

# The nature of nasal discharge in chronic rhinosinusitis: a systematic review and meta-analysis using patient-reported outcomes



**Cover figure.** Endoscopic view showing yellow-brown fungal concretions, characteristic of a fungal ball with associated drainage.

## Summary

**Objective.** The objective of this study is to answer the question “What is the most common and severe type of nasal discharge in patients with chronic rhinosinusitis (CRS) at baseline as measured by patient-reported outcomes?”

**Methodology.** Two independent reviewers evaluated studies for inclusion, extracted data from included studies, and performed critical appraisal of studies. Data on the four Sino-Nasal Outcome Test 22 (SNOT22) discharge questions, demographic, and comorbidity data was collected. Meta-analysis of single means and proportions was performed for demographic, comorbidity, severity, and prevalence data.

**Results.** A total of 53 studies (n = 6584) were included for analysis. Postnasal drip (PND) was the most severe symptom (2.6, 95%CI: 2.2-3) and most prevalent (80.7%, 95%CI: 53.0-97.7). Patients without nasal polyps had a higher PND score than those with polyps (2.56 vs 2.40, 95%CI: 0.1-0.2). However, patients with polyps reported higher symptom scores for need to blow nose, runny nose, and thick nasal discharge (all p < 0.0001).

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**Conclusions.** CRS patients experience PND at a higher prevalence and severity at baseline than the other three forms of nasal discharge captured by the SNOT22. Polyp status influences differing symptoms of nasal drainage. Comorbid asthma or allergies are associated with more severe PND and total SNOT22 scores.

**Key words:** sino-nasal outcome test, rhinosinusitis, prevalence, quality of life

## Introduction

Chronic rhinosinusitis (CRS) has a high prevalence and morbidity in the United States and internationally <sup>1</sup>. The diagnosis of CRS requires two or more of the following cardinal symptoms: nasal discharge, nasal obstruction, hyposmia, and facial pain or pressure, with at least one being nasal discharge or obstruction <sup>1</sup>. The Sino-Nasal Outcome Test (SNOT) is a highly validated and widely used tool to characterise quality of life in CRS <sup>2</sup>. The SNOT22 captures nasal discharge in four ways: “need to blow nose”, “runny nose”, “postnasal discharge” (PND), and “thick nasal discharge” <sup>3</sup>. Nasal discharge is widely prevalent in patients with CRS, as 51 to 83% of patients report its presence <sup>1</sup>. Nasal discharge is considered highly burdensome by most CRS patients, with 77% marking “need to blow nose” as “important” on the SNOT22, followed by thick nasal discharge (71%), PND (70%), and runny nose (57%) <sup>4</sup>.

While the other three cardinal symptoms are represented by a single question on the SNOT22, discharge requires four unique questions. Patients often describe discharge symptoms as “congestion”, which can be confused with separate symptoms such as nasal obstruction or facial pressure <sup>5,6</sup>. The setting in which discharge presents is often further obscured by comorbid conditions such as asthma, allergies, and gastro-oesophageal reflux disease, as all three can affect the upper airway <sup>7,8</sup>. These comorbidities impact treatment plans and likelihood for symptom improvement; thus, they are important considerations when counselling patients.

While there are meta-analyses investigating patient reported outcomes in CRS, there are no studies specifically evaluating nasal discharge. This paucity of literature is highlighted by studies evaluating the clinical burden of other cardinal symptoms of CRS, such as facial pressure <sup>9</sup>. This study seeks to bolster the current understanding of CRS cardinal symptoms by characterising nasal discharge. Understanding the overall burden of CRS is important; however, patients often think of their disease in terms of specific symptoms. By characterising the presentation of a single cardinal symptom of CRS, this study will help inform providers on how to offer a unified, mutually understood dialogue and personalised counselling to patients experiencing discharge. The goal of this systematic review and meta-analysis is to quantify the prevalence and severity of each of the four nasal discharge

questions on the SNOT22 in adults with CRS. The authors hypothesised that there will be differences in both the prevalence and severity of the four nasal discharge symptoms, particularly when stratifying by various comorbidities.

