, > 60% reported upper airway symptoms already at 16 years. In the same group, a significant association was observed with a history of otitis media < 1 year and with heredity for atopic diseases. Moreover, the proportion of atopic features such as asthma, allergic rhinitis and eczema were significantly higher at 4, 8 and 16 years in this group. No clear association was found between CRS at 24 years and early RS infection, antibiotic use<1 year or older siblings.

Conclusions: Early otitis media (< 1 year) and heredity for atopic diseases may represent risk factors for developing CRS symptoms in young adulthood.

Key words: chronic rhinosinusitis, risk factors, birth cohort, otitis media, atopy

Introduction

Chronic rhinosinusitis (CRS) is a multifactorial inflammatory disease of the paranasal sinuses and nasal mucosa, occurring in both children and adults. In pediatric populations, CRS is often associated with recurrent upper respiratory tract infections, adenoidal hypertrophy, and impaired mucociliary clearance [1]. The immature anatomy of the paranasal sinuses and a developing immune system contribute to distinct pathophysiological features in children compared to adults [1,2]. Symptoms of chronic rhinosinusitis often overlap with those of other conditions, such as common cold, allergic rhinitis, and adenoiditis. In addition, clinical presentation may vary by age. Younger children typically exhibit cough and purulent nasal discharge, whereas older children more frequently report nasal obstruction, facial pressure, and headache.

Understanding the development of CRS from childhood to adulthood is critical for improving early diagnosis, tailoring age-specific treatment strategies, and potentially preventing chronic disease. There is limited information on the development of CRS from childhood to adulthood in the general population.

As children transition into adolescence and adulthood, anatomical changes such as sinus pneumatization, reduced adenoidal influence, and maturation of the immune response may alter the clinical presentation and disease course. Environmental exposures (e.g., allergens, pollutants, and smoking), comorbid conditions such as asthma or allergic rhinitis, and microbial biofilms are suggested to contribute to the persistence of chronic disease [1-4].

While many children appear to outgrow CRS symptoms, possibly due to anatomical and immunological maturation, a subset progress to adult CRS which is clinically characterized by either CRS with nasal polyps (CRSwNP) or CRS without nasal polyps (CRSsNP), classified since 2020 by the consensus document "European Position Paper on Rhinosinusitis and Nasal polyps" (EPOS) as primary (diffuse or localized, and diffuse as e-CRS or non e-CRS) or as secondary CRS [2]. Although the adult phenotype often reflects a complex interplay of host immune dysregulation, epithelial barrier dysfunction, and chronic inflammation [2,5], this has been less studied in pediatric cases and in young adults.

The aim of this study was to investigate symptom development and potential early life risk factors for CRS at 24 years of age, examining subjects from an unselected population-based birth cohort with well verified disease symptoms and clinical status.

Materials and methods

The BAMSE birth cohort

Young adults from the population-based birth cohort BAMSE (Children, Allergy, Milieu, Stockholm, Epidemiology) were enrolled. The cohort has previously been described in detail [6]. Briefly, BAMSE consists of 4,089 children recruited within a few months after birth. Repeated questionnaires were used to collect information on allergic diseases and asthma. Clinical examinations were also performed at ages 4, 8, 16, and 24 years.

Subgroup follow-ups at 16- and 24 years

The 16- and 24-year BAMSE questionnaires included questions on symptoms of CRS according to EPOS 2012 [7]. All participants who fulfilled the CRS criteria according to the questionnaire were invited to a clinical subgroup follow-up, to verify the diagnosis, at 16 and 24 years, respectively [8,9]. Firstly, telephone interviews were conducted to confirm ongoing CRS symptoms according to EPOS. Subjects with persistent symptoms at the telephone interview were invited to a clinical follow-up, including a structured interview and nasal endoscopy. For ethical reasons related to radiation exposure, no CT imaging was performed at the 16-year or the 24-year follow-up. At 16 years of age, 27 participants had symptoms according to the questionnaire and the telephone interview, and 23 participants with CRS symptoms underwent clinical examination [8]. At 24 years of age, 81 participants with CRS symptoms underwent clinical examination, 68 subjects had symptoms of primary, diffuse CRS, whereof 42 had endoscopically verified CRS. Only two of these participants had nasal polyps and none had undergone sinus surgery. Details regarding the 16 and 24-year follow-ups have been previously described [8,9].

