Association Between Psoriasis with Arthritis and Hearing Impairment in US Adults: Data from the National Health and Nutrition Examination Survey

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ABSTRACT. ***Objective.*** Emerging data has linked inflammatory arthritis with hearing impairment (HI). The objective of this study was to investigate the relationship between psoriasis with arthritis (PsA) and HI in the US population. Given the known association of HI and depression, a secondary aim is to investigate the effect of PsA on mental well-being.

Methods. Cross-sectional study using the National Health and Nutrition Examination Survey for adults aged ≥ 20 years (n = 10,747). Association of PsA with above outcomes was examined using multivariable generalized linear and ordinal logistic regression models, adjusted for demographics and medical comorbidities. Structural equation models examined the extent to which HI mediated the effect of PsA on mental health.

Results. Individuals with PsA were more likely to report hearing difficulties (OR 1.50, p = 0.043), visit a mental health provider (OR 1.62, p = 0.084), have 1.62 more days of poor mental health over the previous month (p = 0.033), and have depression (OR 2.01, p = 0.015) compared to controls. HI mediated 6.5%, 8.3%, and 5.0% of the effect of PsA on the above mental health outcomes, respectively.

Conclusion. PsA is independently associated with a significantly increased risk of HI, which partially mediates an association with worsened psychiatric outcomes. (J Rheumatol First Release January 15 2019; doi:10.3899/jrheum.171228)

Key Indexing Terms:
PSORIASIS | PSORIATIC ARTHRITIS | HEARING LOSS
DEPRESSION | OUTCOMES | AUTOIMMUNE DISEASE

Psoriatic arthritis (PsA) is a seronegative inflammatory spondyloarthritis (SpA) that affects up to 42% of individuals with psoriasis[1]. Using a more conservative estimate of 30% and given the about 3% prevalence of psoriasis in the United States, estimates suggest that PsA affects up to 1% of the population (about 3.2 million people if extrapolated to the US population in 2016)[2]. Though these patients classically present with articular inflammation and movement limitation, individuals with PsA may also exhibit extraarticular symptoms common to other SpA, including diarrhea, mucous membrane lesions, urethritis, and aortic root dilatation[1]. Studies have identified hearing loss as another extraarticular manifestation of inflammatory arthritis. However, these studies have largely focused on individuals with rheumatoid arthritis (RA), systemic lupus erythematosus (SLE), ankylosing spondylitis (AS), and Sjögren syndrome[3,4,5,6,7,8,9,10], with only a few reports finding an association with psoriasis and PsA. Most of these investigations have been limited to case[11,12] and single-institution analyses[13,14], with 1 retrospective cohort study of the Taiwanese population reporting a 1.5-fold increased incidence of sudden sensorineural hearing loss in patients with psoriasis compared to nonpsoriatic controls[15].

The results of these initial analyses are constrained by small sample sizes, inability to control for effects of confounding variables, or homogeneous patient populations with limited generalizability. Thus, the aim of our present investigation is to determine the independent relationship of PsA with hearing loss in a nationally representative sample of the US population, controlling for demographic and comorbidity variables. Given the well-established relationship between hearing loss and depression[16,17,18,19], we also

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sought to investigate the downstream effect of PsA on mental health outcomes and study the contribution of hearing loss to this relationship.

MATERIALS AND METHODS

This manuscript was exempt from Institutional Review Board approval at the Washington University School of Medicine because the study uses public data with no identifiable patient information.

Study population. The US National Health and Nutrition Examination Survey (NHANES) is an ongoing series of cross-sectional surveys of the civilian, noninstitutionalized population of the United States. Every 2 years, NHANES approaches household individuals at random. Persons are selected to participate if they meet specific demographic profiles (based on sex, race/ethnicity, age, and place of residence) and contribute to the national representativeness of the sample. In each of the last several cycles, 12,000 to 13,000 individuals were selected; participation has ranged from 79% to 84%. Further details of the NHANES sampling process are available[20].