## Materials and methods

### Search criteria

This systematic review was conducted in accordance with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) criteria <sup>10</sup>. The PICOTS question guiding this systematic review is “What is the prevalence and severity of baseline nasal discharge symptoms in adults with CRS?” A broad-scoping literature search was conducted on June 10<sup>th</sup>, 2024 using Cochrane library, PubMed (National Library of Medicine), Scopus (Elsevier), and CINAHL (EBSCO). A literature search designed for PubMed included keywords and medical subjected headings (MeSH) related to CRS, SNOT22, and nasal discharge. The PubMed search strategy was applied to Cochrane, Scopus and CINAHL. The Scopus search was limited to medicine (subject), articles (document), final (publication status), humans (keyword), journal (source type), and English (language). No filters were applied to PubMed, Cochrane, or CINAHL. Once the literature search was completed, articles were uploaded to Covidence systematic review software.

### Study selection

Two authors (ATR and EEB) independently screened articles for inclusion by title and abstract first, followed by full text review. Discrepancies between reviewers were resolved by a third party (EMK). Inclusion criteria were 1) diagnosis of CRS and 2) itemised survey data regarding nasal discharge from SNOT20, SNOT22, or Visual Analogue Scale (VAS) questionnaires. Exclusion criteria were 1) animal studies, 2) studies without available English translation, 3) case studies, 4) review articles, 5) non-itemised questionnaire data, 6) non-extractable data, 7) non-exclusive CRS population, 8) studies post-surgical or medical intervention, and 9) paediatric population < 16 years of age.

### Study appraisal

Each study was assigned a level of evidence according to

the Oxford Centre for Evidence-Based Medicine criteria<sup>11</sup>. Randomised control trials were assessed for risk of bias via the Revised Cochrane risk-of-bias tool for randomised trials (RoB-2), while non-randomised studies were assessed for risk of bias with the Risk of Bias in Non-Randomized Studies – of Interventions (ROBINS-I) assessment tool<sup>12,13</sup>. Case series, cross-sectional, and case-control studies were assessed for risk of bias using the Joanna Briggs Institute (JBI) Critical Appraisal Tool checklist<sup>14</sup>. Two authors (EMK and IVS) independently assessed each study using a checklist, and all conflicting answers were reconciled by a third party (SAN). For studies using the RoB-2 and ROBINS-I assessment, response options included “low risk,” “high risk” or “unclear.” For studies in which the JBI was utilised, each item was given a score of “1” for “yes” and “0” for “no,” “not applicable,” or “unclear.” The case series and case control checklists have 10 questions and were scored out of 10. A score of 5 or higher on either checklist was considered at low risk for bias. Cross-sectional checklists have 8 questions and were scored out of 8. A score of 4 or higher was considered at low risk for bias. Only studies classified as low risk for bias were included in the final analysis.

### Data extraction

Two authors (ATR and EEB) independently extracted data into a standardised spreadsheet. Any conflicts or inaccuracies were resolved by a third party (EMK). Extracted data included author name, year of publication, sample size, study population, demographics, comorbidities, and intervention. Outcome data included total SNOT score, and itemised SNOT or VAS scores for any nasal discharge symptom. VAS scores were standardised to a 0-100 cm scale to improve consistency in measurements. Due to variation in VAS reporting, the following terms were equated to nasal discharge: “nasal secretion”, “sticky secretion”, “purulent rhinorrhoea”, “purulence”, and “discharge”. The terms “runny nose”, and “anterior rhinorrhoea” were categorised as rhinorrhoea. Conversely, “posterior rhinorrhoea” was classified as postnasal drip. The authors were able to obtain patient level data on adults with chronic rhinosinusitis from a longitudinal study discussed in Mattos et al.<sup>4</sup>. These data included patient demographic information, prior therapy attempted, comorbid diagnoses, and itemised baseline SNOT22 scores. The extraction process involved objective and clearly defined criteria, which minimised the potential for subjective interpretation by the reviewers. Therefore, no formal interrater reliability statistics (e.g., Cohen’s Kappa) were calculated.

### Statistical analysis

Meta-analysis of single means (age, symptom duration, body mass index [BMI], SNOT22 scores, VAS scores) and meta-analysis of proportions (gender, comorbidities, patient characteristics, prevalence of SNOT symptoms, prevalence of VAS symptoms) were performed by Comprehensive Meta-Analysis version 4 (Biostat Inc., Englewood, NJ, USA). Each measure (mean/proportion and 95% confidence interval [CI]) was weighted according to the number of patients affected. As some studies reported the outcomes in median (first quartile, third quartile), the quantile estimation (QE) method as specified by Cochrane Review was deployed to calculate the pooled estimates<sup>15-17</sup>. Heterogeneity among studies was assessed using I-squared ( $I^2$ ) statistics with fixed effects ( $I^2 < 50\%$ ) and random effects ( $I^2 > 50\%$ ). To assess the robustness of our findings, we performed a sensitivity analysis using the one-study removal technique, which systematically excludes one study at a time to evaluate the impact of individual studies on the pooled results. In addition, a comparison of means and proportions, expressed as difference ( $\Delta$ ) and 95% CI was done to compare outcomes between two groups. Finally, potential publication bias was evaluated by visual inspection of the funnel plot and Egger’s regression test, which statistically examines the asymmetry of the funnel plot<sup>18,19</sup>. A p value of  $< 0.05$  was considered to indicate a significant difference for all statistical tests.

