

# Impact of Sinonasal Disease on Depression, Sleep Duration, and Productivity Among Adults in the United States

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**Objective:** Examine the relationship between depression symptoms and sinonasal inflammatory diseases, and investigate health disparities associated with allergic rhinitis (AR) and sinusitis in the United States.

**Study Design:** Cross-sectional analysis of 2014 National Health Interview Survey (NHIS) data.

**Methods:** Adult cases of AR and sinusitis were extracted from the 2014 NHIS in addition to demographic, socioeconomic, and related depressive symptom data. The dataset was analyzed with chi-square, t-tests, and multivariate regression.

**Results:** There were  $19.1 \pm 1.1$  million adult AR cases and  $29.4 \pm 1.4$  million adult sinusitis cases. Of these, 20.6% and 22.0% reported depression symptoms in the past 12 months for those with AR or sinusitis, respectively. Both diseases were also associated with significantly fewer mean hours of sleep a night (AR: 7.02 vs. 7.14,  $P < 0.01$ ; Sinusitis: 6.98 vs. 7.14,  $P < 0.01$ ) and greater mean days of work missed (AR: 4.60 vs. 3.62,  $P < 0.01$ ; Sinusitis: 5.87 vs. 3.41,  $P < 0.01$ ). On multivariate analysis, the prevalence of AR and sinusitis was significantly higher among men, Caucasians, older adults, the more educated, and adults with depression symptoms. Only the prevalence of sinusitis varied depending on income and geography.

**Conclusion:** Allergic rhinitis and sinusitis are associated with an increased likelihood of depressive symptoms, shorter sleep duration, and more workdays lost. The prevalence of both are influenced by age, sex, race/ethnicity, and education level. Targeted initiatives should be developed to address these health disparities and comorbidities associated with inflammatory sinonasal disease.

**Key Words:** Sinusitis, chronic rhinosinusitis, allergic rhinitis, health disparities, depression, mood disorders, sinonasal inflammation, epidemiology.

**Level of Evidence:** 4.

## INTRODUCTION

Sinusitis and allergic rhinitis (AR) are two of the most prevalent manifestations of sinonasal inflammation in the United States. In 2014, there were an estimated 29.4 million Americans with sinusitis and an estimated 19.1 million Americans with AR.<sup>1</sup> Sinusitis and AR involve inflammation of the nasal mucosa leading to symptoms of congestion and obstruction, significantly affecting quality of life.

Previous studies have suggested an association between sinusitis and AR with mood disorders such as depression and anxiety.<sup>2–11</sup> Tomoum et al. demonstrated that depression and anxiety were positively correlated with sinusitis utilizing the Hospital Anxiety and Depression score and the Rhinosinusitis Disability Index in a prospective cohort of 124 patients.<sup>11</sup> Similarly, Schmitt

et al. found in a cross-sectional study of German National Health Insurance beneficiaries that patients with AR were at higher risk of being diagnosed with a concurrent depressive or anxiety disorder.<sup>12</sup> In addition to depression, sinusitis and AR have also been linked to sleep disturbances and insomnia.<sup>13–16</sup> A concurrent diagnosis of a mood disorder has been associated with an increase in morbidity and mortality.<sup>17,18</sup> For instance, in patients who had undergone coronary artery bypass surgery, depression was linked to significantly higher mortality rates.<sup>19</sup> In the context of sinusitis, patients with depression have significantly higher medication usage scores for oral antibiotics and worse quality of life outcomes following endoscopic sinus surgery.<sup>10,18</sup>

Mood disorders have a significant impact on the quality of life of patients, but there is little data on the association of depression and sinonasal inflammation on a national level across the United States.<sup>2–11,13–15,20</sup> This study examines the relationship between sinonasal inflammation and depression symptoms in the United States at a population level by utilizing the National Health Interview Survey. Additionally, this study will also investigate the association between sleep and work days lost with AR and sinusitis.

## METHODS

Adult data was collected from the 2014 National Health Interview Survey (NHIS) using the Minnesota Population Center and State Health Access Data Assistance Center's Integrated Health Interview Series (IHIS).<sup>21</sup> The data from the NHIS reports information about the health of the civilian

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TABLE I.  
Demographics and Socioeconomic Characteristics of AR and Sinusitis.