Study base at 24 years

At 24 years of age 3037 participants completed the questions on CRS from where subjects with CRS symptoms were identified and addressed for telephone interview. In addition, subjects with confirmed symptoms of CRS at the 16-year subgroup follow-up, not completing the 24-year-questionnaire, were contacted by telephone, and targeted for inclusion if symptoms of CRS were confirmed. Thus, the study base consisted of 3037 participants with data on CRS symptoms at the 24-year questionnaire, plus 6 additional participants from the 16 year-follow up with confirmed symptoms at 24 years (total n=3043).

Study populations

In the study populations we included participants who had attended the 24-year CRS subgroup study and with complete data on the exposures of interest. Consequently, to minimize internal missing, we defined separate study populations for each analysis. The populations used were compared with the original cohort and the study base at 24 years (Table S1).

Definitions

- *CRS symptoms*: Defined according to EPOS [2] as ≥12 weeks duration of ≥2 of 4 symptoms: nasal obstruction/congestion, nasal discharge (anterior/posterior), facial pain/pressure and/or reduction or loss of smell, one of which being nasal ob-

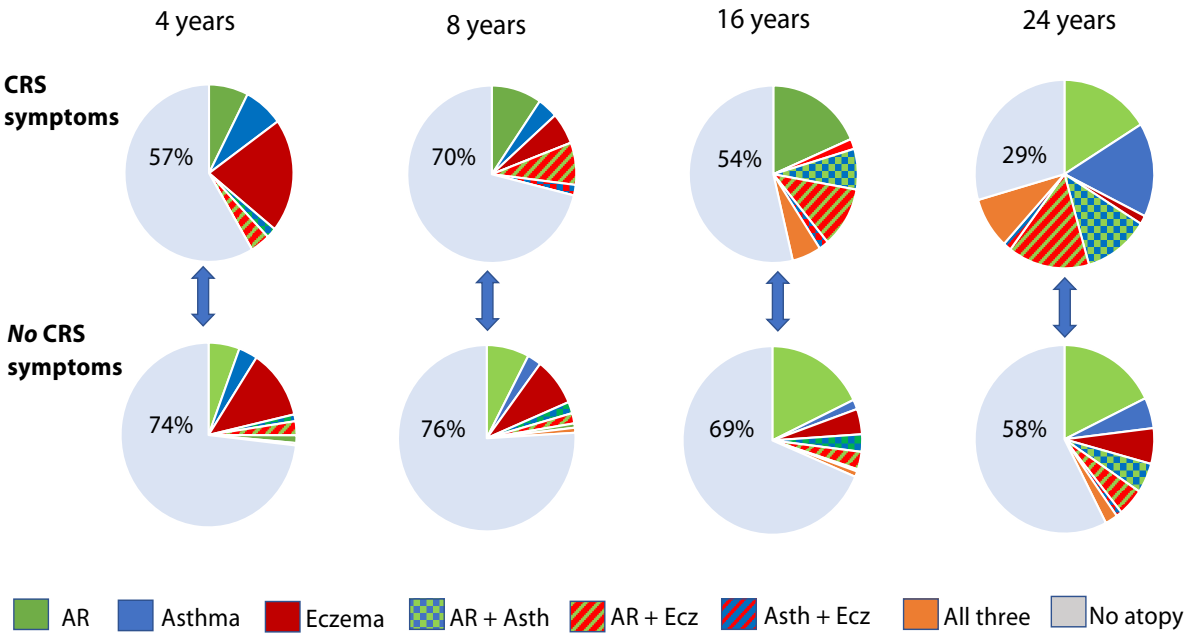

Figure 1. Atopic features at different ages in subjects with, or without, CRS symptoms at 24 years.

struction/congestion or nasal discharge.

- *Endoscopically verified CRS*: CRS symptoms as above, with endoscopic signs of mucopurulent discharge primarily from the middle meatus and/or mucosal oedema/obstruction in the middle meatus or with endoscopic signs of nasal polyps.
- *Asthma*: Doctor's diagnosis of asthma ever, plus episodes of breathing difficulties or asthma medication use during the past 12 months.
- *Allergic rhinitis* (AR): Nasal/ocular symptoms upon exposure to an inhalant allergen.
- *Rhinitis*: Fulfilling the International Study of Asthma and Allergies in Childhood (ISAAC) definition of rhinitis: Prolonged sneezing or a runny or blocked nose without common cold in the last 12 months prior to the date of questionnaire [10].
- *Atopic eczema*: Dry skin with itchy rash lasting ≥2 weeks and typical localization (face, extensor surfaces of arms/legs, flexures of arms/legs, wrists, or ankles) up to questionnaire, and/or doctor's diagnosis of eczema by that time [11].
- *Otitis*: Otitis media (secretory or acute) before 1 year.
- *Family history of atopy*: Mother and/or father with doctor's diagnosis of asthma and asthma medication and/or doctor diagnosed hay fever in combination with furred pets- and/or pollen allergy and/or doctor's diagnosis of eczema (contact allergy among parents is excluded) at the time of baseline questionnaire.
- *Early exposure to tobacco smoke*: Any parent smoking in household at birth and at 1 year and 2 years
- *RS 1 year*: Infection caused by Respiratory Syncytial (RS) virus before 1 year.
- *Siblings*: Other children in household (0-12 years) at time of birth.
- *AB 1 year*: Antibiotics treatment before 1 year.