## Results

### Search results and study characteristics

The literature search yielded 1628 studies, of which 252 duplicates were removed. 1376 articles underwent title and abstract screening. Full text review was performed on 403 studies and 350 studies were excluded. Reasons for exclusion included wrong outcomes, no SNOT score, no individual component SNOT scores, wrong population, improper study design, non-English text, unavailable full text, and concern for bias. At the conclusion of the review, 53 articles met the inclusion criteria<sup>20-68</sup>. A PRISMA diagram detailing the systematic review is provided in Figure 1. The most common grounds for exclusion were wrong outcomes; either no SNOT22 score or no itemised SNOT22 scores for nasal discharge. A summary of the studies included is provided in Table I.

Studies included for analysis were published between 2002 and 2024. Descriptive features of included studies are listed in Table I. Critical appraisal of studies indicated an acceptably low risk of bias for all studies included. Potential sources of bias were most pronounced with con-

founding, missing data, classification of interventions, and selective reporting in the non-randomised studies (Fig. 2). All randomised studies were considered low risk, the greatest sources of potential bias were observed in the randomisation process and in deviations from study protocol. JBI assessment also found a low risk of bias for cross-sectional, case series, and case-control studies, all having scores higher than 4, 5, or 5, for each respective study design.

ROBINS-I Risk of BiasA funnel plot with Egger's test, -0.11 ([95% CI: -1.4 - 1.2],  $p = 0.86$ ), showed that 49 of 53 studies were within the funnel plot with little asymmetry, suggesting low potential for publication bias (Fig. 3). This suggests a low likelihood that studies included in this analysis were more likely to publish significant results compared to non-significant results.

### Patient characteristics

A total of 7193 patients with CRS were included with a mean age of 45.9 (range: 16-94; 95% CI: 44-48.1). Slightly over half the study population was male. The study population had a notably higher rate of nasal polyposis than the overall CRS

population. This could be due to the inclusion of studies that selected specifically for CRS with nasal polyps (CRSwNP). Cystic fibrosis was also overrepresented as one study included exclusively these patients. Additional characteristics and comorbidities of the CRS group are provided in Table II.

### Severity of symptoms

Data comparing the severity of SNOT and VAS nasal discharge symptoms in CRS patients, including data stratified by polyp status and comorbidities, are provided in Table III. Across all studies, "post-nasal drip" (PND) was the SNOT-22 symptom score reported with highest severity (2.60) in patients with CRS. This was significantly higher than "need to blow nose" at 2.50, "runny nose" at 2.44, and "thick nasal discharge" at 2.32 ([95% CIs: 0.09-0.11, 0.15-0.17, and 0.27-0.29, respectively], all  $p < 0.0001$ ). While these differences are statistically significant, they do not meet the threshold for clinical significance (0.8) <sup>69</sup>. VAS "nasal discharge", "post-nasal drip" and "rhinorrhoea" were 54.3, 57.2 and 57.3, respectively. VAS "rhinorrhoea" and "post-nasal drip" were both significantly higher than "nasal discharge" ([95% CIs: 2.8-3.1 and 2.8-3, respectively], both  $p < 0.0001$ ); however, no significant difference exists between the two ([95% CI: -0.04-0.3],  $p = 0.16$ ).

When comparing CRS subtypes, patients without polyps (CRSsNP) reported significantly higher PND scores than patients with polyps (2.56 vs 2.40, 95% CI 0.12-0.20,  $p < 0.0001$ ). However, patients with polyps (CRSwNP) reported significantly higher scores for need to blow nose, runny nose, and thick nasal discharge ([95% CIs: 0.7-0.8, 0.8-0.9, and 0.2-0.3], all  $p < 0.0001$ ). Patients with comorbid asthma reported PND 3.1 and thick nasal discharge 3.1 as the most severe. Those with allergies also reported PND as most severe.

