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ORIGINAL RESEARCH

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Comparing the severity of chronic rhinosinusitis symptoms before versus during the COVID-19 pandemic

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Abstract

Background: COVID-19 measures such as masking, social distancing, and staying indoors may mitigate chronic rhinosinusitis (CRS) symptoms. We evaluate whether these measures correlated with improved symptoms in patients with CRS.

Methods: This retrospective study compared SNOT-22 survey data from the Northwestern CRS Registry at the time of enrollment and at years 1–5 of follow-up. The final sample consisted of 1826 SNOT-22 surveys for 598 patients. April 10, 2020 to December 31, 2021 was considered "during the pandemic" and prior to March 11, 2020 was considered "pre-pandemic." Wilcoxon test was used to compare SNOT22 at enrollment pre-pandemic versus during pandemic. Separate linear mixed models were performed to estimate SNOT22 at 1 to 5 years after enrollment pre-pandemic versus during pandemic.

Results: Subjects enrolled during the pandemic had worse SNOT22 scores than those enrolled pre-pandemic (53 vs. 42, $p = .0024$). Total SNOT-22 scores were improved during the pandemic than before the pandemic at 1 year follow-up (18.17 vs. 12.22, $p = .001$). This effect persists when evaluating the nasal (7.33 vs. 5.13, $p = .003$), sleep (2.63 vs. 1.39, $p = .008$), function (1.40 vs. 0.72, $p = .015$), and emotion (0.77 vs. 0.17, $p < .001$) domains individually. There was no statistically significant difference in total SNOT-22 score at Years 2–5 of follow-up.

Conclusions: Patients with CRS experience a greater reduction in symptom severity in their first year of treatment during the pandemic than before the pandemic, plausibly from measures such as masking and staying indoors.

Level of Evidence: 4

KEYWORDS
chronic rhinosinusitis, SNOT-22, quality of life, rhinosinusitis, sinusitis, COVID-19

Institution at which work performed: Northwestern Medicine Group

1 | INTRODUCTION

Chronic rhinosinusitis (CRS) is a clinical syndrome characterized by persistent inflammation of the nasal and paranasal sinus mucosa with symptoms including nasal blockage, discharge, facial pressure and reduction or loss of smell. In most patients, CRS cannot be "cured," and therapy is directed at controlling symptoms and improving quality of life.[1] Interventions such as intranasal saline, intranasal corticosteroid sprays, oral corticosteroids, and antibiotics aim to control mucosal inflammation and edema, maintain adequate sinus ventilation and drainage, and reduce or treat acute exacerbations.[2,3] In addition, patients are encouraged to avoid exacerbating factors and environmental triggers such as cigarette smoke, allergens, and air pollution.[4–8] However, proven interventions for improving CRS symptoms are limited beyond these recommendations, and studies testing the utility of other novel measures are currently lacking.

The onset of the COVID-19 pandemic in the United States created significant modifications to many activities of daily life. It profoundly impacted individual and collective behaviors through mandated masking, social distancing, stay at home orders, travel restrictions, and other policies.[9–14] Although intended to combat the spread of COVID specifically, many of these practices have had important impacts on other diseases as well. They have effectively delayed or suppressed the usual seasonal surge of other respiratory viral illnesses, including influenza and pediatric bronchiolitis,[15–21] and they have even reduced the incidence of non-respiratory contagious diseases such as norovirus and enterovirus.[22,23] In addition, studies have found a significant reduction in the severity of allergic rhinitis symptoms during the COVID-19 pandemic, proposing reduced allergen exposure as the result of face masks and lockdown policies as the likely mechanism for the observed improvement.[24–26] Therefore, measures such as masking, social distancing, and staying indoors may have been taken with the intention of avoiding COVID exposures, but one might also expect for them to have the effect of minimizing exposure to environmental triggers (such as secondhand smoke, pollen, or air pollution) for patients with CRS.

Thus, this study aims to compare the severity of CRS symptoms in relation to the COVID-19 pandemic, a time when many people undertook measures such as masking and social distancing, and a time when exposure to other upper respiratory infections was relatively low.[16,17] This information could provide valuable insight into the potential impact of upper respiratory infections on CRS symptoms, as well as potential solutions for individuals seeking strategies for controlling their CRS symptoms.