Dermatology questionnaires were collected in three 2-year study periods (2003–2004, 2005–2006, and 2009–2010), which were combined per National Center for Health Statistics recommendations[20]. A total of 31,007 people took part in NHANES in 2003–2006 and 2009–2010. Of these, 10,747 individuals were eligible for inclusion in the medical history questionnaire and provided responses to self-reported hearing function, psoriasis, arthritis, and psychiatric comorbidity questionnaires. Included patients were more likely to be female (51.7% vs 50.2%, $p < 0.001$), non-Hispanic white (48.8% vs 35.6%, $p < 0.001$), older (43.5 vs 23.0 yrs, $p < 0.001$), and college graduates (21.0% vs 16.2%, $p < 0.001$).

Demographic and health-related variables. Trained interviewers administered detailed questionnaires[21]. Race-ethnicity was grouped as non-Hispanic white ("white"), non-Hispanic black ("black"), Hispanic, or other. Education was grouped as less than high school, high school diploma (including General Equivalency Diploma), some college, and college graduate.

Presence of psoriasis and arthritis was ascertained through subject responses to medical history questionnaires ("have {you/SP} ever been told by a doctor or other health care provider that {you/he/she} had psoriasis" and "has a doctor or other health professional ever told {you/SP} that {you/s/he} had arthritis"). Owing to limitations of the survey, the presence of PsA could not be assessed using formal diagnostic criteria. Instead, a coincident diagnosis of psoriasis and arthritis (PsA) was used as a proxy for PsA. This study group was then compared against 2 controls: individuals reporting a history of psoriasis without arthritis ("intermediate controls"), and individuals without psoriasis ("normal controls").

Smoking status was considered positive if a patient had smoked at least 100 cigarettes in a lifetime. Hypertension (HTN) was defined based on physician diagnosis, use of antihypertensive medication, or an average systolic blood pressure > 140 mmHg or diastolic blood pressure > 90 mmHg during examination. Mean blood pressure was composed of up to 4 readings on 2 occasions. Diabetes was defined based on physician diagnosis, use of antihyperglycemic medication, an 8-h fasting glucose ≥ 126 mg/dl, or a nonfasting glucose ≥ 200 mg/dl. Stroke was defined based on physician diagnosis.

Audiometric and hearing function data. Self-reported hearing function was ascertained using patient rating of general hearing and reported on a 1 to 4 Likert scale ("Which of the following best describes hearing without hearing aid? Would you say your hearing is good, that you have a little trouble, a lot of trouble, or are you deaf?"). Additionally, a quantitative hearing metric was available for a subset of the population (n = 2356, 21.9%). Details of NHANES audiometric testing procedures have been published previously[22] and are available at www.cdc.gov/nchs/data/nhanes/au.pdf. Pure tone audiometry (PTA) average hearing thresholds were computed across 0.5-, 1-, 2-, and 4-kHz frequencies in the better-hearing ear.

Mental health outcomes. Presence of psychiatric comorbidities was evaluated using subject responses to a self-rated assessment of mental health, use of mental health services, and a validated depression screening tool. All participants self-rated the number of days with poor mental health over the 30 days preceding the survey administration and reported whether they had seen a mental healthcare provider over the last year. Depression was measured using the Patient Health Questionnaire (PHQ-9), a 9-item screening instrument that asks questions about the frequency of depression symptoms over the past 2 weeks. Response categories "not at all," "several days," "more than half the days," and "nearly every day" were given a score ranging from 0 to 3. A total score was calculated ranging from 0 to 27. A score of 10 or higher was used to define the presence of depression in the current study, as has been well-validated in the field. Responses to the depression screening questionnaire were available for a subset of the study population (n = 7574, 70.5%).

Analysis. Baseline demographic, socioeconomic, and medical history factors were characterized as means and SD for continuous variables and as frequency distributions and percent of total for categorical variables. Baseline comparisons stratified by study group (psoriasis with arthritis, psoriasis without arthritis, and no psoriasis) were tested using ANOVA for continuous variables and chi-square for categorical variables. Multivariable regression models, adjusted for demographic and health-related variables, were used to estimate the association between PsA and our primary and secondary outcome variables. Further, we constructed a series of structural equation models (SEM) to study the extent to which hearing loss mediated the relationship between PsA and psychiatric outcomes. SEM are multivariate regression models meant to represent causal relationships among variables in the model. Unlike more traditional multivariate linear models, the response variable in 1 regression equation in an SEM may appear as a predictor in another equation. The path analysis is a special case of the SEM in which there are no latent factors in the model; the models we used are indeed path analyses as well as SEM. STATA version 14 (StataCorp.) was used for all analyses. A p value < 0.05 was considered statistically significant.