### Prevalence of symptoms

On a scale from 0-5, the most frequently reported score for PND was 4. The other three nasal discharge symptoms were most frequently reported with a score of 3. Figure 4 describes the total distribution for each nasal discharge symptom. The distribution of scores was stratified into "mild" for 0-2 and "severe" for 3-5. This stratification was based upon what the authors considered a natural break in the distribution of nasal discharge scores reported in Figure 4. In the overall cohort, PND had the highest proportion of severe scores at 67.3% of patients, followed by thick nasal discharge (65%), need to blow nose (61.6%), and runny nose (48.5%).

Figure 5 describes the percentage of patients reporting severe symptoms by polyp status, with asthma, and with al-

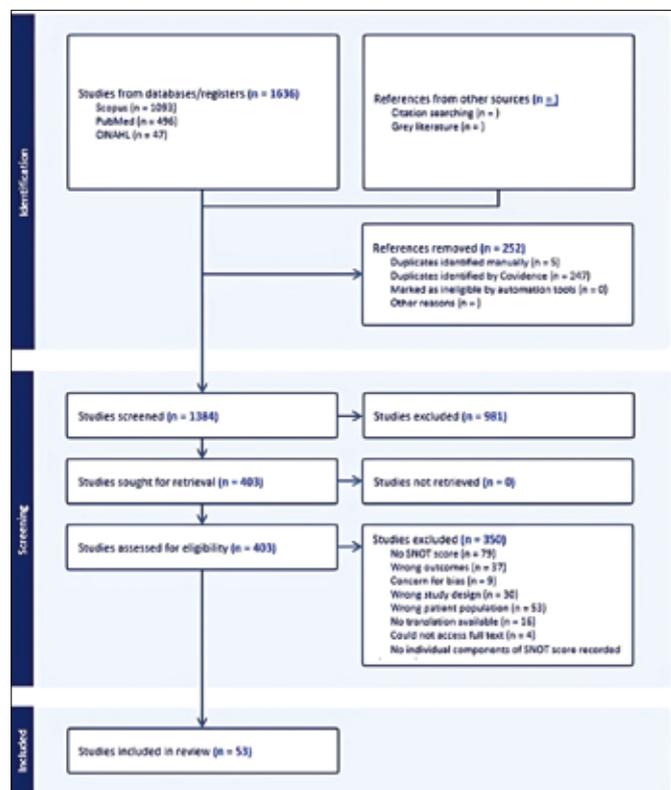


Figure 1. PRISMA systematic review flow diagram.

**Table I.** Summary of studies included.

Author, yr	OLE	Patients (n)	Male (n)	Age in years, mean (range)	CRSwNP/CRSSNP (n)	Outcomes
Alicandri-Ciufelli, 2024	2	145	89	55.1 (27-86)	145/0	SNOT, VAS
Anushivari, 2018	2	39	-	-	-	SNOT
Bachert, 2017	2	105	75	50.5	105/0	SNOT, VAS
Byun, 2013	2	25	18	49.9 (18-77)	25/0	SNOT, VAS
Cervin, 2002	4	17	-	(18-67)	-	VAS
Chen, 2016	3	42	-	45.9	10/0	VAS
Dabirmoghaddam, 2013	4	43	23	40.7 (17-64)	40/0	VAS
Deconde, 2014	3	339	151	51	123/216	SNOT
De Corso, 2023	4	648	400	54	648/0	SNOT, VAS
De Corso, 2024	3	101	60	46.8	101/0	SNOT, VAS
Ebbens, 2006	2	116	77	46.8	95/21	VAS
Gelardi, 2022	2	330	202	52.1	330/0	SNOT
Ghadersohi 2020	3	51	-	-	21/30	SNOT
Greguric, 2016	4	117	57	44.5	0/117	SNOT, VAS
Guo, 2024	4	87	54	42.5	87/0	SNOT, VAS
Hao, 2022	4	106	83	49.3	106/0	SNOT, VAS
Huang, 2019	3	60	39	37.6	-	SNOT, VAS
Jamtoy, 2021	4	10	7	47.3 (18-70)	10/0	SNOT, VAS
Ji, 2019	4	124	67	50.4	-	SNOT
Lal, 2016	4	272	140	54.6	141/131	SNOT
Ling - AJRA, 2007	4	201	104	49 (18-80)	-	SNOT, VAS
Ling - Laryngoscope, 2007	2	158	85	49.4 (18-80)	-	VAS
Liu, 2024	2	69	44	34.6	36/33	SNOT
Liu, Gardner, 2023	4	115	47	50.6	0/115	SNOT
Liu, Woodworth, 2023	4	105	44	53.7	0/105	SNOT
Lourijssen, 2022	2	234	142	50.5	234/0	SNOT
Mattos, 2019	3	100	54	54.7	59/41	SNOT
Nabavi, 2023	2	90	41	41.1	90/0	SNOT, VAS
Nguyen, 2017	4	63	32	51	63/0	VAS
Niknami, 2021	2	100	60	37.4 (17-60)	-	VAS
Pacaci Cetin, 2024	4	28	12	46.6 (21-70)	28/0	SNOT, VAS
Pan, 2021	2	298	190	44	-	VAS
Paoletti, 2023	4	33	13	54.2	33/0	SNOT
Penezic, 2020	2	250	123	45.6	97/0	SNOT
Pham, 2023	2	62	27	45.1	13/0	SNOT
Qi, 2021	3	56	30	46.3 (18-78)	56/0	VAS
Salama, 2009	4	143	-	-	85/56	VAS
Savietto, 2020	2	30	15	(18-65)	0/30	SNOT, VAS
Shao, 2023	4	32	11	40.9	32/0	VAS
Sima, 2023	3	44	22	45.3	44/0	SNOT, VAS
Soler, 2008	3	275	113	44.4	91/184	VAS
Stolovitzky, 2019	2	400	243	49.6	400/0	VAS
Suh, 2012	3	11	8	53.0 (32-70)	11/0	SNOT