2 | METHODS

2.1 | Data collection

This retrospective study analyzed deidentified demographic and survey data collected from participants in the Northwestern CRS Registry, consisting of patients aged 18–89 years old with an existing or new diagnosis of CRS (including all sub-types as defined by the American Academy of Otolaryngology[27] and the European Position Statement on Rhinosinusitis and Nasal Polyps[3]) seen in the Northwestern Medical

Group (NMG) Otolaryngology clinic and NMG Department of Medicine, Division of Allergy/Immunology. The registry collects survey data from participants at the time of enrollment and again at approximately 3 months, 6 months, 46 weeks, and 1 year after the date of enrollment. After 1 year from enrollment, surveys are readministered annually. Surveys from participants undergoing either medical or surgical management for their CRS symptoms were included.

The administered survey includes multiple validated questionnaires, including the Sino-Nasal Outcome Test (SNOT-22), a 22-item self-administered disease-specific health related quality of life instrument validated for use in CRS.[28] Subjects rate a list of 22 symptoms on a Likert scale of 0 to 5, where 0 = "No problem", 1 = "Very mild problem", 2 = "Mild or slight problem", 3 = "Moderate problem", 4 = "Severe problem", and 5 = "Problem as bad as it can be." Lower total scores indicate milder, less bothersome symptoms while higher scores indicate more severe and problematic symptoms, with a Minimal Clinically Important Difference (MCID) of 12.[29] Of the total 2287 registry records, 2138 were identified as having SNOT-22 data at the time of enrollment. Records from patients with an enrollment SNOT-22 score of <8 were excluded. A washout period of November 3, 2020 to October 4, 2020 was defined to exclude survey data during the first month of the COVID-19 pandemic from the analysis. Any date between April 10, 2020 and December 31, 2021 was categorized as "during the COVID pandemic" and any date before March 11, 2020 was considered to be "pre-pandemic." These dates correspond closely with pandemic policies implemented in the state of Illinois, where our institution is located. The initial stay at home order was implemented from March 21 to April 7, 2020, and was subsequently extended through May 29, 2020 with modifications, including an added face-covering requirement effective starting May 1.[30] Records from within 3 months after enrollment for patients being seen for medical management of their CRS symptoms and within 46 weeks after enrollment for patients undergoing surgery for their CRS symptoms were also removed.

2.2 | Statistical analysis

The primary goal was to evaluate whether SNOT22 varies according to enrollment and follow-up period pre-pandemic and during-pandemic. Primary outcomes for analyses included SNOT22 and each sub-domain (as defined in Khan 2021[31]) including nasal, ear/facial, sleep, function and emotion at enrollment, 1 to 5 years after enrollment.

Descriptive statistics summarized baseline characteristics at the participant level. Categorical variables were summarized with frequencies and percentages, and continuous variables were summarized with means and standard deviations.