RESULTS

Baseline characteristics. Overall, 10,747 patients from the NHANES were included in this analysis. Summary demographic characteristics of the study population are included in Table 1. The prevalence of PsA in the study population was 1.1%; 1.6% had psoriasis without arthritis; and 97.3% did not have psoriasis. Statistically significant baseline differences existed across the 3 study groups for all included variables except sex and history of stroke. Most significant clinically meaningful baseline differences existed for history of smoking, heart disease, and HTN, which were all considerably elevated in individuals with PsA compared to both the intermediate and normal control groups. For 22% of the sample with quantitative audiometric testing, patients with PsA had on average a 12-dB increase in PTA hearing threshold compared to normal controls ($p < 0.001$). Overall, patients with PsA were considerably less likely to rate their hearing as excellent, and more likely to report difficulty in their hearing function ($p < 0.001$).

Multivariable modeling of hearing impairment. In the multivariable logistic regression analysis of self-reported hearing impairment (Table 2), individuals with PsA were 1.50-fold more likely to report difficulty with hearing compared to normal controls (95% CI 1.01–2.21, $p = 0.043$). For the subset of patients with audiometric testing, individuals with PsA were also independently associated with an average 4.79-dB higher PTA than normal controls (95% CI 0.65–8.92, $p = 0.023$; Table 3).

Table 1. Population baseline characteristics, US National Health and Nutrition Examination Survey, 2003–2006 and 2009–2010.

Characteristic	Psoriasis with Arthritis, n = 113	Psoriasis without Arthritis, n = 171	No Psoriasis, n = 10,463	p
Age, yrs, mean (SD)	53.8 (13.9)	41.3 (14.1)	43.3 (15.9)	< 0.001
Pure tone hearing threshold, mean (SD)[1]	30.7 (19.8)	13.0 (16.9)	18.7 (14.5)	< 0.001
Sex, N (%)				
Male	54 (47.8)	79 (46.2)	5048 (48.2)	0.865
Female	59 (52.2)	92 (53.8)	5415 (51.8)	
Race, N (%)				
Non-Hispanic white	86 (76.1)	109 (63.7)	5062 (48.4)	< 0.001
Non-Hispanic black	10 (8.8)	24 (14.0)	2150 (20.5)	
Hispanic	16 (14.2)	30 (17.5)	2762 (26.4)	
Other	1 (0.9)	8 (4.7)	489 (4.7)	
Educational status, N (%)				
Less than high school	33 (29.2)	25 (14.6)	2622 (25.1)	0.014
High school graduate	28 (24.8)	40 (23.4)	2467 (23.6)	
Less than college	35 (31.0)	56 (32.7)	3176 (30.4)	
College graduate	17 (15.0)	50 (29.2)	2198 (21.0)	
Hearing function, N (%)				
Excellent	66 (58.4)	138 (77.1)	8351 (79.8)	< 0.001
Some difficulty	40 (35.4)	30 (16.8)	1870 (17.9)	
A lot of difficulty	7 (6.2)	3 (1.7)	222 (2.1)	
Deaf	(0.0)	8 (4.5)	19 (0.2)	
History of smoking, N (%)				
Yes	88 (77.9)	85 (49.7)	4729 (45.2)	< 0.001
No	25 (22.1)	86 (50.3)	5734 (54.8)	
History of heart disease, N (%)				
Yes	18 (15.9)	10 (5.8)	493 (4.7)	< 0.001
No	95 (84.1)	161 (94.2)	9970 (95.3)	
History of diabetes, N (%)				
Yes	18 (15.9)	9 (5.3)	954 (9.1)	0.009
No	95 (84.1)	162 (94.7)	9509 (90.9)	
History of stroke, N (%)				
Yes	2 (1.8)	2 (1.2)	248 (2.4)	0.542
No	111 (98.2)	169 (98.8)	10,215 (97.6)	
History of HTN, N (%)				
Yes	63 (55.8)	49 (28.7)	2856 (27.3)	< 0.001
No	50 (44.2)	122 (71.3)	7607 (72.7)	

[1] Pure tone average hearing threshold across 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz, using best hearing ear (dB); data available for a subset of the population. HTN: hypertension.