**Table I. continues.**

Author, yr	OLE	Patients (n)	Male (n)	Age in years, mean (range)	CRSwNP/CRSsNP (n)	Outcomes
Tat, 2022	4	17	8	41.9	17/0	SNOT, VAS
Thunberg., 2020	2	34	12	52 (34-77)	18/16	VAS
Tiotiu, 2002	4	24	14	49	24/0	VAS
Tomljenovic, 2014	2	32	11	43.6 (23-65)	0/32	SNOT, VAS
Verma, 2022	4	40	24	40.5	25/15	SNOT, VAS
Xu, 2020	2	99	62	40.2	99/0	VAS
Young, 2007	4	82	43	47.5 (26-77)	-	VAS
Yu, 2022	2	502	338	46	502/0	VAS
Zeng, 2011	2	43	29	32.6	0/43	VAS
Zhou, 2023	2	49	30	39.8 (18-67)	49/0	VAS

OLE: Oxford level of evidence; CRSwNP: chronic rhinosinusitis with nasal polyps; CRSsNP: chronic rhinosinusitis without nasal polyps; SNOT: study provides data from SNOT22; VAS: study provides data using the visual analog scale.

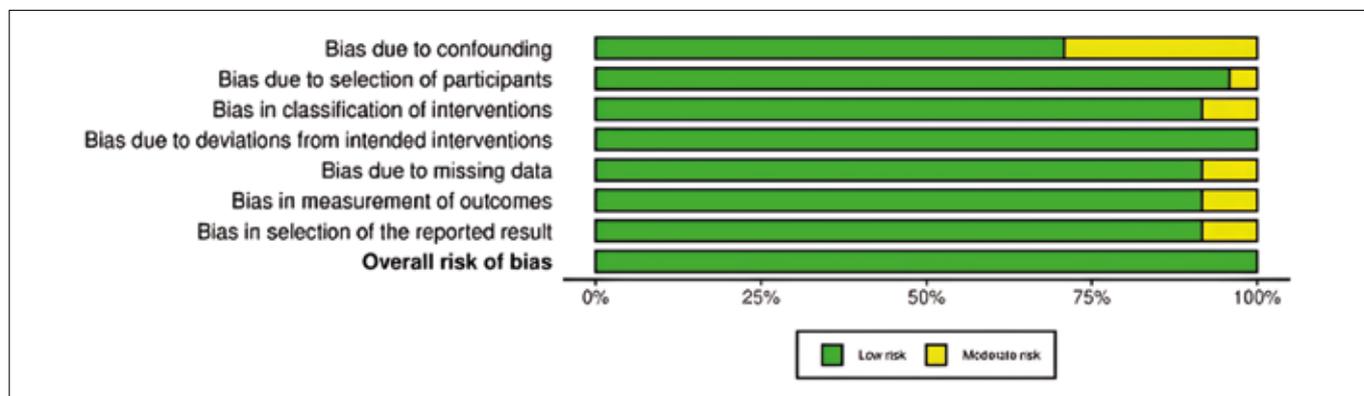
lergies. Patients without polyps more frequently reported severe PND compared to those with polyps (71 vs 63% [95% CI: 2.2-13.6]). However, the CRSwNP group more frequently reported severe scores for the other three nasal discharge symptoms. Patients with comorbid asthma and allergies also reported severe PND in high proportions, at 70% and 72%, respectively.

