



Sleep problems increase school accidents related to allergic diseases

To the editor

The incidence of school accidents, a leading cause of mortality and a major public health issue, has increased over the past decades.^{1,2} The major risk factors for school accidents are sports activities, impaired sleep, and psychological and behavioral disorders.² A recent study also suggested that allergic diseases are associated with a higher incidence of school injuries that require medical attention.¹ However, the evidence supporting an association between school accidents and allergic diseases is not definitive,¹ and no studies have investigated the possibility that sleep problems mediate the association of school accidents with allergic diseases.

We examined the associations of school accidents with the prevalence of asthma, allergic rhinitis, atopic dermatitis, and allergic multimorbidity, and the role of sleep problems mediating this association, in the general population of Korean adolescents. Data were from the Korea Youth Risk Behavior Web-based Survey (KYRBS), a nationally representative survey of Korean school adolescents performed by the Korea Center for Disease Control and Prevention (KCDC). The study protocol was approved by the Institutional Review Board of the KCDC and the Armed Forces Medical Command (AFMC-18-IRB-046), and written informed consent was provided by the parents or caregivers of all participants.

We designed questionnaires to identify demographic factors and determine the prevalence of allergic diseases. The presence of asthma, atopic dermatitis, and allergic rhinitis was based on diagnoses made by physicians during the previous 12 months.³ Allergic multimorbidity was defined as the coexistence of at least two allergic diseases (asthma, allergic rhinitis, and/or atopic dermatitis).³ A school accident was defined as an injury that occurred in school that required medical attention within the previous 12 months. Sleep satisfaction was categorized as very satisfactory, satisfactory, average, unsatisfactory, and very unsatisfactory, based on response to the following question: "In the last week, how satisfactory was your sleep in terms of relieving your fatigue?"

Data were analyzed using weighted complex sampling analysis with binary logistic regression and conditional process analysis (mediation analysis) that were determined from non-parametric bootstrapping with 1000 resamples.⁴ Mediation analyses were conducted to assess the direct and indirect effect presented as odds ratios (ORs) with 95% bias-corrected confidence intervals (CIs). The effect of poor sleep as a mediation proportion was calculated as follows: $100\% \times \text{indirect effect}/(\text{indirect}$

effect + direct effect). Outcomes were adjusted for the following confounding factors: age, sex, body mass index category, region of residence, highest educational level of parents, smoking, alcohol consumption, economic level, school performance, depressive mood, physical activity, and sleep satisfaction. These analyses were performed using SPSS version 25.0 (IBM Co) and R software (version 3.1.1). A *P* value below .05 was considered statistically significant.

A total of 400 382 adolescents (12-18 years old) were enrolled in the KYRBS surveys from 2013 through 2018, and 388 838 (97.1%) of them met the study criteria by completing the questionnaires (Table 1). Among these participants, 2.3% (8954) had asthma, 18.3% (71 257) had allergic rhinitis, 6.9% (27 002) had atopic dermatitis, 3.6% (13 877) had allergic multimorbidity, and 21.9% (85 182) had school accidents during the previous 12 months (Table 2). School accidents were significantly associated with asthma (aOR = 1.544, 95% CI = 1.475-1.617), allergic rhinitis (1.477, 1.450-1.506), atopic dermatitis (1.347, 1.309-1.387), and allergic multimorbidity ($P_{\text{trend}} < .001$). Statistical adjustment for sleep satisfaction attenuated these relationships, although they remained significant.

Analysis of the effect of poor sleep on mediating the relationship of allergy and school accidents showed that asthma had a direct effect (aOR = 2.279, 95% CI = 1.282-4.050) and an indirect effect on school accidents (aOR = 1.050, 95% CI = 1.010-1.121). The results were similar for allergic rhinitis (direct effect: aOR = 1.328, 95% CI = 1.039-1.697; indirect effect: aOR = 1.018, 95% CI = 1.002-1.045), atopic dermatitis (direct effect: aOR = 1.177, 95% CI = 1.070-1.296; indirect effect: aOR = 1.022, 95% CI = 1.000-1.051), and allergic multimorbidity (direct effect: aOR = 1.472, 95% CI = 1.111-1.950; indirect effect: aOR = 1.141, 95% CI = 1.014-1.284). Thus, the mediating effect of sleep deprivation explained 5.7% (asthma), 5.8% (allergic rhinitis), 11.8% (atopic dermatitis), and 3.3% (allergic multimorbidity) of the association (Figure 1).