Analyses

Clinical findings and interview data at 24 years were compared to earlier questionnaire reports on respiratory symptoms and early-life exposures and to clinical findings and reported symptoms at the subgroup follow-up at 16 years. For comparison, and because of the fluctuating nature of the CRS disease, we used both CRS symptoms (verified by the structured interview) and endoscopically verified CRS as outcomes in the analyses.

Statistics

For calculations on differences of proportions between two groups with dichotomous variables (CRS symptoms yes/no), χ^2 test was used and Fishers exact test when appropriate ($n < 5$). P-values ≤0.05 were considered statistically significant. A logistic multivariate regression model was used for calculation of odds ratios (OR) for the potential early life risk factors for CRS at 24 years. Risk factors, based on earlier literature [2,3,12,13] and with available data from the cohort, were analyzed; other children

Table 1. Number and proportion of subjects with airway symptoms at 16 years of age, among those with CRS at 24 years of age, compared to those without CRS at 24 years of age.

N=2488	24 years of age									
	CRS symptoms					Endoscopically verified CRS				
	Yes (n=56)		No (n=2432)		p-value	Yes (n=37)		No (n=2451)		p-value
16 years	n	%	n	%		n	%	n	%	
CRS symptoms (n=18)	6	10.7	12	0.49	<0.001	5	13.5	13	0.53	<0.001
CRS endoscopically (n=7)	2	3.6	5	0.21	<0.001	2	5.4	5	0.20	<0.001
Rhinitis (n=689)	34	60.7	655	26.9	<0.001	23	62.2	666	27.2	<0.001
Symptoms of AR (n=619)*	23	41.8	596	25.0	0.005	15	41.7	604	25.1	0.023
Asthma (n=157)	9	16.1	148	6.1	0.002	5	13.5	152	6.2	0.069
No nasal symptoms (n=1630)	21	38.2	1609	67.4	<0.001	13	36.1	1617	67.2	<0.001

*Internal missing =1.9%. Study population: Complete answers on questions of CRS at 24-years, and on CRS, AR, rhinitis and asthma at 16 years.

in the household at birth, family history of atopic disease, otitis media <1 year, RS-infection <1 year, antibiotics <1 year, presented as crude (ORc) and adjusted (ORa). Adjustments were made for the different risk factors towards each other. STATA statistical software (Version 16.1 SE StataCorp, Collage Station, TX, USA) was used for all statistical analyses.

Ethics

Ethical permission for the cohort (2016/1380-13/2), as well as for the subgroup study (2018/209-32), was obtained from the Regional Ethical Review Board at Karolinska Institutet, Stockholm, Sweden. Parents, and later the grown-up participants, gave informed consent for each follow up.

Results

Study populations

Relative to the original cohort, the study base at 24 years included a slightly higher proportion of females and a lower proportion of participants with low socioeconomic status. However, when compared with the study base, no significant differences were seen for the six different study populations, used in Table 1, Table 2 and Figure 1, regarding their main characteristics (Table S1).

Symptom development

Among participants with CRS symptoms at 24 years of age, 10.7% (6/56) reported CRS symptoms already at 16 years, compared to 0.49% (12/2432) among those without CRS symptoms at 24 years (Table 1). Participants with CRS symptoms at 24 years also reported other upper airway symptoms at 16 years more often than those without CRS, such as "allergic rhinitis" (41.8% vs. 25.0%, p=0.005) and "rhinitis" as defined by the ISAAC criteria (60.7% vs. 26.9%, p <0.001). Furthermore, they more often reported asthma at 16 years of age (16.1% vs. 6.1%, p=0.002). Among participants with CRS symptoms at 24 years, 38.2% reported "no upper airway symptoms" at 16 years, compared to 67.4% of those without CRS symptoms at 24 years (Table 1). Similar figures were observed for the group with endoscopically verified CRS at 24 years (Table 1).