## Discussion

Nasal discharge is one of the four cardinal symptoms used to diagnose CRS and affects up to 83% of patients<sup>1</sup>. There are various ways that patients can describe nasal discharge, which can obscure a clinician’s understanding of their disease burden<sup>6</sup>. This picture can be further distorted by patient-specific comorbidities. For example, it may not be

readily clear in an atopic patient if rhinorrhoea is due to their allergies, their sinus disease, or a mixture of both. Dysphonia may be attributed to PND when in reality it is caused by laryngopharyngeal reflux. A nuanced understanding of how these comorbidities affect nasal discharge reporting on the SNOT22 is important, as it can help providers determine the true source of symptoms, guide treatment plans, and allow for better patient counselling.

Nasal discharge can be divided into two categories; anterior and posterior<sup>1</sup>. Across all studies, patients reported PND as the most severe discharge symptom on the SNOT22, followed by need to blow nose, runny nose, and thick nasal discharge, respectively. While need to blow nose and thick nasal discharge do not fit specifically into anterior or posterior, the difference between postnasal discharge and runny nose suggests that PND may be more closely associated with severe CRS.



**Figure 2.** ROBINS-I risk of biasA funnel plot with Egger's test.

**Table II.** Patient characteristics.

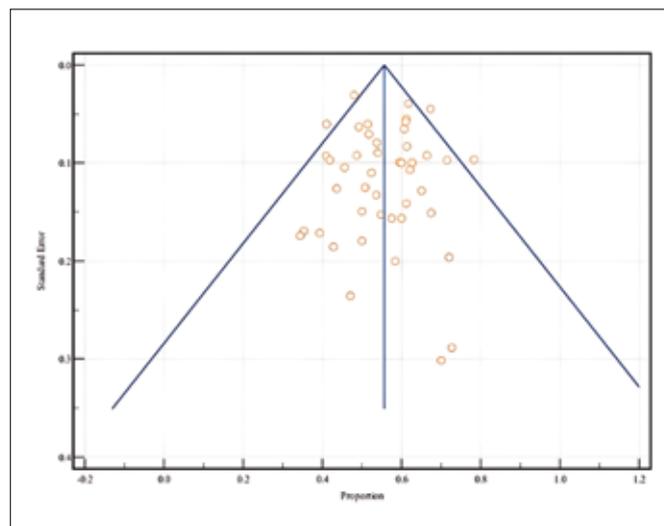
CRS patient characteristics	Proportion (%)	95% CI
CRSwNP	78.8	65.5-89.6
CRSSNP	20.4	9.9-33.5
Asthma	54.7	47.2-62.2
Allergy	50.1	38.2-61.9
AERD/ASA sensitivity*	26.8	22.1-31.8
AFRS*	25.1	7.3-49
CF*	59.3	12.3-73.1
GERD	6.5	0.56-18.3
Smoking history	30.7	20.3-42.3
Prior surgery	76	63-86.9

CRS: chronic rhinosinusitis; CI: confidence interval; CRSwNP: chronic rhinosinusitis with nasal polyps; CRSSNP: chronic rhinosinusitis without nasal polyps; AERD: aspirin exacerbated respiratory disease; ASA: aspirin; AFRS: allergic fungal rhinosinusitis; CF: cystic fibrosis; GERD: gastro-oesophageal reflux disease. \*These proportion calculations were among the CRSwNP study population, not the entire study population.

Further analysis by CRS subtypes and comorbidities presented a similar pattern. PND was the most severe symptom for patients without nasal polyps and for patients with comorbid asthma and allergies. However, this was not the case for patients with nasal polyps, who reported need to blow nose as the most severe symptom. In fact, the severity of PND for polyp patients was significantly lower than that of patients without polyps. Runny nose was also more severe than PND in patients with nasal polyps. In contrast with the rest of the study population, it appears that higher scores for anterior nasal symptoms are associated with nasal polyposis.

An interesting finding from this study is the severe nasal discharge observed in patients with asthma. While total SNOT22 takes into account many systemic symptoms that may be impacted by asthma, such as fatigue, cough, and impact upon sleep, it is surprising that it also appears to result in more severe nasal drainage symptoms. Patients with comorbid allergies also reported severe PND; however, there were not significant differences in nasal discharge symptoms between comorbid asthma and allergy groups. Interestingly, the asthma group had a more severe baseline presentation than the allergy group, as illustrated by a significantly higher total SNOT22 score.