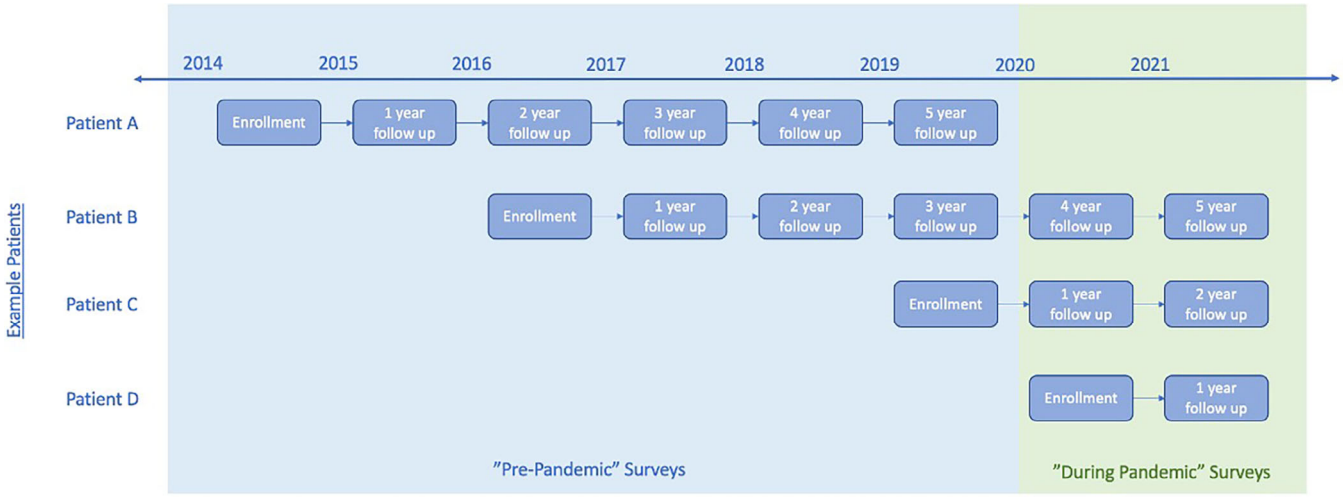

FIGURE 1 Example categorization of Pre-Pandemic and During Pandemic Surveys. All surveys collected before March 11, 2020 were considered "pre-pandemic," including all surveys at the time of enrollment at and 1–5 years of follow up. All surveys collected after April 10, 2020 were considered "during pandemic." For example, comparison of SNOT-22 scores at 5 year follow up pre-pandemic versus during pandemic would include Patient A's 5 year survey in the pre-pandemic group and Patient B's 5 year survey in the during pandemic group, despite Patient B's having enrolled pre-pandemic. Similarly, comparison of SNOT-22 scores at 1 year follow up pre-pandemic versus during pandemic would include Patients A & B's 1 year surveys in the pre-pandemic group and Patients C & D's 1 year surveys in the during pandemic group. Both Patient C & D's 1 year surveys were collected during the pandemic and therefore qualify as during pandemic data points, despite Patient C's enrollment being pre-pandemic while Patient D enrolled during the pandemic

To compare SNOT22 at enrollment pre-pandemic and during pandemic, Wilcoxon test was used due to lack of normality. To examine SNOT22 at follow-up period, separate linear mixed models (LMMs) were performed to estimate SNOT22 at 1 to 5 years after enrollment pre-pandemic and during pandemic. The model compared the change in scores for patients before- versus during the pandemic: for example at 5 year follow up, the pre-pandemic group comprised of all 5-year follow up surveys collected before November 3, 2020, while the during-pandemic group comprised of all 5-year follow up surveys collected after October 4, 2020, regardless of whether the time of enrollment for the corresponding patient was pre-pandemic or during the pandemic (Figure 1). Doing so also accounted for missing surveys by enabling the model to consider all survey responses, even if not all patients completed every survey at every follow up time point. Due to violation of normality assumption, we performed squared root transformation on SNOT22 and all sub-domains. Specifically, models we reported hereafter for SNOT22 included a fixed effect for baseline SNOT22 category (mild vs. moderate vs. severe), time point, indicator of pandemic period, and two-way interaction term, and a random participant effect to account for within-participant correlation. Moreover, a similar analytical strategy was utilized to include additional baseline characteristics such as age, gender, race and ethnicity. The conclusion stayed the same and therefore the following results were present without additional baseline characteristics except for baseline SNOT22 category. Series plots displaying mean and standard deviation values or model-estimated outcome over time, by pandemic period, were used to illustrate outcome over time. Multivariable analyses were conducted at each survey time point to assess the individual contribution of COVID-19 status to SNOT22 scores while controlling for surgical status. All analyses were conducted in SAS version 9.4 (The SAS Institute; Cary, NC), R 4.1.1, or STATA SE.

3 | RESULTS

Analyses included a total of 598 participants, 356 participants with 1-year follow up data, 311 with 2-year follow up data, 238 with 3-year follow up data, 196 with 4-year follow up data, and 127 with 5-year follow up data. The final sample consisted of 1826 survey records (including all time points). At enrollment, the average age was 46.09 (SD = 14.85) years old with 50.93% female, 70.74% White, 78.76% non-Hispanic. 61 (10.20%) subjects were defined as having mild CRS (SNOT22 8-20), 316 (52.84%) as having moderate CRS (SNOT22 21-50), and 221 (36.96%) as having severe CRS (SNOT22 >50) at enrollment. A total of 127 patients received medical therapy, while 471 patients underwent surgery. The patient demographics of the cohort are described in Table 1.