Of the cohort participants who met the EPOS symptom criteria for CRS at the 16-year follow-up (1.5%), 28.2% (n=48) continued to meet the criteria at 24 years, and 23.1% had endoscopically verified CRS at 24 years of age. None had undergone sinus surgery.

Atopic diseases during childhood

Participants with CRS symptoms at 24 years showed higher prevalence of childhood atopic conditions, such as asthma, allergic rhinitis, and atopic eczema, throughout ages 4, 8, 16 and 24 years compared to non-CRS participants (Table S2). The proportion of participants without any atopic symptoms was consistently higher at all ages among those without CRS symptoms at 24 years, although the difference was not significant at 8 years (Figure 1). Even non-respiratory atopic symptoms (eczema) were more prevalent during childhood among those who developed CRS at 24 years. This pattern remained at the 24-year follow-up [9].

Early risk factors

CRS symptoms and endoscopically verified CRS at 24 years were significantly associated with a history of otitis media before 1 year of age (ORa 2.1, 95% CI 1.1-4.1 and 2.9, 95% CI 1.2-7.1 respectively) and with parental history of atopic disease (ORa 2.1, 95% CI 1.2-3.4, resp 2.2, 95%CI 1.2-4.1) (Table 2). For comparison, not shown in table 2, we analyzed otitis media between 1-2 years which was significantly associated to endoscopically veri-

Table 2. Possible early exposures and risk factors for CRS at 24 years of age.

N=2486	Symptoms of CRS at 24 years (n=63)						Endoscopically verified CRS at 24 years (n=40)					
	n	%	ORc	95% CI	ORa*	95% CI	n	%	ORc	95%CI	ORa	95% CI
Other children in household, n=1182	34	2.9	1.7	1.0-2.8	1.6	1.0-2.7	19	1.6	1.3	0.7-2.4	1.2	0.6-2.3
Family history of atopy, n=870	38	3.0	2.0	1.2-3.4	2.1	1.2-3.4	25	2.0	2.3	1.2-4.4	2.2	1.2-4.1
Otitis media <1y, n=731	25	3.4	2.0	1.2-3.3	2.1	1.1-4.1	18	2.5	2.4	1.3-4.6	2.9	1.2-7.1
RS infection <1y, n=129	4	3.1	1.5	0.5-4.1	1.4	0.5-3.9	3	2.3	1.8	0.5-5.7	1.7	0.5-5.7
Antibiotics <1 y, n=1211	31	2.6	1.3	0.8-2.2	0.8	0.4-1.6	20	1.7	1.4	0.7-2.6	0.6	0.2-1.5
Early exposure to tobacco smoke, n=237	8	3.4	1.6	0.8-3.5	1.8	0.8-3.8	5	2.1	1.6	0.6-4.1	1.7	0.7-4.5

Number, proportion, and odds ratio (OR) for having CRS at 24 years of age among those with the early exposure compared to those with without the early exposure. OR expressed as crude OR (ORc) and OR for risk factor adjusted towards each other (ORa).
Study population: Answers on questionnaire 0, 1 and 2 (positive answers were considered as "yes", negative or no answer on the relevant exposure were considered as "no") and complete answers on CRS at 24 years.

fied disease (ORc 1.6, 95% CI 1.2-4.1) but not with questionnaire-defined CRS (ORc 1.5 95% CI NS).
No associations were found between CRS and early respiratory syncytial virus infection or antibiotic use under 1 year of age (Table 2). Having other children in the household was weakly associated to questionnaire-defined CRS (ORa 1.6, 95% CI 1.0-2.7) but not to endoscopically verified disease (Table 2).