Multivariable modeling of mental health outcomes. Combined results of the multivariate analyses for the above mental health outcomes are presented in Table 4 (details in Supplementary Tables A–C, available from the authors on request). In the first model, patients with PsA had an average of 1.62 more days of poor mental health in the last month compared to normal controls (95% CI 0.13–3.12, p = 0.033; Table 4). They were 1.6-times as likely to seek mental healthcare services (95% CI 0.94–2.79, p = 0.084), and had a 2.01-fold increased risk of depression compared to the normal controls (95% CI 1.15–3.52, p = 0.015). A similar trend, albeit to a lesser degree and not statistically significant, was observed in the intermediate control group (1.10 more days of poor mental health in the last month, CI –0.11 to 2.31, p = 0.074; 1.23-fold risk of visiting a mental healthcare professional, 95% CI 0.75–2.03, p = 0.419; and a 1.55-fold risk of depression, 95% CI 0.91–2.64, p = 0.110) when compared to normal controls.

Mediation analyses. SEM were developed to study the extent to which hearing impairment mediated the observed effect of PsA on mental health outcomes (Figure 1). SEM analysis revealed that hearing impairment mediated 5.0% of the effect of PsA on depression, 8.3% of the effect of PsA on days of poor mental health, and 6.5% of the effect of PsA on seeing a mental healthcare provider.

DISCUSSION

To our knowledge, this is the first study to evaluate the effect of PsA on hearing function in the US population. Prior studies have evaluated the relationship between PsA and audiovestibular manifestations either in a single institution[13,14] or on a population level in other countries[15]. The 1.1% preva-

Table 2. Multivariable adjusted ordinal logistic regression model of association between PsA and hearing impairment.

Variable	Coefficient	95% CI	p
Psoriatic arthritis			
No psoriasis	ref‡	ref‡	ref‡
Psoriasis without arthritis	0.96	0.64–1.45	0.8614
Psoriasis with arthritis	1.50	1.01–2.21	0.0431
Female	0.74	0.64–1.45	0.8614
Age[1]	1.45	1.01–2.21	0.0431
Race			
Non-Hispanic white	ref‡	ref‡	ref‡
Non-Hispanic black	0.43	0.37–0.50	< 0.0001
Hispanic	0.68	0.60–0.78	< 0.0001
Other	0.81	0.63–1.04	0.0974
Educational status			
Less than high school	ref‡	ref‡	ref‡
High school graduate	1.09	0.95–1.26	0.2344
Less than college	0.90	0.78–1.04	0.1411
College graduate	0.65	0.55–0.77	< 0.0001
Smoking	1.30	1.17–1.44	< 0.0001
Stroke	1.49	1.13–1.96	0.0044
Heart disease	1.75	1.45–2.13	< 0.0001
DM	1.02	0.86–1.20	0.8402
HTN	1.31	1.16–1.47	< 0.0001

‡ Reference group. [1] Decades. PsA: psoriatic arthritis; DM: diabetes mellitus; HTN: hypertension.

Table 3. Multivariable adjusted generalized linear model of association between PsA and pure tone hearing threshold (dB)†.

Variable	Coefficient	95% CI	p
PsA			
No psoriasis	ref‡	ref‡	ref‡
Psoriasis without arthritis	–2.89	–6.94 to 1.16	0.1619
Psoriasis with arthritis	4.79	0.65–8.92	0.0232
Female	–4.13	–6.94 to 1.16	0.1619
Age[1]	5.12	0.65–8.92	0.0232
Race			
Non-Hispanic white	ref‡	ref‡	ref‡
Non-Hispanic black	–3.25	–4.51 to –1.99	< 0.0001
Hispanic	–1.85	–3.19 to –0.51	0.0068
Other	–0.65	–3.08 to 1.77	0.5973
Educational status			
Less than high school	ref‡	ref‡	ref‡
High school graduate	–0.63	–1.98 to 0.73	0.3634
Less than college	–2.86	–4.16 to –1.56	< 0.0001
College graduate	–4.36	–5.81 to –2.91	< 0.0001
Smoking	0.30	–0.66 to 1.25	0.5429
Stroke	3.26	1.03–5.49	0.0041
Heart disease	2.15	0.51–3.78	0.0101
DM	0.21	–1.25 to 1.67	0.7756
HTN	–0.07	–1.18 to 1.04	0.8977