There is a well-established association between CRS and asthma, with 25% of CRS patients having a diagnosis of asthma compared to 5% of the general population<sup>1</sup>. Within CRS, there has been a more specific association between nasal polyposis and asthma. The current understanding is that Type 2 (T2) inflammation is a mediator for both diseases, using IL-5 and IL-13 to promote eosinophilia<sup>70</sup>. A recent study

**Figure 3.** Funnel plot for publication bias.

found that 62% of patients with nasal polyps have solely T2 inflammation mediating their disease, and 87% of these patients have T2 inflammation present in some capacity<sup>70</sup>. Patients across all CRS subtypes with T2 inflammation were significantly more likely to also have a diagnosis of polyps and asthma compared to the T1 and T3 inflammation types<sup>70</sup>. The mechanism behind severe discharge in asthma is not entirely clear. Our main hypothesis is that patients with comorbid asthma are more likely to have a higher overall burden of inflammation, which can worsen nasal symptoms. This is in line with the “unified airway” concept, which postulates that the diseases of the upper and lower airway can affect both areas due to similar anatomy, immune defense mechanisms, and exposures<sup>1</sup>. A recent study comparing asthma severity and SNOT22 questions found a strong correlation between poor asthma control and more severe postnasal discharge scores<sup>71</sup>. The same study examined nasal symptoms in patients who had recently visited the emergency department for asthma exacerbations. In this group, authors observed higher total SNOT22 scores and runny nose scores compared to patients who had not sought emergency care<sup>71</sup>. While these results were not stratified by polyp status, both associations support the idea that poorly controlled inflammation in the lower airway can have negative effects on the upper airway. This concept is important when creating a holistic treatment plan for patients, as upper airway symptoms might not resolve if treatment does not include therapy directed at their lower airway pathologies.

A strength of this review is that we included all available studies to quantify the prevalence and severity of each

**Table III. Severity of SNOT and VAS baseline symptoms.**

Metric	Group	Total patients	Mean score	95% CI
Total SNOT Score	Overall	4803	45.7	42.1-49.2
	CRSwNP	2456	51.4**	45.9-56.8
	CRSsNP	973	42.1	36.7-47.5
	Asthma	521	59.9	41.5-78.5
	Allergy	534	50.9	47-54.8
SNOT Need to Blow Nose	Overall	2266	2.5	2.3-2.7
	CRSwNP	783	3**	2.9-3.1
	CRSsNP	826	2.3	2-2.5
	Asthma	424	2.9	2.8-3
	Allergy	492	2.8	2.7-2.9
SNOT Runny Nose	Overall	2266	2.4	2.2-2.7
	CRSwNP	783	2.8**	2.5-3.2
	CRSsNP	826	2	1.8-2.2
	Asthma	424	2.5	2.4-2.7
	Allergy	492	2.4	2.3-2.6
SNOT Postnasal Drip	Overall	2266	2.6	2.2-3
	CRSwNP	783	2.4	1.6-3.2
	CRSsNP	826	2.6*	1.9-3.2
	Asthma	424	3.1	3-3.2
	Allergy	492	3.1	3-3.3
SNOT Thick Nasal Discharge	Overall	2266	2.3	2.1-2.6
	CRSwNP	783	2.5**	1.5-3.5
	CRSsNP	826	2.3	1.7-2.9
	Asthma	424	3.1	2.9-3.2
	Allergy	492	3	2.8-3.1
VAS Nasal Discharge	Overall	1549	54.3	50.5-58.2
	CRSwNP	318	57.2**	44.4-69.9
	CRSsNP	133	45.5	45.4-45.6
	Asthma	107	61.2	50-72.3
	Allergy	-	-	-
VAS Postnasal Discharge	Overall	1550	57.2	54.2-60.1
	CRSwNP	446	57.6**	50-65.1
	CRSsNP	147	46.6	22.2-70.9
	Asthma	75	68	42.2-93.8
	Allergy	14	79.3	68.5-90.1
VAS Rhinorrhoea	Overall	1892	57.3	51.7-62.9
	CRSwNP	1415	64.5**	61.9-67.1
	CRSsNP	73	48.9	24.9-72.9
	Asthma	56	74.6	60.6-88.6
	Allergy	14	60.7	46.3-71.1