Discussion

In this large population-based longitudinal study, we observed that CRS symptoms in young adulthood often originate early in life. Approximately two-thirds of individuals with CRS at 24 years reported nasal symptoms already at 16 years, suggesting that CRS, in some individuals, may develop gradually over adolescence rather than appearing abruptly in adulthood.
Our results also demonstrate a clear association between CRS and atopic conditions, not only cross-sectionally but throughout childhood and adolescence. Interestingly, among several potential early-life factors, only two emerged as significant predictors of CRS at 24 years: family history of atopic disease and a history of otitis media in infancy. These findings suggest that both genetic susceptibility and early infectious events may play a role in the pathogenesis of CRS. However, RS infection showed no association and having siblings, as a proxy for early general infections, showed no convincing association.
Overall, most individuals with endoscopically verified CRS or CRS symptoms based on EPOS criteria at 24 years had already reported upper airway symptoms at 16 years. Many reported "rhinitis" at this age—symptoms resembling CRS but not fulfilling all EPOS criteria. This underscores the importance of early identification and monitoring of persistent nasal symptoms during adolescence. Determining the onset and manifestation of CRS symptoms can be challenging due to the fluctuating nature of the disease and the symptom overlap between CRS, rhinitis, and allergic rhinitis, which can be difficult to distinguish in questionnaire-based assessments. Consequently, some of these cases may represent early-stage CRS, while others likely reflect allergic rhinitis or non-allergic rhinitis.
As reported in our previous cross-sectional study [9], atopic diseases were significantly more common among 24-year-olds with CRS compared to those without CRS symptoms. Our longitudinal data now confirm that this pattern persists throughout childhood—at ages 4, 8, and 16 years—in individuals who later developed CRS at 24 years. The consistently higher prevalence of non-sinonasal symptoms (such as eczema and asthma) at all ages among those with subsequent CRS suggests a genuine association in this population, rather than misclassification between CRS and allergic rhinitis. Whether a causal relationship exists between atopic inflammation and CRS remains unclear, except in Central Compartment Allergic Disease (CCAD) and allergic fungal rhinosinusitis (AFRS), where allergic inflammation is considered to predispose CRS development [2,3,14]. Although some studies have reported associations between neutrophilic inflammation and allergy [15], current literature on the subject revealed conflicting evidence. While some studies found links between allergy, atopy, and CRS, others did not [2,3,16]. These discrepancies raise the question of whether CRS pathogenesis differs between children, young adults, and adults in general.

Supporting this hypothesis, a retrospective registry-based study from Finland reported higher rates of allergy, chronic otitis media, and tonsillar disease in pediatric CRS patients compared to adult CRS patients [13]. It is plausible that similar patterns may apply to young adults with CRS, but further investigation is needed.

As early risk factors we observed a significant association to family history of atopic diseases, which accentuates the finding above mentioned. Moreover, having otitis media at an early age seems to be associated with the development of CRS, possibly indicating an underlying dysfunction of the mucosal barrier. Other studies have demonstrated a connection between CRS and chronic otitis media in adults [17], especially between eosinophilic otitis media and eosinophilic CRS, but also a higher incidence of middle ear cholesteatoma [18]. Two reviews on the topic published in 2023 reported a higher prevalence of otologic symptoms among patients with CRS [19,20]. Notably, eosinophilic otitis has shown to improve when treating patients with eCRS and bronchial asthma with dupilumab [21]. Kim et al. compared 8,057 CRS patients in Korea with 506,306 control subjects and found that CRS patients had twice the incidence of chronic otitis media, with a higher incidence in CRSwNP compared to CRSsNP [17]. Similarly, Hong et al. also found that chronic otitis was more prevalent in subjects with CRS. However, their subgroup analysis showed that this association was significant only in older patients (≥50 years) with nasal polyps [22]. In our cohort of young adults, only 2 participants were identified as having nasal polypes. Given this very limited number of cases, we were unable to draw any meaningful conclusions regarding potential differences in phenotypes. So far, the available evidence is strongest for Eustachian tube dysfunction, which has been shown to be particularly impaired in CRS patients. Additionally, the Eustachian tube function appears to improve after treatment for CRS [21,23,24]. A recently published prospective follow-up study from Valencia, Spain, including all cases of chronic rhinosinusitis with nasal polyps seen between January 2019 and October 2024 (N=155), reported that approximately 70% showed a type 2 inflammatory profile. Interestingly, this group showed a higher incidence of acute and secretory otitis media, compared to the group without type 2 inflammation. The regression analysis indicated that type 2-inflammation may play a greater role for otologic symptoms than nasal obstruction itself. The formation of polyps can alter the function of the eustachian tube, but the question is whether this is due to obstruction or to the underlying allergic-inflammatory pathogenesis [25]. Nevertheless, a clear link between otitis media in infancy or childhood and the later development of CRS remains poorly documented in the current literature.

A major strength of this study is that all data originates from the well-characterized, unselected BAMSE birth cohort, which is large and has a high participation rate. This is combined with access to well validated data on comorbidities as well as hereditary factors, living conditions and exposures during childhood. We have also had the opportunity to follow the adolescents with CRS symptoms from the 16-year subgroup follow-up to young adulthood at 24-years, with nasal endoscopy performed on both occasions.