† Pure tone average hearing threshold across 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz, using best ear (dB), data available for a subset of the population (n = 2356; 21.9% of study population). ‡ Reference group. [1] Decades. PsA: psoriatic arthritis; DM: diabetes mellitus; HTN: hypertension.

lence of PsA in our study is consistent with prior US population estimates[1]. Overall, individuals with PsA were considerably less likely to rate their hearing as excellent and more likely to report difficulty in their hearing function, compared to both the intermediate and normal controls. Moreover, they had on average a PTA of 30.7 dB compared

Table 4. Multivariable adjusted linear and logistic regressions between PsA and multiple mental health outcomes.

Outcome Variable	Group	Coefficient	95% CI	p
Days of poor mental health in last month[2]	No psoriasis	ref[1]	ref[1]	ref[1]
	Psoriasis without arthritis	1.10	–0.11 to 2.31	0.0740
	Psoriasis with arthritis	1.62	0.13–3.12	0.0330
Outcome Variable	**Group**	**OR**	**95% CI**	**p**
Visit to mental healthcare professional in last year[3]	No psoriasis	ref[1]	ref[1]	ref[1]
	Psoriasis without arthritis	1.23	0.75–2.03	0.4185
	Psoriasis with arthritis	1.62	0.94–2.79	0.0839
Depression[3]	No psoriasis	ref[1]	ref[1]	ref[1]
	Psoriasis without arthritis	1.55	0.91–2.64	0.1100
	Psoriasis with arthritis	2.01	1.15–3.52	0.0148

[1] Reference group. [2] Multivariable generalized linear model, adjusted for age, sex, race, educational status, and medical comorbidities. [3] Multivariable logistic regression model, adjusted for age, sex, race, educational status, and medical comorbidities. PsA: psoriatic arthritis.