	Allergic Rhinitis			Sinusitis		
	Yes (%)	No (%)	<i>P</i> *	Yes (%)	No (%)	<i>P</i> *
Subjective Depression <sup>†</sup>						
Yes	20.6%	16.7%		22.0%	16.3%	
No	79.4%	83.3%	<0.001 <sup>†</sup>	78.0%	83.7%	<0.001 <sup>†</sup>
Gender						
Male	41.0%	48.8%		34.4%	50.1%	
Female	59.0%	51.2%	<0.001	65.6%	49.9%	<0.001
Region						
Northeast	17.4%	17.3%		14.1%	17.8%	
Midwest	20.4%	23.2%		23.0%	23.0%	
South	35.0%	37.4%		44.8%	36.2%	
West	27.2%	22.1%	0.001	18.1%	23.1%	<0.001
Education						
Less than high school graduate	10.0%	13.7%		10.8%	13.7%	
High school graduate	22.1%	26.2%		25.5%	25.9%	
Some college	20.0%	19.6%		19.8%	19.7%	
College degree	47.7%	40.0%		43.5%	40.2%	
Unknown	0.2%	0.6%	<0.001 <sup>†</sup>	0.4%	0.5%	<0.001 <sup>†</sup>
Income (% of FPL)						
<100	10.7%	13.3%		12.3%	13.2%	
100–199	15.9%	18.0%		17.8%	17.8%	
200–399	23.8%	24.4%		23.4%	24.5%	
400+	37.4%	30.2%		33.0%	30.4%	
Unknown	12.2%	14.1%	<0.001 <sup>†</sup>	13.4%	14.1%	0.1 <sup>†</sup>
Age						
18–30	13.0%	24.1%		12.1%	24.8%	
31–45	22.9%	25.5%		24.1%	25.5%	
45–65	46.0%	33.1%		42.8%	32.9%	
65+	18.1%	17.3%	<0.001	21.0%	16.8%	<0.001
Ethnicity						
White	73.8%	65.0%		72.8%	64.7%	
Asian	4.0%	5.6%		2.9%	5.9%	
American Indian	0.6%	0.5%		0.4%	0.5%	
Black	9.3%	11.9%		11.9%	11.6%	
Hispanic	10.3%	15.7%		10.4%	16.0%	
Multiracial	2.1%	1.3%	<0.001	1.6%	1.3%	<0.001

\*Based on chi-squared testing between the condition and the socioeconomic variable

<sup>†</sup>Excludes unknown values

FPL = Federal Poverty Level

noninstitutionalized U.S. population.<sup>22</sup> Since the data was already de-identified and is publicly available, this study was exempt from institutional review board approval.

The variables “Told had sinusitis, past 12 months” and “Had hay fever, past 12 months” were used to identify a subset of NHIS participants who reported having sinusitis or AR, respectively. The term “sinusitis” encompassed acute rhinosinusitis, recurrent acute sinusitis, and chronic rhinosinusitis. The study population was identified from survey participants who answered yes or no to these questions. There was a small minority of persons in which one of the variables was labeled as not in use (NIU). Those cases were grouped with respondents who did not have the disease.

The variable “How often feel depressed” was then used to identify the respondents who reported feeling depressed.

“Yes, I am depressed” (daily, weekly, monthly, a few times a year) was coded as a positive binary, and the response “Never” was coded as a negative binary. This variable does not represent an objective clinical diagnosis or the symptom severity. The variable is also not indicative of a positive Diagnostic and Statistical Manual of Mental Disorders (DSM) 5 diagnosis. Other indicators of the respondents’ quality of life were also collected. These included hours of sleep and lost workdays.

Socioeconomic variables were also collected. “Self-reported race” was joined with “Hispanic ethnicity, dichotomous” to create the categories of Asian, American Indian/Alaskan Native, Black, Hispanic, and non-Hispanic White. Age and educational attainment were grouped into categories as represented by Table I. Finally, poverty levels were defined using the NHIS

TABLE II.  
Relationship of Sinonasal Inflammation with Hours of Sleep and Missed Work Days.