Compared with subjects enrolled before pandemic, subjects enrolled during pandemic had higher SNOT22 (median [Q1–Q3]: 53 [38–64] vs. 42 [30.5–57], p value = .0024), higher sleep score (median [Q1–Q3]: 12 [8–15] vs. 9 [4–13], p value = .0001), higher function score (median [Q1–Q3]: 8 [6–11] vs. 6 [3–9], p value = .0039), and higher emotion score (median [Q1–Q3]: 4 [2–8] vs. 3 [1–6], p value = .0061) at enrollment indicating more severe symptoms during the pandemic. There is no difference in nasal and ear/facial score (p value = .78 and .053).

TABLE 1 Baseline demographics

Variable of interest	Groups	Overall ($N = 598$)	
		N	*N* (%) Mean (SD) Median (Q1–Q3)
Age		590	46.09 (14.85)
Gender		593	
	Female		302 (50.93)
	Male		291 (49.07)
Race		598	
	White		423 (70.74)
	Black		38 (6.35)
	Asian		20 (3.34)
	Native American		3 (0.50)
	Other/Unknown		112 (18.73)
	Mixed		2 (0.33)
Ethnicity		598	
	Not Hispanic		471 (78.76)
	Hispanic		24 (4.01)
	Unknown		103 (17.22)
SNOT22 at enrollment		598	43.00 (32.00, 58,00)
Nasal		598	17.00 (12.00, 21.00)
Ear/facial		598	5.00 (3.00, 9.00)
Sleep		598	9.00 (5.00, 13.00)
Function		598	6.00 (3.00, 9.00)
Emotion		598	3.00 (1.00, 6.00)

Note: (1) There are 8 (1.34%) missing in age and (2) there are 5 (0.84%) missing in gender.

In examining the model-estimated SNOT22 (two-way interaction term p value = .11), SNOT22 scores were higher for subjects completing 1-year follow up surveys before the pandemic than during the pandemic (estimated outcome [95% CI]: 18.17 [16.20, 20.15] vs. 12.22 [9.12, 15.32], p value = .0013). There was no significant difference in year 2 to 5 (p value = .10, .72, .25, and .52, respectively).

In examining the model-estimated nasal score (two-way interaction term p value = .02), subjects enrolled before pandemic tended to have higher nasal score at year 1 and year 2 (Year 1: 7.33 [6.53, 8.14] vs. 5.13 [3.85, 6.42], p value = .0034; Year 2: 7.34 [6.45, 8.22] vs. 5.88 [4.66, 7.11], p value = .040). There is no significant difference in year 3 to 5 (p value = .14, 0.26, and 0.66, respectively).

In examining the model-estimated ear and facial score (two-way interaction term p value = .3187), subjects enrolled before pandemic tended to have higher ear and facial score at year 4 (1.95 [1.46, 2.44] vs. 1.06 [0.63, 1.50], p value = .0036). There is no significant difference in year 1, 2, 3 and 5 (p value = .084, 0.073, 0.69, and 0.39, respectively).

In examining the model-estimated sleep score (two-way interaction term p value = .62), subjects enrolled before pandemic tended to have higher sleep score at year 1 (2.63 [2.12, 3.13] vs. 1.39 [0.67, 2.11], p value = .0075). There is no significant difference in year 2 to 5 (p value = .25, 0.31, 0.40, and 0.24, respectively).

In examining the model-estimated function score (two-way interaction term p value = .67), subjects enrolled before pandemic tended to have higher function score at year 1 and 2 (Year1: 1.40 [1.09, 1.71] vs. 0.72 [0.28, 1.15], p value = .015; Year 2: 1.62 [1.26, 1.98] vs. 1.05 [0.58, 1.51], p value = .047). There is no significant difference in year 3 to 5 (p value = .26, 0.61, and 0.44, respectively).

In examining the model-estimated emotion score (two-way interaction term p value = .017), subjects enrolled before pandemic tended to have higher emotion score at year 1 (0.77 [0.57, 0.98] vs. 0.17 [−0.02, 0.35], p value = .0001). There is no significant difference in year 2 to 5 (p value = .13, 0.74, 0.95, and 0.84, respectively; Table 2).