The study has limitations that should be acknowledged. Owing to the study design and epidemiological setting, the possibility of subject misclassification cannot be excluded. Participants completed the questionnaire at a single time point; therefore, some individuals with CRS who were asymptomatic at that time may have been overlooked, most likely leading to an underestimation of the true prevalence. Another constraint is the relatively small sample size of subjects with CRS, which partly reflects the underlying prevalence of the condition. Among all participants with presumed CRS symptoms, nasal endoscopy was performed in 81 out of 141 cases. However, the data revealed minimal differences between those classified as having "CRS symptoms" based on EPOS criteria and those with "endoscopically verified CRS." More females than males participated in the 24-year follow-up. A previous sensitivity analysis [26] indicated that atopic eczema, rhinitis, and IgE sensitization were slightly more common among participants compared to non-participants at the 24-year BAMSE cohort follow-up, although no sex-related differences were observed. This may lead to a slight overestimation of these conditions among individuals with CRS. However, the relative proportions compared to individuals without CRS are likely to remain unaffected. No sex-stratified analyses were performed on our results due to the limited number of subjects. The findings in our cohort of young adults predominantly represent cases of symptomatic, endoscopically confirmed primary CRS, primarily among individuals without nasal polyps and without prior surgical intervention. This distinction is important to bear in mind when generalizing the results to the wider adult CRS population.

Conclusions

- Most young adults with CRS at 24 years of age reported upper airway symptoms already at 16 years of age.
- Atopic disease throughout childhood is associated with CRS symptoms at young adulthood, suggesting that allergic disease may contribute to chronic inflammation in the upper airways and thereby predispose development of CRS.
- Early otitis media and family history of atopic disease appear to indicate an increased risk of developing CRS in young adulthood.
- These are observed associations, and we have no data supporting causation. However, this demonstrates a potential link between early immune dysregulation and later chronic airway inflammation. We believe that these findings need further exploration.

Author contributions

KÅ, MvH, AA, MH, LOC and MW were involved in planning and writing. KÅ and MW conducted the clinical examination, data collection and data analyses on the subgroup follow-up. EM, IK and AB are managing the planning, follow-ups and data collection in the cohort. All authors were involved in interpretation of data, provided critical feedback during development of the manuscript, and approved the final version of the manuscript.

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Conflict of interest

AA has received lecture fees from Orion Pharma, Nestlé, Semper, ThermoFisher, and ALK and advisory board fees from Novartis, Sanofi, Danone, and Nestlé Health Science, all outside the submitted work. EM has received lecture and/or advisory board fees from Airsonett, ALK, AstraZeneca, Chiesi and Sanofi, all outside the submitted work. MvH has received lecture fees from Thermo Fisher Scientific, Astra Zeneca and ALK, and personal fee from Thermo Fisher Scientific, all outside the submitted work. MW has received lecture fees from Sanofi, Orion Pharma and ALK, personal fees from Viatris and research funding from ALK, all outside the submitted work.