	Hours of Sleep			Missed Work Days		
	Average	SE	P	Average	SE	P
Allergic Rhinitis						
Yes	7.02	0.04		4.60	0.33	
No	7.14	0.01	0.002	3.62	0.16	0.008
Sinusitis						
Yes	6.98	0.03		5.87	0.44	
No	7.14	0.01	<0.001	3.41	0.16	<0.001
Among Adults without Comorbid Subjective Depression						
	Hours of Sleep			Missed Work Days		
	Average	SE	P	Average	SE	P
Allergic Rhinitis						
Yes	6.98	0.11		4.60	0.33	
No	7.04	0.03	0.61	5.45	0.45	0.410
Sinusitis						
Yes	6.96	0.08		8.77	1.24	
No	7.04	0.03	0.32	4.94	0.45	0.004
Among Adults without Comorbid Subjective Depression						
	Hours of Sleep			Missed Work Days		
	Average	SE	P	Average	SE	P
Allergic Rhinitis						
Yes	7.06	0.05		3.55	0.52	
No	7.23	0.02	0.005	2.50	0.23	0.068
Sinusitis						
Yes	7.00	0.05		4.46	0.62	
No	7.24	0.02	<0.001	2.38	0.23	0.001

SE = standard error

income variable, categorizing respondents as less than 100% of the federal poverty level (FPL), 100% to 199% FPL, 200% to 399% FPL, and 400% or more of the FPL.

The complex, multistage probability sampling used by the NHIS incorporates stratification, clustering, and oversampling of some racial subpopulations (Black, Hispanic, and Asian). In order to account for this complex sample design, the NHIS provides sampling weights to produce representative estimates of the total U.S. population. Sampling weights were incorporated into the dataset prior to statistical analysis.

The data was then imported into R ([www.r-project.org](http://www.r-project.org)) using the publicly available SAScii package and analyzed using the survey package. Both chi-squared statistics and multivariate analysis were used to look at socioeconomic characteristics and the relationship of depression to sinonasal disease. The chi-squared test was the only test used to analyze the impact of sinonasal disease and depression on sleep and work-days lost.

## RESULTS

The overall study population consisted of 240 million adults with an average age of  $47.0 \pm 0.2$  years;  $51.8\% \pm 1.8\%$  were male and  $48.2\% \pm 1.7\%$  were female. The univariate analyses of the distribution of allergic rhinitis and sinusitis stratified by demographic and socioeconomic variables are described in Table I.

Controlling for all socioeconomic variables and depression, patients with AR were more likely to have sinusitis and vice versa.

### Allergic Rhinitis

AR was reported by  $19.1 \pm 1.1$  million adults during 2014. Among those, 20.6% also reported symptoms of depression in the same period. Comparatively, among those who did not report AR in the past 12 months, only 16.7% reported symptoms of depression (Table I). Furthermore, those with AR symptoms had fewer mean hours of sleep per night (7.02 vs. 7.14 hours,  $P < 0.01$ ) and greater mean days of work missed (4.60 vs. 3.41 days,  $P < 0.01$ ) compared to those who did not report AR (Table II).

The findings of multivariate logistic regression looking at socioeconomic indicators and depression symptoms affecting the likelihood of having allergic rhinitis are summarized in Table III. Depression symptoms were more likely to be reported in adults with AR (OR: 1.32,  $P = 0.001$ ) after adjustment for all sociodemographic factors listed in Table III. Demographically, Asian, Black, and Hispanic adults were less likely to be diagnosed with AR compared to White adults with Hispanics being the

TABLE III.  
Logistic Regression of Sinonasal Inflammation versus Socioeconomic and Demographic Characteristics.