We conducted a subgroup analysis of the effect of poor sleep on mediating the relationship of allergy and school accidents among subjects who have the data on the pattern of allergic medication use ($n = 210\ 174$) (each pattern of asthma, allergic rhinitis, and atopic dermatitis medication use [none, regular long-term use, short-term use for symptoms, respectively]). The mediating effects of sleep deprivation after additional adjustment for pattern of allergic medication use were also significant (data not shown).

Our results suggest that asthma, allergic rhinitis, atopic dermatitis, and allergic multimorbidity are associated with an increased risk of school accidents in Korean adolescents and that poor sleep partly mediates these associations. This suggests that poor sleep and allergic diseases may share underlying mechanisms and/or susceptibility pathways.

The sleep disruption in an allergic patient is caused by increased levels of inflammatory cytokines and may aggravate symptoms of the underlying disease (airway obstruction in asthma, nasal congestion in allergic rhinitis, and increased itching in atopic dermatitis).⁵ Moreover, the sleep disruption caused by allergic diseases may negatively affect a patient's quality of life and cognitive function by leading to daytime somnolence, poor concentration, reduced

Key Message

Asthma, allergic rhinitis, atopic dermatitis, and allergic multimorbidity are associated with an increased risk of school accidents in Korean adolescents, and that poor sleep partly mediates these associations. This suggests that poor sleep and allergic diseases may share underlying mechanisms and/or susceptibility pathways.

psychomotor and cognitive abilities, and fatigue.⁵ The harmful effects of sleep impairment may also increase the risk of school accidents,^{5,6} which corresponds well with our results.

TABLE 1 Demographic and clinical characteristics of participating adolescents in the KYRBS (n = 388,838)

Characteristic	Total	Asthma			Allergic rhinitis			Atopic dermatitis		
		No	Yes	P value	No	Yes	P value	No	Yes	P value
Number (%)	388 838 (100)	379 884 (97.7)	8954 (2.3)		317 581 (81.7)	71 257 (18.3)		361 836 (93.1)	27 002 (6.9)	
Age, years (SD)	14.96 (1.75)	14.97 (1.75)	14.69 (1.74)	<.001	14.94 (1.76)	15.06 (1.74)	<.001	14.96 (1.75)	14.97 (1.75)	.367
Sex, male (%)	198 294 (51.0)	192 835 (50.8)	5459 (61.0)	<.001	163 223 (51.4)	35 071 (49.2)	<.001	186 763 (51.6)	11 531 (42.7)	<.001
BMI, kg/m ² , n (%)										
Underweight (below 5th percentile)	22 394 (5.8)	21 910 (5.8)	484 (5.4)	<.001	18 628 (5.9)	3766 (5.3)	<.001	21 192 (5.9)	1 202 (4.5)	<.001
Normal or less (5–85 th percentile)	295 816 (76.1)	289 293 (76.2)	6523 (72.9)		241 486 (76.0)	54 330 (76.2)		275 576 (76.2)	20 240 (75.0)	
Overweight (85–95 th percentile)	36 069 (9.3)	35 122 (9.2)	947 (10.6)		29 280 (9.2)	6 789 (9.5)		33 279 (9.2)	2 790 (7.7)	
Obese (above 95 th percentile)	34 559 (8.9)	33 559 (8.8)	1000 (11.2)		28 187 (8.9)	6357 (8.9)		31 789 (8.8)	2770 (10.3)	
Region of residence, n (%)										
Rural	215 646 (55.5)	210 452 (55.4)	5194 (58.0)	<.001	176 676 (55.6)	38 970 (54.7)	<.001	200 594 (55.4)	15 052 (55.7)	.329
Urban	173 192 (44.5)	169 432 (44.6)	3750 (42.0)		140 905 (44.4)	32 287 (45.3)		161 242 (44.6)	11 950 (44.3)	
Smoking, n (%)	64 242 (16.5)	62 395 (16.4)	1847 (20.6)	<.001	52 558 (16.5)	11 684 (16.4)	.322	59 777 (16.5)	4465 (16.5)	.948
Alcohol consumption										
0 days/month	353 621 (90.9)	345 674 (91.0)	7947 (88.8)	<.001	289 356 (91.1)	64 265 (90.2)	<.001	329 249 (91.0)	24 372 (90.3)	<.001
1–5 days/month	15 536 (4.0)	15 170 (4.0)	366 (4.1)		12 520 (3.9)	3016 (4.2)		14 383 (4.0)	1153 (4.3)	
6–30 days/month	19 681 (5.1)	19 040 (4.9)	641 (7.2)		15 705 (4.9)	3976 (5.6)		18 204 (5.0)	1477 (5.5)	
Physical activity										
≤1 sessions per week	202 483 (52.1)	198 322 (52.2)	161 (46.5)	<.001	66 742 (52.5)	35 741 (50.2)	<.001	188 149 (52.0)	14 334 (53.1)	.001
2–4 sessions per week	132 390 (34.0)	129 091 (34.0)	3299 (36.8)		107 021 (33.7)	25 369 (35.6)		123 330 (34.1)	9060 (33.6)	
5–7 sessions per week	53 965 (13.9)	52 471 (13.8)	1494 (16.7)		43 818 (13.8)	10 147 (14.2)		50 357 (13.9)	3608 (13.4)	