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References

1. Ramadan HH. Pediatric chronic rhinosinusitis. Eur Arch Otorhinolaryngol. 2024;281(3):1131-7.
2. Fokkens WJ, Lund VJ, Hopkins C, et al. European Position Paper on Rhinosinusitis and Nasal Polyps 2020. Rhinology. 2020;58(Suppl S29):1-464.
3. Choi A, Xu S, Luong AU, Wise SK. Current review of comorbidities in chronic rhinosinusitis. Curr Allergy Asthma Rep. 2024;25(1):4.
4. Ahmad JG, Marino MJ, Luong AU. Unified airway disease: future directions. Otolaryngol Clin North Am. 2023;56(1):181-95.
5. Kato A, Peters AT, Stevens WW, Schleimer RP, Tan BK, Kern RC. Endotypes of chronic rhinosinusitis: relationships to disease phenotypes, pathogenesis, clinical findings, and treatment approaches. Allergy. 2022;77(3):812-26.
6. Wickman M, Kull I, Pershagen G, Nordvall SL. The BAMSE project: presentation of a prospective longitudinal birth cohort study. Pediatr Allergy Immunol. 2002;13(s15):11-3.
7. Fokkens WJ, Lund VJ, Mullol J, et al. EPOS 2012: European position paper on rhinosinusitis and nasal polyps 2012. A summary for otorhinolaryngologists. Rhinology. 2012;50(1):1-12.
8. Westman M, Stjärne P, Bergström A, et al. Chronic rhinosinusitis is rare but bothersome in adolescents from a Swedish population-based cohort. J Allergy Clin Immunol. 2015;136(2):512-4.e6.
9. Aberg K, Asarnoj A, Georen SK, et al. The prevalence of primary chronic rhinosinusitis in young adults from a Swedish birth cohort. Rhinology. 2025;63(2):180-9.
10. Asher MI, Keil U, Anderson HR, et al. International Study of Asthma and Allergies in Childhood (ISAAC): rationale and methods. Eur Respir J. 1995;8(3):483-91.
11. Johansson EK, Ballardini N, Kull I, Bergström A, Wahlgren CF. Association between preschool eczema and medication for attention-deficit/hyperactivity disorder in school age. Pediatr Allergy Immunol. 2017;28(1):44-50.
12. Khan A, Vandeplas G, Huynh TMT, et al. The Global Allergy and Asthma European Network (GALEN rhinosinusitis cohort: a large European cross-sectional study of chronic rhinosinusitis patients with and without nasal polyps. Rhinology. 2019;57(1):32-42.
13. Murtomäki A, Helevä A, Torkki P, et al. Comorbidities of chronic rhinosinusitis in children and adults. Clin Transl Allergy. 2024;14(4):e12354.
14. DelGaudio JM, Loftus PA, Hamizan AW, Harvey RJ, Wise SK. Central compartment atopic disease. Am J Rhinol Allergy. 2017;31(4):228-34.
15. rebro J, Ekstedt S, Hjalmarsson E, Winqvist O, Kumlien Georén S, Cardell LO. A possible role for neutrophils in allergic rhinitis revealed after cellular subclassification. Sci Rep. 2017;7:43568.
16. Wilson KF, McMains KC, Orlandi RR. The association between allergy and chronic rhinosinusitis with and without nasal polyps: an evidence-based review with recommendations. Int Forum Allergy Rhinol. 2014;4(2):93-103.
17. Kim SK, Park MW, Min C, et al. Increased risk of chronic otitis media in chronic rhinosinusitis patients: a longitudinal follow-up study using a national health screening cohort. Rhinology. 2021;59(3):292-300.
18. Kuo CL, Yen YC, Chang WP, Shiao AS. Association between middle ear cholesteatoma and chronic rhinosinusitis. JAMA Otolaryngol Head Neck Surg. 2017;143(8):757-63.
19. Calvo-Henriquez C, Di Corso E, Alobid I, Cantone E, Di Cesare T, Mullol J. Pathophysiological link between chronic rhinosinusitis and ear disease. Curr Allergy Asthma Rep. 2023;23(7):389-97.
20. Brescia G, Frosolini A, Franz L, et al. Chronic otitis media in patients with chronic rhinosinusitis: a systematic review. Medicina (Kaunas). 2023;59(1).
21. Nakashima D, Nakayama T, Minagawa S, et al. Dupilumab improves eosinophilic otitis media associated with eosinophilic chronic rhinosinusitis. Allergol Int. 2023;72(4):557-63.
22. Hong SN, Lee WH, Lee SH, Rhee CS, Lee CH, Kim JW. Chronic rhinosinusitis with nasal polyps is associated with chronic otitis media in the elderly. Eur Arch Otorhinolaryngol. 2017;274(3):1463-70.
23. Maniakas A, Desrosiers M, Asmar MH, et al. Eustachian tube symptoms are frequent in chronic rhinosinusitis and respond well to endoscopic sinus surgery. Rhinology. 2018;56(2):118-21.
24. Yang KS, Chen WC, Wu CN, Wee YS, Wang CS, Wu CC, et al. Endoscopic sinus surgery significantly reduces Eustachian tube dysfunction symptoms in patients with chronic rhinosinusitis: a systematic review and meta-analysis. Biomedicines. 2024;12(11).
25. García-Callejo FJ, Azpilicueta MJ, Ferrer MD, Almeida PTG, Henao JDC. Impact of chronic rhinosinusitis with nasal polyps on Eustachian tube dysfunction. Acta

Otorrinolaringologica Espanola. 2025;76(4).
26. Melén E, Bergström A, Kull I, et al. Male sex is strongly associated with IgE-sensitization to airborne but not food allergens: results up to age 24 years from the BAMSE birth cohort. Clin Transl Allergy. 2020;10:15.

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SUPPLEMENTARY MATERIAL

Table S1. The study populations used, compared to the study base and the original cohort, regarding background characteristics.