Multivariate analysis showed that at enrollment, both enrollment in the surgical arm and pandemic status were independently predictive of a higher total SNOT22 (surgical status: 7.03 [4.23, 9.82], $p < .001$; pandemic status: 6.58 [1.56, 11.60], $p = .01$). At 1 year follow up, both positive surgical status and pandemic status were independently predictive of lower total SNOT22 (surgical status: −5.40 [−9.56, −1.23], $p = .011$; pandemic status: −6.60 [−11.56, −1.66], $p = .009$). At 2-year follow up, only pandemic status was independently predictive of a lower total

TABLE 2 Model estimates for SNOT22

Follow up time point	Pre-pandemic estimated mean (95% CI)	During pandemic estimated mean (95% CI)	*p* value[a]
Total SNOT22			
Year 1	18.17 (16.20, 20.15)	12.22 (9.12, 15.32)	**0.001**
Year 2	17.84 (15.68, 20.00)	14.96 (11.90, 18.03)	0.10
Year 3	17.00 (14.68, 19.33)	17.64 (14.50, 20.78)	0.72
Year 4	19.44 (16.65, 22.22)	17.19 (13.96, 20.41)	0.25
Year 5	16.49 (13.00, 19.98)	15.15 (12.18, 18.12)	0.52
Nasal			
Year 1	7.33 (6.53, 8.14)	5.13 (3.85, 6.42)	**0.003**
Year 2	7.34 (6.45, 8.22)	5.88 (4.66, 7.11)	**0.040**
Year 3	6.55 (5.61, 7.49)	7.61 (6.29, 8.93)	0.14
Year 4	7.72 (6.58, 8.87)	6.81 (5.48, 8.14)	0.26
Year 5	6.42 (4.93, 7.91)	6.02 (4.74,7.30)	0.66
Ear/Facial			
Year 1	1.59 (1.26, 1.92)	1.05 (0.53, 1.57)	0.08
Year 2	1.51 (1.17, 1.86)	1.03 (0.58, 1.47)	0.07
Year 3	1.38 (1.00, 1.75)	1.27 (0.79, 1.74)	0.69
Year 4	1.95 (1.46, 2.44)	1.06 (0.62, 1.50)	**0.004**
Year 5	1.42 (0.90, 1.93)	1.16 (0.75, 1.57)	0.39
Sleep			
Year 1	2.63 (2.12, 3.13)	1.39 (0.67, 2.11)	**0.008**
Year 2	2.56 (2.03, 3.09)	2.04 (1.29, 2.80)	0.25
Year 3	2.80 (2.17, 3.44)	2.32 (1.53, 3.11)	0.31
Year 4	3.29 (2.54, 4.05)	2.84 (1.97, 3.71)	0.40
Year 5	3.04 (2.10, 3.98)	2.40 (1.66, 3.15)	0.24
Function			
Year 1	1.40 (1.09, 1.71)	0.72 (0.28, 1.15)	**0.015**
Year 2	1.62 (1.26, 1.98)	1.05 (0.58, 1.51)	**0.047**
Year 3	1.56 (1.17, 1.94)	1.25 (0.78, 1.71)	0.26
Year 4	1.66 (1.20, 2.12)	1.50 (0.96, 2.03)	0.61
Year 5	1.71 (1.02, 2.40)	1.39 (0.84, 1.94)	0.44
Emotion			
Year 1	0.77 (0.57, 0.98)	0.17 (−0.02, 0.35)	**<0.001**
Year 2	0.71 (0.50, 0.92)	0.45 (0.18, 0.72)	0.13
Year 3	0.69 (0.45, 0.94)	0.76 (0.41, 1.11)	0.74
Year 4	0.72 (0.46, 0.99)	0.74 (0.41, 1.06)	0.95
Year 5	0.65 (0.28, 1.02)	0.70 (0.36, 1.04)	0.84

Note: *The model estimates (95% CI) are from linear mixed models with interaction term (time point and pandemic period) and controlling for baseline SNOT22 category.

[a]*p* value for testing whether the estimated outcome are different pre-pandemic and during pandemic.