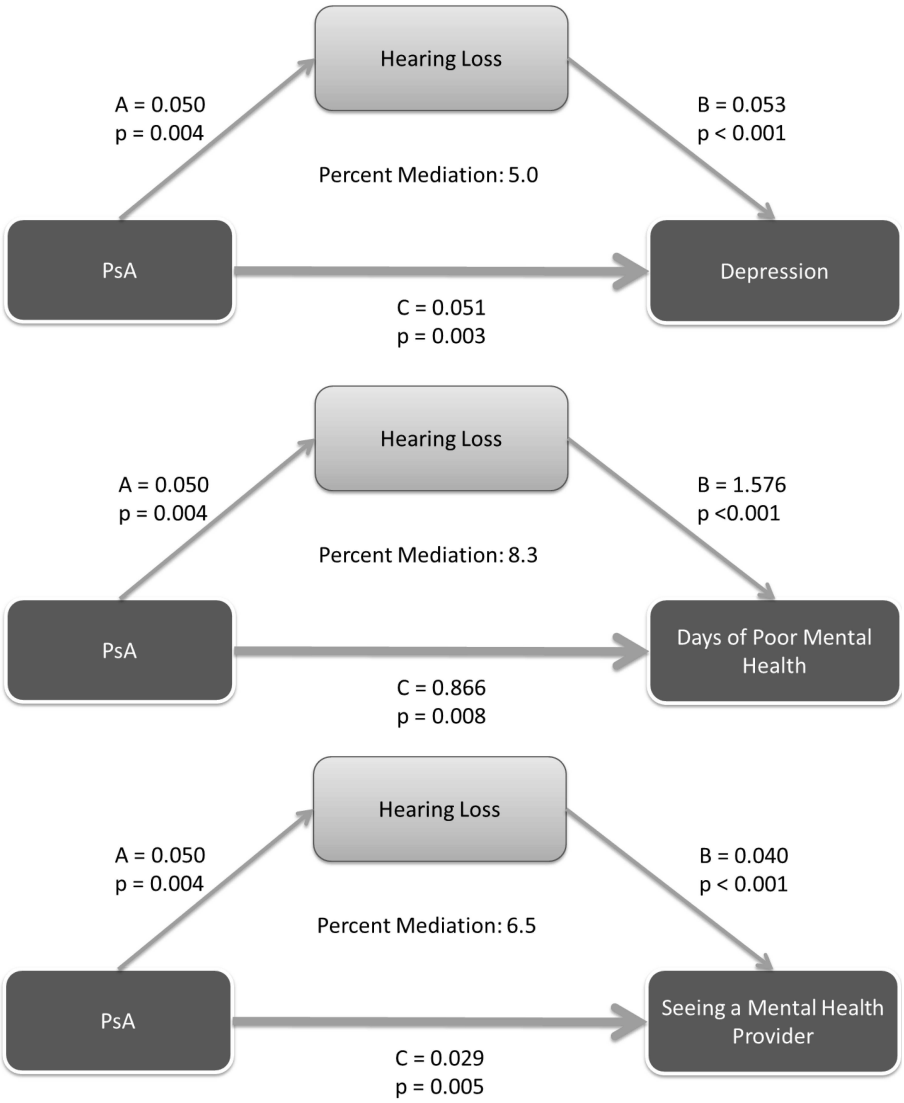

Figure 1. Structural equation models of hearing impairment as a mediator of the association between PsA and various psychiatric outcomes. The percent mediation is calculated based on the formula: (A*B)/((A*B)+C), where A*B is the indirect effect of PsA on psychiatric outcome mediated by hearing loss, C is the direct effect of PsA on psychiatric outcome, and (A*B)+C is the total effect of PsA on psychiatric outcome. Top: Hearing loss mediates 5.0% of the association between PsA and depression. Middle: Hearing loss mediates 8.3% of the association between PsA and days of poor mental health. Bottom: Hearing loss mediates 6.5% of the association between PsA and seeing a mental healthcare provider. PsA: psoriatic arthritis.

to 18.7 dB in normal controls, a difference between normal hearing and mild hearing loss. Even after adjusting for individual effects of medical comorbidities and demographic factors, we found that PsA was independently associated with hearing loss, regarding both qualitative perception and quantitative measurement of hearing impairment. Notably, the adjusted increase in PTA observed among individuals with PsA was about equivalent to 10 years of aging. While this study is the first, to our knowledge, to evaluate self-reported hearing function in patients with PsA, our PTA results are consistent with findings of 2 prior studies, which observed increased incidence of mild hearing loss in patients with PsA[13,14]. These studies found an increased prevalence of hearing loss in patients with PsA compared to controls across all frequencies tested (0.5–8 kHz), with greater severity of hearing loss at higher frequencies (4–8 kHz). Our analysis demonstrates a strong association of PsA with hearing loss at frequencies between 0.5 and 4 kHz. These findings have significant clinical implications because this frequency range is the most important for speech processing[23]. Hearing loss within this frequency range has also been reported in other systemic autoimmune diseases, including RA, AS, and SLE[24,25,26,27,28].

The mechanism of hearing impairment in PsA is not fully understood, but is likely caused by nonspecific autoimmune-mediated inflammation with resulting damage to the inner ear[3]. Indeed, among patients with autoimmune inner ear disease, 15–30% have an identified systemic autoimmune disorder[29]. A recent update to the classification of autoinflammatory diseases identifies psoriasis and PsA as mixed pattern diseases with MHC type class I associations and autoinflammatory components[30]. Specifically, psoriasis is a Th1 and Th17 cell-driven systemic autoimmune disorder with overproduction of proinflammatory cytokines such as tumor necrosis factor-α (TNF-α)[31]. TNF-α has been shown to mediate damage to the inner ear, which can result in sensorineural hearing loss. *In vitro*, excessive levels of TNF-α have been shown to induce cochlear cell death[32,33]; in various animal studies, high levels of TNF-α led to leukocyte infiltration in the inner ear and loss or malformation of stereocilia of outer hair cells[34,35,36]. One small clinical study evaluating blood levels of inflammatory cytokines in patients with idiopathic sudden sensorineural hearing loss found that those who did not respond to combined drug treatment had significantly higher levels of serum TNF-α[37].