	BAMSE Cohort N=4089		Study base N=3043			Pop Table 1* N=2488			Pop Table 2** N=2886		
	n	%	n	%	95% CI	n	%	95% CI	n	%	95% CI
Males	2065	50.5	1428	47.0	45.2-48.8	1153	46.3	44.4-48.3	1361	47.2	45.3-49.0
Family history of atopy	1746	43.2	1326	44.0	42.2-45.8	1110	44.9	43.0-46.9	1265	44.2	42.4-46.0
Low socioeconomic status	695	17.3	461	15.4	14.0-16.6	355	14.5	13.1-15.9	430	15.1	13.8-16.5
Any parent born outside Scandinavia	543	16.0	417	15.6	14.2-17.0	357	15.1	13.7-16.6	392	15.1	13.8-16.5
Any parent smoking at time of birth	855	21.0	611	20.2	18.8-21.7	488	19.7	18.2-21.3	572	19.9	18.9-21.4
***	Pop 4 y Fig 1 N=2823			Pop 8 y Fig 1 N=2656			Pop 16 y, Fig 1 N=2527				
	n	%	95% CI	n	%	95% CI	n	%	95% CI		
Males	1321	46.8	45.0-48.6	1249	47.0	45.1-48.9	1186	46.9	45.0-48.9		
Family history of atopy	1238	44.2	42.3-46.0	1171	44.4	42.5-46.3	1126	45.0	43.0-46.9		
Low socioeconomic status	426	15.3	14.0-16.7	377	14.4	13.1-15.8	359	14.4	13.1-15.9		
Any parent born outside Scandinavia	388	15.0	13.7-16.4	410	15.5	14.2-17.0	363	15.0	13.7-16.5		
Any parent smoking at time of birth	565	20.1	18.7-21.7	524	19.8	18.4-21.4	507	20.2	18.7-21.8		
***	Pop 24 y, Fig 1 N=2995										
	n	%	95% CI								
Males	1403	46.8	45.1-48.6								
Family history of atopy	1311	44.1	42.3-45.9								
Low socioeconomic status	452	15.4	14.1-16.7								
Any parent born outside Scandinavia	413	15.6	14.3-17.1								
Any parent smoking at time of birth	596	20.2	18.6-21.5								

Study base: Complete answers on questions of CRS at 24 years (n= 3037) or fulfilled EPOS criteria for CRS at the subgroup follow-up at 16 years and at the telephone interview at 24 years (n=6).

*Population Table 1: Complete answers on questions of CRS at 24-years, and on CRS, AR, rhinitis and asthma at 16 years.

**Population Table 2: Answers on questionnaire 0, 1 and 2.

***Population Figure 1 and Table S2 at 4, 8, 16 and 24 years: Complete answers on questions of CRS at 24 years, and on AR, rhinitis and asthma at each age.

Table S2. Atopic diseases at 4, 8, 16 and 24 years in individuals with, and without, CRS symptoms at 24 years.

	CRS symptoms				
	Yes		No		p-value
	n	%	n	%	
4 years (N=2823)	(n=58)		(n=2765)		
AR (n=276)	9	15.5	267	9.7	0.14
asthma (n=184)	6	10.3	178	6.4	0.23
eczema (n=462)	15	25.9	447	16.2	0.05
no atopy (n=1980)	33	56.9	1947	70.4	0.03
8 years (N=2656)	(n=53)		(n=2603)		
AR (n=338)	10	18.9	327	12.6	0.18
asthma (n=162)	3	5.7	159	6.1	0.89
eczema (n=318)	8	15.1	310	11.9	0.48
no atopy (n=1911)	35	67.3	1876	73.6	0.31
16 years (N=2527)	(n=56)		(n=2471)		
AR (n=635)	24	42.9	611	24.7	0.002
asthma (n=156)	8	14.3	148	6.0	0.01
eczema (n=222)	11	19.6	211	8.5	0.004
no atopy (n=1735)	30	53.6	1705	69.0	0.01
24 years (N=2995)	(n=68)		(n=2927)		
AR (n=912)	35	51.5	877	30.0	<0.001
asthma (n=430)	26	38.2	400	13.7	<0.001
eczema (n=438)	18	26.5	414	14.1	0.004
no atopy (n=1707)	20	29.4	1687	57.6	<0.001

4 years: Study population: Complete answers on AR, asthma and eczema at 4 years and complete answers on CRS at 24 years. N=2823.

8 years: Study population: Complete answers on AR, asthma and eczema at 8 years and complete answers on CRS at 24 years. N=2656.

16 years: Study population: Complete answers on AR, asthma and eczema at 16 years and complete answers on CRS at 24 years. N=2527.

24 years: Study population: Complete answers on AR, asthma, eczema and CRS at 24 years. N=2995.