CI, confidence interval; CRSwNP, chronic rhinosinusitis with nasal polyps; CRSsNP, chronic rhinosinusitis without nasal polyps  
 Total SNOT22: 0-110 scale; Individual SNOT22 symptom: 0-5 scale; VAS: 0-100 scale

\*Greater than CRSwNP group ( $p < 0.05$ )

\*\*Greater than CRSsNP group ( $p < 0.05$ )

\*\*\*Greater than both CRSwNP and CRSsNP groups ( $p < 0.05$ )

of the four nasal discharge questions on the SNOT22 in adults with CRS. There are several limitations that should still be considered. First, as demonstrated by Fischer et al., patients often describe their symptoms in ways that vary from providers<sup>6</sup>. While the SNOT22 attempts to characterise nasal discharge in four distinct ways, patients may think of their symptoms differently and struggle to place them within one of these domains. Second, the majority of studies investigating nasal discharge report SNOT22 data either in total score only or as a rhinologic domain, which accounts for the scores of all 7 nasal questions. Thus, the number of studies that included itemised SNOT22 data was limited in relation to the total body of literature regarding nasal discharge.

Discrete patient data was limited in the studies included, which posed difficulties in our subgroup analysis. Additionally, it was not feasible to completely account for overlap that may occur between polyp status and diagnosis of asthma or allergies. These limitations highlight the challenges posed by the availability of data and the rarity of certain outcomes in the studies included. Future studies should attempt to further stratify these data to analyse the individual effect that each of these diseases has on nasal discharge.

This stratified analysis can be used to personalise a clinician's approach to managing the symptoms of nasal discharge in CRS. The findings presented show that there is variability in the prevalence and severity of the four types of nasal discharge captured by the SNOT22. The results of this study also illustrate how comorbidities and CRS subtype can associate with nasal discharge presentation. A personalised approach to clinical care can consider how patients experience each of the four symptoms and incorporate management of comorbidities with CRS treatment.

## Conclusions

Our findings suggest that patients with CRS tend to report postnasal discharge as the most severe nasal discharge symptom on the SNOT22. Patients without nasal polyps experience more severe PND. Comorbid asthma may be a factor that worsens PND, both in patients with and without nasal polyps. Consideration of individual SNOT22 items, in addition to overall score, can enable clinicians to tailor their approach to each patient.

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The authors declare no conflict of interest.

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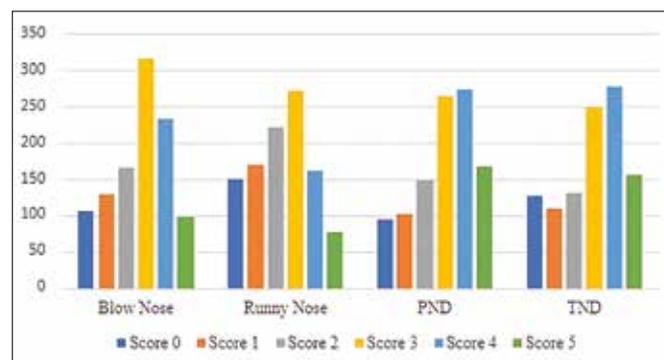


Figure 4. SNOT22 score distribution in adults with CRS.

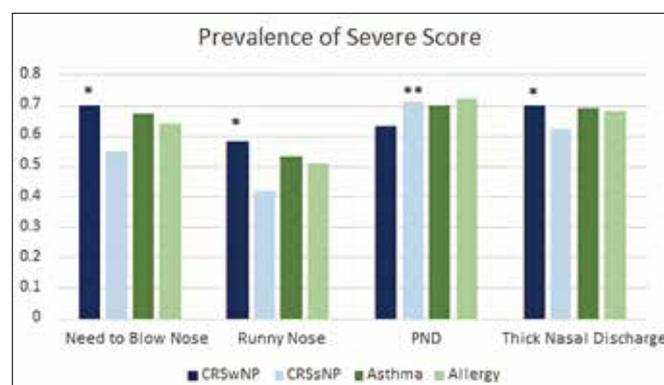


Figure 5. Proportion of patients reporting severe symptoms (score 3-5).

ing agencies in the public, commercial, or not-for-profit sectors.

### Author contributions

EMK, ATR, EEB: data curation, formal analysis, writing; SAN: formal analysis, writing (review), supervision; AND, TLS, ZMS: writing (review); IVS – data curation; JCM: data curation, writing (review); RJS: conceptualization, supervision, writing (review).

### Ethical consideration

Not applicable.

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