	Allergic Rhinitis			Sinusitis		
	OR	95% CI	P	OR	95% CI	P
Region						
Northeast		1.00-REF			1.00-REF	
Midwest	0.77	0.56 1.04	0.091	1.10	0.87 1.39	0.425
South	0.95	0.72 1.24	0.687	<b>1.55</b>	<b>1.26 1.90</b>	<b>&lt;0.001</b>
West	1.24	0.94 1.64	0.131	1.04	0.83 1.31	0.709
Sex						
Male	<b>0.74</b>	<b>0.63 0.87</b>	<b>&lt;0.001</b>	<b>0.52</b>	<b>0.45 0.60</b>	<b>&lt;0.001</b>
Female		1.00-REF			1.00-REF	
Race						
White		1.00-REF			1.00-REF	
Asian	<b>0.70</b>	<b>0.51 0.96</b>	<b>0.028</b>	<b>0.41</b>	<b>0.28 0.60</b>	<b>&lt;0.001</b>
American Indian	1.35	0.52 3.47	0.539	0.88	0.35 2.19	0.780
Black	<b>0.76</b>	<b>0.60 0.96</b>	<b>0.024</b>	1.03	0.85 1.25	0.744
Hispanic	<b>0.60</b>	<b>0.45 0.79</b>	<b>&lt;0.001</b>	<b>0.75</b>	<b>0.59 0.95</b>	<b>0.017</b>
Multiracial	1.26	0.84 1.91	0.267	1.35	0.92 1.98	0.121
Income (% of FPL)						
<100	0.87	0.64 1.17	0.363	1.04	0.82 1.31	0.770
100–199	0.84	0.64 1.09	0.194	<b>0.80</b>	<b>0.64 1.00</b>	<b>0.049</b>
200–399	0.84	0.67 1.05	0.122	<b>0.80</b>	<b>0.66 0.99</b>	<b>0.036</b>
400+		1.00-REF			1.00-REF	
Education						
Less than high school graduate	<b>0.73</b>	<b>0.55 0.96</b>	<b>0.028</b>	0.82	0.66 1.01	0.069
High school graduate or equiv	0.78	0.59 1.05	0.103	<b>0.70</b>	<b>0.55 0.88</b>	<b>0.003</b>
Some college	0.94	0.76 1.17	0.590	0.90	0.74 1.10	0.312
College graduate		1.00-REF			1.00-REF	
Subjective depression						
Yes	<b>1.32</b>	<b>1.12 1.54</b>	<b>0.001</b>	<b>1.54</b>	<b>1.35 1.77</b>	<b>&lt;0.001</b>
No		1.00-REF			1.00-REF	
Age						
18–30	<b>0.58</b>	<b>0.40 0.82</b>	<b>0.003</b>	<b>0.42</b>	<b>0.33 0.54</b>	<b>&lt;0.001</b>
31–45	0.86	0.67 1.10	0.225	<b>0.69</b>	<b>0.57 0.84</b>	<b>&lt;0.001</b>
45–65	1.18	0.96 1.44	0.117	0.89	0.75 1.05	0.170
65+		1.00-REF			1.00-REF	

CI = confidence interval  
FPL = Federal Poverty Level  
Bold indicates  $P < 0.05$

lowest. Additionally, men were less likely to be diagnosed with AR than women (OR: 0.74,  $P < 0.001$ ). Furthermore, 18–30-year-old adults were almost half as likely to be diagnosed with AR compared to those older than 65 (OR: 0.58,  $P < 0.001$ ). Finally, when compared with those who graduated from college, respondents who had a high school degree or less had a lower probability of receiving a diagnosis of AR (OR: 0.73,  $P = 0.028$ ). Income level and geography were not shown to have a statistically significant effect on the probability of having AR.

### Sinusitis

Sinusitis was reported by  $29.4 \pm 1.4$  million adults during 2014. Among those with sinusitis, 22.0% also had

symptoms of depression in the same period. Among those who did not report sinusitis in the past 12 months, 16.3% reported suffering symptoms of depression (Table I). Furthermore, those with sinusitis symptoms had fewer mean hours of sleep per night (6.98 vs. 7.14 hours,  $P < 0.001$ ) and greater mean days of work missed (5.87 vs. 3.41 days,  $P < 0.001$ ) compared to those who did not report sinusitis (Table II).

The findings of multivariate logistic regression looking at socioeconomic indicators and depression symptoms affecting the likelihood of having sinusitis are summarized in Table III. Depression symptoms were more likely to be reported in adults with sinusitis (OR: 1.54,  $P < 0.001$ ) after adjustment for all sociodemographic factors listed in Table III. Asian and Hispanic

adults were less likely to be diagnosed with sinusitis relative to white adults with Asians being the lowest. Furthermore, men were less likely to be diagnosed with sinusitis compared to women (OR: 0.52,  $P < 0.001$ ). When stratified by region, respondents living in the South were more likely to be diagnosed with sinusitis than respondents living in the Northeast (OR: 1.55,  $P < 0.001$ ). Additionally, those with a high school education were less likely to be diagnosed with sinusitis than those who were college graduates (OR: 0.70,  $P < 0.01$ ). Adults with income levels between 100% to 399% of the poverty level were also less likely to be diagnosed with sinusitis (OR: 0.80,  $P < 0.05$ ). Finally, those 45 and under were less likely to report sinusitis compared to those older than 65 ( $P < 0.001$ ).