SNOT22 (surgical status: −1.84 [−5.89, −2.22], $p = .375$; pandemic status: −8.54 [−12.85, −4.23], $p < .001$). Neither variable was predictive of total SNOT22 at year 3 (surgical status: −1.80 [−7.11, −3.51], $p = .505$; pandemic status: 1.99 [−2.99, 6.99], $p = .432$), year 4 (surgical status: −1.26 [−6.72, 4.20], $p = .649$; pandemic status: −0.786 [−6.28, 4.70], $p = .778$), or year 5 (surgical status: 0.158 [−6.55, 6.87], $p = .963$; pandemic status: −2.25 [−8.58, 4.09], $p = .485$).

4 | DISCUSSION

We sought to determine if there were differences in patient reported CRS symptoms during the COVID pandemic compared with pre-pandemic life. We found that at the time of enrollment, total SNOT-22 scores were significantly higher during the pandemic than before the pandemic; that is, patients presenting to the ENT clinic during the

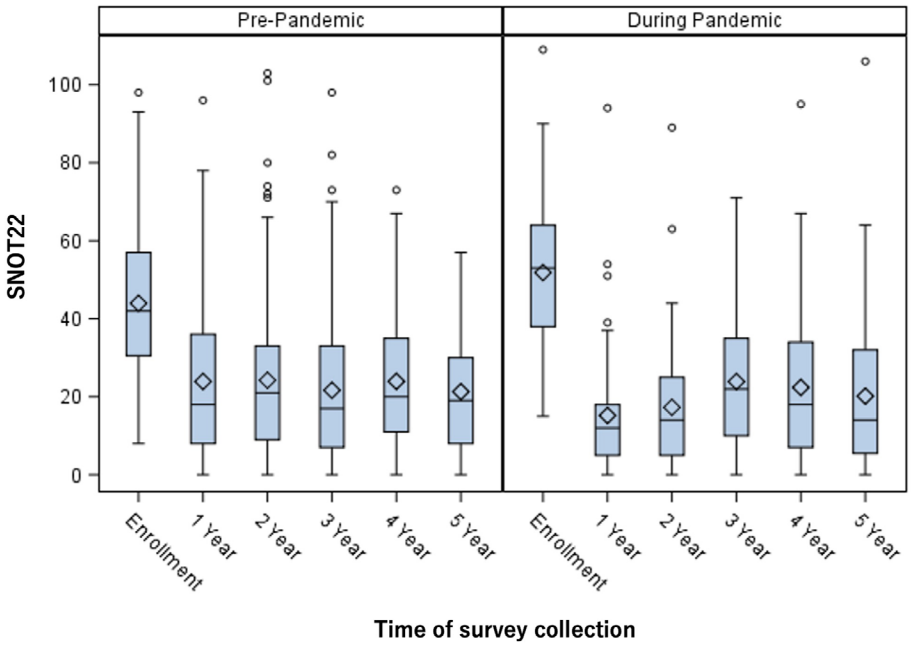

FIGURE 2 Model-estimated SNOT22 at enrollment and follow-up time points pre-pandemic versus during pandemic. Compared with subjects enrolled before the pandemic, subjects enrolled during pandemic scored higher on the SNOT22 at the time of enrollment (median [Q1–Q3]: 53 [38–64] vs. 42 [30.5–57]). In examining the model-estimated SNOT22, scores were higher for subjects at 1-year follow-up surveyed before the pandemic than those surveyed during the pandemic: 18.17 (16.20, 20.15) versus 12.22 (9.12, 15.32). There was a greater improvement in SNOT22 between enrollment and 1 year follow-up during the pandemic than pre-pandemic (53–12 vs. 42–18)

pandemic presented with more severe symptoms than patients presenting before the pandemic (Figure 2). This was also the case when evaluating the sleep, function, and emotion domains individually—patients presented with more severe symptoms in these categories during COVID compared with before COVID. In contrast, there was no difference in the severity of nasal symptoms or in the severity of ear/facial symptoms before versus during the pandemic.