(Continues)

TABLE 1 (Continued)

		Asthma			Allergic rhinitis			Atopic dermatitis		
Characteristic	Total	No	Yes	P value	No	Yes	P value	No	Yes	P value
Highest educational level of parents, n (%)										
Middle school or less	5379 (1.4)	5223 (1.4)	156 (1.7)	<.001	4601 (1.4)	778 (1.1)	<.001	5021 (1.4)	358 (1.3)	<.001
Middle school	100 171 (25.8)	98 030 (25.8)	2141 (23.9)		83 023 (26.1)	17 148 (24.1)		93 004 (25.7)	7167 (26.5)	
College or above	220 376 (56.7)	215 138 (56.6)	5238 (58.5)		174 981 (55.1)	45 395 (63.7)		204 686 (56.6)	15 690 (58.1)	
Unknown	62 912 (16.2)	61 493 (16.2)	1419 (15.8)		54 976 (17.3)	7936 (11.1)		59 125 (16.3)	3787 (14.0)	
Economic level, n (%)										
Highest	34 769 (8.9)	33 668 (8.9)	1101 (12.3)	<.001	27 853 (8.8)	6916 (9.7)	<.001	32 426 (9.0)	2343 (8.7)	<.001
Middle-high	105 733 (27.2)	103 306 (27.2)	2427 (27.1)		84 684 (26.7)	21 049 (29.5)		98 783 (27.3)	6950 (6.6)	
Middle	184 635 (47.5)	180 834 (47.6)	3801 (42.5)		152 588 (48.0)	32 047 (45.0)		171 946 (47.5)	12 689 (47.0)	
Middle-low	51 684 (13.3)	50 498 (13.0)	1186 (13.2)		42 532 (13.4)	9152 (12.8)		47 685 (13.2)	3999 (14.8)	
Lowest	12 017 (3.1)	11 578 (3.0)	439 (4.9)		9924 (3.1)	2093 (2.9)		10 996 (3.0)	1021 (3.8)	
School performance, n (%)										
Highest	48 760 (12.5)	47 535 (12.5)	1225 (13.7)	<.001	37 725 (11.9)	11 035 (15.5)	<.001	45 461 (12.6)	3299 (12.2)	<.001
Middle-high	97 930 (25.2)	95 981 (25.2)	2079 (23.2)		78 156 (24.6)	19 774 (27.8)		91 174 (25.2)	6756 (25.0)	
Middle	110 816 (28.5)	108 386 (28.5)	2430 (27.1)		91 183 (28.7)	19 633 (27.6)		103 324 (28.6)	7492 (27.7)	
Middle-low	90 725 (23.3)	88 673 (23.3)	2052 (22.9)		76 171 (24.0)	14 554 (20.4)		84 257 (23.3)	6468 (24.0)	
Lowest	40 607 (10.4)	39 439 (10.4)	1168 (13.0)		34 346 (10.8)	6261 (8.8)		37 620 (10.4)	2987 (7.4)	
Sleep satisfaction, n (%)										
Very unsatisfactory	29 889 (7.7)	29 159 (7.7)	730 (8.2)	<.001	25 272 (8.0)	4617 (6.5)	<.001	28 113 (7.8)	1776 (6.6)	<.001
Unsatisfactory	72 015 (18.5)	70 420 (18.5)	1595 (17.8)		60 639 (19.1)	11 376 (16.0)		67 599 (18.7)	4416 (16.4)	
Average	126 665 (32.6)	123 923 (32.6)	2732 (30.5)		104 768 (33.0)	21 887 (30.7)		118 356 (32.7)	8299 (30.7)	
Satisfactory	109 444 (28.1)	107 025 (28.2)	2419 (27.0)		87 729 (27.6)	21 715 (30.5)		101 331 (28.0)	8113 (30.0)	
Very satisfactory	50 835 (13.1)	49 357 (13.0)	1478 (16.5)		39 173 (12.3)	11 662 (16.4)		46 437 (12.8)	4398 (16.3)	
Depressive mood during 12 months, n (%)	101 837 (26.2)	98 693 (26.0)	3144 (35.1)	<.001	79 645 (25.1)	22 192 (31.1)	<.001	92 998 (25.7)	8839 (32.7)	<.001
School accidents during 12 months, n (%)	85 182 (21.9)	82 334 (21.7)	2848 (31.8)	<.001	65 526 (20.6)	19 656 (27.6)	<.001	78 155 (21.6)	7027 (26.0)	<.001