## DISCUSSION

While previous studies have addressed the relationship between depression and sinonasal inflammation within the context of a prospective study limited to tertiary care settings,<sup>5–10</sup> there have been no other studies looking at this relationship across the entire U.S. population. While informative, tertiary care environments see a higher proportion of severe disease that requires advanced consultation by otolaryngologists or rhinologists.<sup>20</sup> Investigating at a national level improves the external validity and therefore the relevance to primary care physicians who care for the general population in the U.S.

The findings from this study suggest a strong association between sinonasal disease and symptoms of depression. The prevalence of depression symptoms (22%) among adults with sinusitis roughly corresponds to that found in Schlosser et al.'s prospective study (24.4%).<sup>10</sup> However, the prevalence of depression symptoms among adults with allergic rhinitis (20.6%) differed significantly from the Allergies in America survey (36%).<sup>8</sup> This discrepancy is likely due to the differences in sample design between the two surveys. Nonetheless, these results support the strong association of subjective depression with sinonasal inflammation.

The relationship of sinonasal inflammation with depression is likely two-fold. Depression shares many inflammatory markers with sinonasal inflammation. This “immune-brain pathway” involves several inflammatory markers such as C-reactive protein (CRP), interleukin (IL)-6, and IL-1.<sup>14,23,24</sup> Of note, IL-1 and IL-6 are both upregulated in sinusitis, and may possibly contribute to the pathophysiology of sinusitis's positive association with depression.<sup>13,25,26</sup> The physiologic response is complemented by the social limitations the symptoms of sinonasal inflammation impose. Chronic rhinorrhea, sneezing, purulent discharge, or vocal congestion create difficulties in social interaction.<sup>8</sup> This is further complicated by the anosmia that is often a symptom of chronic sinonasal inflammation.<sup>20</sup>

These symptoms and association with concurrent depression strongly suggest that sinusitis and AR may impact sleep and work productivity. On average, this study finds that those with sinonasal disease had

statistically significant less hours of sleep. However, among adults with symptoms of depression, the presence of sinusitis or AR did not create statistically significant differences in mean hours of sleep, suggesting that symptoms of depression are likely a confounder. Additionally, while the results are statistically significant, they may not be clinically significant. Disturbed sleep quality can manifest itself as reduced hours of sleep and also increased hours of sleep. Quantitative measures of hours of sleep may not adequately capture true sleep quality. Also, the survey and our analysis does not take into account other potential confounding factors such as comorbid sleep apnea, or other chronic medical conditions. In the literature, sinusitis has been proposed to have a significant impact on sleep.<sup>14</sup> In a multi-center study by Alt et al., the majority of patients with sinusitis were found to have poor quality of sleep measured using the Pittsburgh Sleep Quality Index and there were associations with gender, comorbid depression, and tobacco use.

The number of workdays lost was clinically and statistically significant. Taken as an aggregate, AR and sinusitis increased average workdays lost by approximately 1 day and 2.5 days, respectively. Among adults with sinonasal disease, comorbid depression resulted in twice as many workdays lost for both AR and sinusitis. Yet in adults with symptoms of depression, the presence of allergic rhinitis did not significantly increase the number of missed workdays. These results suggest that comorbid depression may play a greater role in lost productivity than AR itself, accentuating the importance of treating comorbidities.

These results parallel the findings of previous studies at tertiary care centers regarding sinusitis's impact on workdays lost.<sup>2,10,27</sup> Schlosser et al. found that mean lost workdays among patients with sinusitis are far higher than that reported in this study.<sup>10</sup> Among those with sinusitis, patients with comorbid depression missed an average of 22.8 days of work in a 90-day period, 4 times more than those without comorbid depression. The significantly higher average is likely due to study population differences. Since the study included only patients with refractory sinusitis at tertiary academic rhinology centers, the average severity of disease would expectedly be greater than that in our study.