In addition, we found that total SNOT-22 scores were significantly lower during the pandemic than before the pandemic at 1 year follow up (Figure 2). This effect persists when looking at each of the nasal, sleep, function, and emotion domains individually—subjects who presented for 1 year follow up during the pandemic had significantly less severe symptoms in the nasal, sleep, function, and emotion domains than those who presented for 1 year follow up before the pandemic. There was no significant difference at 1 year of follow up in ear/facial symptoms.

The greater observed improvement in nasal symptoms during the pandemic might be explained by the effect of masking, social distancing, and patients' staying indoors more frequently. All these practices would have the effect of reducing exposure to environmental triggers of CRS symptoms (secondhand smoke, pollen, air pollution).

The finding that sleep and emotion symptoms improved during COVID compared with before are particularly surprising—contrary to studies demonstrating a high prevalence of sleep problems, stress, anxiety, and depression in the general population during the pandemic, our study found an improvement in sleep and emotion symptoms in CRS patients.[32–34] The reason for this difference in outcome is unclear, although it could suggest that CRS symptoms may have a relatively large influence on quality of life such that the magnitude of impact would be great enough to counterbalance the stressors of the pandemic.

Though there was no statistically significant difference in total SNOT-22 score at Years 2–5 of follow up, most of these scores were slightly better during the pandemic. We suspect that the results did not achieve statistical significance due to lower sample sizes. Nasal and function symptoms continued to be less severe at Year 2 of follow up during the pandemic, but this effect was also lost in Years 3–5 of follow up. Ear/facial scores were significantly lower at Year 4 of follow up during the pandemic compared with before, but there were no statistically significant differences found at any other time points. Sleep and emotion domain scores were not statistically different before versus during the pandemic at Years 2–5 of follow up.

We also found that whether they enrolled pre-pandemic or during the pandemic, patients noticed an improvement in their chronic rhinosinusitis symptoms between enrollment and Year 1 of follow up: SNOT-22 scores at enrollment averaged 43.97 and improved to 23.92 at 1 year follow up pre-pandemic (a difference of 20.05 points); during the pandemic, SNOT-22 scores averaged 51.83 at baseline and improved to 15.19 one year later (a difference of 36.64 points). Phillips et al has proposed a minimal clinically important difference (MCID) for CRS symptoms as measured by SNOT-22 to be 12.[29] While this was not the primary focus of this study, it is noteworthy that all patient groups exceeded this MCID regardless of the treatment they received (medical or surgical) after 1 year. This is consistent with established literature demonstrating clear improvements in SNOT-22 after surgical or medical management.[35–40]

One limitation of our study is that our model could not stratify patients by medical versus surgical management (did not control for surgical status) due to sample size constraints. However, multivariate analysis demonstrated that pandemic status was independently predictive of SNOT22 scores at enrollment, 1-year, and 2-year follow up regardless of surgical status. Moreover, medical versus surgical

management did not contribute to changes in SNOT-22 after 1 year. In addition, to mitigate potential effects of initial medical and surgical treatment, records from within 3 months after enrollment for patients being seen for medical management of their CRS symptoms and within 46 weeks after enrollment for patients undergoing surgery for their CRS symptoms were removed from our model, since these scores would likely reflect response to initial treatment by an otolaryngologist or allergist/immunologist, rather than pandemic versus pre-pandemic status. Finally, while we speculate that behavior changes such as masking, social distancing, and staying indoors had the effect of reducing exposure to aggravating environmental triggers, causality cannot be determined from retrospective, uncontrolled data.

5 | CONCLUSION

Our study demonstrates that (1) patients with CRS presented with more severe symptoms at initial visit during the pandemic compared with before the pandemic, (2) patients with CRS experienced less severe symptoms at 1 year of follow up during the pandemic compared with before the pandemic, and (3) patients experienced a greater reduction in symptom severity in their first year of treatment during the pandemic compared with before the pandemic. These findings suggest a clinically significant contribution from the COVID-19 pandemic to patients' symptom severity, which we speculate might be due to widespread behavior changes such as masking, social distancing, and staying indoors that have had the effect of reducing exposure to aggravating environmental triggers. If this is the case, then these same measures may be repurposed, even after the end of the COVID-19 pandemic, by CRS patients seeking additional strategies for symptom prevention and management.

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CONFLICT OF INTEREST

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