Note: Continuous and categorical variables were calculated by the design-based Wilcoxon rank-sum test and the chi-square test, respectively. Numbers in bold indicate a significant difference ($P < .05$).

Abbreviations: BMI, body mass index; KYRBS, Korea Youth Risk Behavior Web-based Survey; SD, standard deviation.

Although previous studies have focused on the association between asthma and risks of injury,^{1,7-10} our study more comprehensively analyzed the associations of injury risk with the

prevalence of asthma, atopic dermatitis, allergic rhinitis, and allergic multimorbidity. Previous studies that implicated allergic disease as a risk factor for injury proposed several possible

TABLE 2 Multivariable analysis of the relationship of school accidents with asthma, atopic dermatitis, allergic rhinitis, and allergic multimorbidity among participating adolescents in the KYRBS (n = 388 838). Values are given as number (%) or OR [95% CI]

Dependent variable			Independent variable								
			School accidents (n = 85,182 [21.9%])								
			Crude OR [95% CI]		P value	Adjusted OR ^a [95% CI]		P value	Additionally adjusted OR ^b [95% CI]		P value
Asthma	No	379 884 (97.7)	1.000 [reference]			1.000 [reference]			1.000 [reference]		
	Yes	8954 (2.3)	1.686 [1.611-1.763]		<.001	1.544 [1.475-1.617]		<.001	1.449 [1.383-1.517]		<.001
Allergic rhinitis	No	317 581 (81.7)	1.000 [reference]			1.000 [reference]			1.000 [reference]		
	Yes	71 257 (18.3)	1.465 [1.438-1.493]		<.001	1.477 [1.450-1.506]		<.001	1.401 [1.374-1.428]		<.001
Atopic dermatitis	No	361 836 (93.1)	1.000 [reference]			1.000 [reference]			1.000 [reference]		
	Yes	27 002 (6.9)	1.277 [1.241-1.314]		<.001	1.347 [1.309-1.387]		<.001	1.292 [1.255-1.330]		<.001
Allergic multimorbidity ^c											
None		296 943 (76.4)	1.000 [reference]			1.000 [reference]			1.000 [reference]		
Single allergic disease		78 018 (20.1)	1.380 [1.355-1.406]		<.001	1.403 [1.377-1.429]		<.001	1.339 [1.314-1.365]		<.001
Multiple allergic diseases		13 877 (3.6)	1.778 [1.713-1.845]		<.001	1.794 [1.728-1.863]		<.001	1.658 [1.596-1.722]		<.001
			P _{trend} < .001						P _{trend} < .001		
									P _{trend} < .001		

Note: Numbers in bold indicate a significant difference ($P < .05$).

Abbreviations: BMI, body mass index; CI, confidence interval; KYRBS, Korea Youth Risk Behavior Web-based Survey; OR, odds ratio.

^aRisk factors were adjusted for age, sex, BMI category (underweight, normal weight, overweight, and obese), region of residence (urban and rural), highest educational level of parents (middle school or less, high school, college or above, and unknown), smoking, alcohol consumption (0, 1-5, and 6-30 days/month), economic level (highest, middle-high, middle, middle-low, and lowest), school performance (highest, middle-high, middle, middle-low, and lowest), depressive mood, and physical activity (≤ 1 , 2-4, and 5-7 sessions per wk).