Only one paper in the literature has described sinusitis' impact on workdays lost at a population level.<sup>20</sup> That study similarly found a loss of 1.04 lost workdays per year in sinusitis patients compared to 2.46 in the present study. The small discrepancy between results may be due to differences in study methodology. While this study relied on self-reports of AR and sinusitis diagnosis in the NHIS database, Bhattacharyya's study utilized ICD9 codes from the Medical Expenditure Panel Survey (MEPS) database.

Similar to our results, Bhattacharyya reported AR significantly increased the number of workdays lost per year to 0.60 lost workdays per year. Interestingly, both Bhattacharyya's study and our study have found that sinusitis resulted in significantly more workdays lost



than AR, suggesting that sinusitis may have a more severe impact on quality of life than AR.

While the apparent effect AR and sinusitis have on missed work days appear to be small, the aggregate productivity loss is substantial. Based on our results, AR and sinusitis result in 18.7 million and 72.4 million annual lost workdays, respectively. These results highlight the staggering economic impact of sinonasal inflammatory disease.

Finally, this study highlights a few of the complex socioeconomic and ethnic disparities inherent in AR and sinusitis. There are few population studies of socioeconomic variation among adults with AR.<sup>28,29</sup> The present study finds a statistically significant lower rate of AR diagnosis among Asians, African Americans, and Hispanics relative to white adults. While these results parallel those found in Shay et al.'s pediatric study, they differ from those found by Chen et al.<sup>28,29</sup> Namely, Chen et al. found that Asians had an elevated odds ratio of hay fever relative to white adults. Additionally, the study reported no difference in AR prevalence between African Americans and white adults.<sup>28</sup> The discrepancy likely is the result of the differing sample population in different time periods. Chen et al. only sampled from members of the Kaiser Permanente Medical Care Program between 1964 and 1972 located in the San Francisco Bay Area. In contrast, this study's data was from a recent national survey whose respondents are more representative of the racial and socioeconomic heterogeneity present in the current U.S. population.

Additionally, respondents with less than a high school education were also less likely to have AR. This observation and the evidence that ethnic minorities are less likely to have AR strongly supports the theory that disparities in AR prevalence are due to socially mediated patterns of allergen exposure.<sup>30–35</sup> Interestingly, income was not associated with the prevalence of AR, complicating the common assumption that AR is a disease of affluence.

In many ways, the results of sinusitis parallel those of AR. Asian and Hispanic adults were less likely to have sinusitis than White children. These results corroborate with Soler et al.'s findings that Hispanic and Asians had the lowest prevalence of sinusitis.<sup>36</sup> This may be secondary to cultural practices or limited health literacy affecting healthcare utilization. Also, those with incomes between 100% and 400% of the FPL had significantly lower rates of sinusitis. These results may be related to insurance coverage. Those that fall within this middle income level may be too wealthy to qualify for adequate government support while being too poor to afford sufficient health insurance. This disparity may result in lower rates of diagnosis compared to their wealthier and poorer counterparts. To fully elaborate on these observed disparities, further study is needed regarding the access to care and insurance status of those with sinusitis.

There are several notable limitations to this study. First, the reliance on self-reporting by individuals raises the possibility of recall bias in the results and must be taken into consideration. Second, the lack of definitive

physician-reported diagnoses and metrics possibly affects the accuracy of the results. Third, the survey oversimplifies sinusitis and allergic rhinitis and does not distinguish between acute and chronic conditions. Fourth, there is a paucity of responses from minority populations, necessitating the use of complex survey methods. This under-sampling may introduce a small degree of selection bias into the study. Finally, the results of this study are generalizable only to the U.S. population.

## CONCLUSION

In this large cross-sectional study, our analysis demonstrates a strong association between depression symptoms and sinonasal inflammatory disease. Adults with sinusitis and AR are also shown to have a shorter sleep duration and increased missed workdays. Diagnosing and treating comorbid symptoms should be incorporated into the current standard of care for sinusitis and AR to effectively improve the quality of life of patients. This study also reports several socioeconomic disparities among those with sinusitis and AR. Targeted interventions should be developed to improve outcomes in disproportionately affected populations.

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