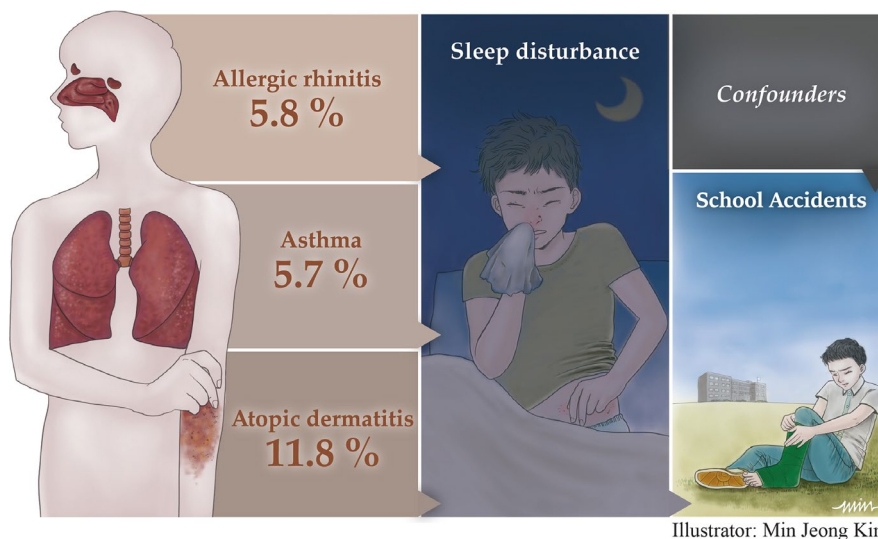
^bRisk factors were adjusted for the same factors as above and for sleep satisfaction (very unsatisfactory, unsatisfactory, average, satisfactory, and very satisfactory).

^cThe presence of asthma, atopic dermatitis, and allergic rhinitis was based on diagnoses by physicians in the previous 12 mo, and allergic multimorbidity was defined as a coexistence of at least two allergic diseases (asthma, allergic rhinitis, and/or atopic dermatitis).

underlying mechanisms. For example, parents of children with chronic illnesses (rather than healthy children) are more likely to restrict their physical activity, and this could lead to inadequate development of balance or motor skills and thereby increase the risk of injury.^{1,7-10} Also, psychiatric and behavioral disorders have established associations with allergic diseases, and drugs for allergic diseases, such as sedating antihistamines and steroids, could increase the risk of psychological, cognitive, and behavioral disturbances, and thereby increase the risk of injury.¹ Moreover, changes in attention, risk-taking behavior, self-confidence, and/or self-regulation following a diagnosis of allergic diseases may also increase the risk of injury.^{1,7-10} A previous study showed that allergic rhinitis increased the risk of driving accidents, because poor quality of sleep led to increased daytime drowsiness.¹¹ The current study suggests that allergic diseases contribute to sleep disorders, and these contribute to the increased risk of school accidents in adolescents.¹¹

The main strengths of our study were the large sample size (n = 400 382) and the comprehensive investigation of poor sleep as a factor that mediates the relationship between school accidents and allergic diseases. However, our cross-sectional design does not allow definitive establishment of causal or temporal relationships. Furthermore, we did not adjust for the potential confounding effects of daytime attention symptom, attention-deficit/hyperactivity disorder, and using of drugs such as corticosteroids and antihistamines that may cause behavioral and cognitive disturbances, although we adjusted for academic performance and patterns of allergic medication use.

In conclusion, we found that asthma, allergic rhinitis, atopic dermatitis, and allergic multimorbidity were significantly associated with increased risk of school accidents in Korean adolescents, and this effect is partly mediated by poor sleep. This suggests that the improved management of allergic diseases and sleep disorders may help to reduce school accidents in adolescents.



Illustrator: Min Jeong Kim

FIGURE 1 Sleep problems partly explain the association of asthma, allergic rhinitis, and atopic dermatitis with school accidents in Korean adolescents based on data from the KYRBS ($n = 388\,838$). The mediating effect of sleep deprivation explained 5.7% (asthma), 5.8% (allergic rhinitis), and 11.8% (atopic dermatitis) of the association. Direct and indirect effects were adjusted for age, sex, BMI category (underweight, normal weight, overweight, and obese), region of residence (urban and rural), highest educational level of parents (middle school or less, high school, college or above, and unknown), smoking, alcohol consumption (0, 1-5, and 6-30 days/month), economic level (highest, middle-high, middle, middle-low, and lowest), depressive mood, and physical activity (≤ 1 , 2-4, and 5-7 sessions per week). BMI, body mass index; CI, confidence interval; KYRBS, Korea Youth Risk Behavior Web-based Survey; OR, odds ratio

CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.

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Functional burden and limitations in children with chronic sinusitis

To the editor,

Chronic rhinosinusitis (CRS) is characterized by persistent inflammation of the sinus cavities and, in pediatric patients, is responsible for 5.6 million outpatient visits annually.¹ Although previous studies have established substantial activity, work, and social limitations among adults with CRS,² studies in children have been single-center analyses of tertiary hospitals and focused on establishing the efficacy of surgical intervention in improving quality of life (QOL).^{3,4} Data are limited on QOL in pediatric CRS in the broader, non-surgical population.

Most QOL measures in CRS and other chronic conditions do not address pediatric issues such as behavioral concerns and peer relationships. This study employs the Columbia Impairment Scale, a 13-question tool validated to evaluate functional health status in children, specifically in the domains of four major areas: interpersonal relations, broad psychopathological domains, functioning in job or schoolwork, and use of leisure time.^{5,6}

The objective of this study was to use a validated pediatric QOL tool to quantify the impact of pediatric CRS in a representative epidemiological sample. To contextualize the QOL impact of CRS, we compared it to that of a well-studied chronic disease, asthma. We hypothesized a decrease in QOL associated with CRS diagnosis, similar to the QOL burden of asthma.

We analyzed data from children (aged 5–17 years) in the 2002–2015 Medical Expenditure Panel Survey (MEPS), a representative survey of the US population (weighted frequency: 837 769 147) published annually by the Agency for Healthcare Research and Quality. This study protocol was approved by the Northwestern University Institutional Review Board.

We used *International Classification of Diseases, Ninth Revision* (ICD-9) codes to determine diagnosis of CRS (473.x). Because there is no ICD-9 coding for CRS, we used the closest term, chronic sinusitis. Throughout the paper, we refer to chronic sinusitis as CRS for clarity. Parent-reported diagnoses were recorded and converted

by professional coders into ICD-9 codes. Previous studies have established the Columbia Impairment Scale (CIS) scores associated with asthma.⁷ As such, the control group comprised of children with asthma (ICD-9 493.x).

Dependent variables were domains of functional impairment, assessed by the Columbia Impairment Scale. The CIS rates severity of impairment from 0 ("No problem") to 4 ("A very big problem") in 13 domains. Previous studies found that summed (range 0–52) CIS score ≥ 16 indicates severe impairment.⁵

We generated weighted frequency and prevalence of children who experienced problems (CIS ≥ 1) with each CIS domain. Logistic regression models were constructed to test the null hypothesis that there were no differences in CIS domains and severe impairment (dependent variables) associated with CRS diagnosis. All multivariable models were adjusted for age (continuous), sex, race, and income covariates.

We conducted multivariable linear regression analysis to determine whether CRS diagnosis affects total CIS score. Multivariable models invoking stepwise variable selection ($\alpha = 0.10$) were constructed to determine predictors of total CIS score in children with CRS.

All statistical analyses were performed using SAS version 9.4 (SAS Institute). Complete case analysis was performed. A two-sided P -value $< .05$ was considered statistically significant.

Among an estimated 837 769 147 (unweighted frequency: 98 873) children, there were 45 258 629 (unweighted: 4102) with CRS and 85 654 234 (unweighted: 10 931) with asthma. In Rao-Scott chi-square analysis, CRS was associated with differences in sex, income, race, region, insurance payer, and comorbid allergic rhinitis, migraines, or asthma ($P \leq .005$; Figure 1; Table S1; all supplemental materials are available at: <https://data.mendeley.com/datasets/9m-hskr788r/1>).

In multivariable survey logistic regression models adjusted for age (continuous), sex, race, and income, diagnosis of CRS was associated with problems with unhappiness, having fun, nervousness,