While most of the literature on the etiology of hearing loss in PsA has focused on inner ear damage, few have considered damage to the middle ear and the resulting conductive hearing loss. Studies of hearing impairment in RA suggest that the joint articulation between middle ear bones may be subject to synovial inflammation similar to other articulations in the body[4,38]. Thus, both conductive and sensorineural etiologies of hearing loss have been demonstrated in association with RA[5,6,7,25,39]. One such study found that patients with RA showed significantly higher air-bone conduction gaps than normal controls, and that stapedectomy procedures reduced the air-bone conduction gap in all 4 patients with RA selected for intervention[7]. Other studies have suggested either increased stiffness[6,39] or laxity of the middle ear transducer mechanism[25,40] as possible etiologies for conductive hearing loss in patients with RA. Given that PsA is also an inflammatory arthritis, we posit that the hearing loss seen in PsA is both conductive and sensorineural. The presence of conductive hearing loss is further strengthened by observations of TNF-mediated otosclerotic damage to the middle ear[41]. However, the relative contributions of each type of etiology to the overall degree of hearing loss observed in PsA is to date unclear.

Individuals with psoriasis have been found to be at increased risk for depression and suicidal ideation[42,43]. The link between hearing loss and depression has also been well established across the entire age spectrum[16,17,18,19]. Moreover, damage to other parts of the ear, such as the vestibular apparatus, has been linked to depression, cognitive decline, and balance problems[44,45]. For these reasons, we investigated whether the hearing impairment associated with PsA resulted in clinically meaningful impairment of mental well-being. Our findings of considerable psychiatric morbidity are consistent with previous findings of increased depression among individuals with PsA, as evidenced by increased days of self-rated poor mental health, a 1.6-fold increase in mental healthcare visits, and a 2.0-fold increased risk of depression compared to those without PsA[42,43]. Here, we add to this body of knowledge by showing that the hearing loss observed among patients with PsA partially mediates the association with poorer psychiatric outcomes demonstrated in the mediation analyses.

Interestingly, although the PsA group had a greater burden of hearing impairment than nonpsoriatic controls, the overall burden of hearing impairment and downstream psychiatric comorbidities among the "intermediate control" population (psoriatics without arthritis) was not significantly different from those without psoriasis. This is likely due to a difference in psoriasis severity between the PsA and intermediate control groups, with the former being a marker of greater disease severity[46,47,48]. Further, individuals with PsA have been shown to carry a higher burden of soluble biomarkers and inflammatory cytokines[49], which may contribute to their greater incidence of hearing impairment.

There are several limitations to our study. First, cross-sectional data analysis allows for correlational rather than causal inferences. Additionally, true mediation effects from SEM analysis cannot be determined from cross-sectional analysis, because mediation suggests a temporal direction. Thus, the SEM analysis in our study should be viewed as hypothesis-generating. Second, we were unable to evaluate for the presence of PsA using formal diagnostic criteria given

the limitations of the NHANES database, and instead defined PsA as a coincident diagnosis of psoriasis and arthritis. This definition may have resulted in the misclassification of patients with coincident diagnosis of psoriasis and osteoarthritis (OA) as PsA. However, the prevalence of PsA found in our study is aligned with estimates of the prevalence of PsA reported in literature[1], suggesting that this did not materially affect our analysis. In addition, the limited evidence of the direct effect of OA on hearing impairment suggests that the misclassification of patients with incident psoriasis and OA as PsA would likely result in a more conservative estimation of hearing impairment in PsA[50]. Third, we were unable to control for effects of systemic antiinflammatory therapy among the PsA patient population, given that this information was not included in the NHANES database, which likely conservatively biases our estimates and underestimates the true effect of PsA on hearing impairment and psychiatric outcomes. Fourth, a degree of residual confounding likely remains present in our analyses despite explicitly adjusting for all available confounders in our multivariable models. Additionally, there are several confounders, such as family history of hearing impairment, environmental noise exposure, and medication side effects, that are not collected by NHANES and could not be explicitly included in our analyses. However, there is no evidence to suggest that a greater degree of environmental or iatrogenic ototoxic exposure exists among patients with PsA than the general population.

These results call for a greater awareness of potential hearing impairment and downstream psychiatric comorbidities when examining patients with PsA. This could be accomplished through asking about both hearing function and psychiatric symptoms during review of systems, incorporating PHQ-9 surveys or other assessments of mental health into the clinical encounter, and timely referral for audiometric testing and intervention. Future research evaluating the effect of systemic therapy on the above outcomes and investigating the etiology of hearing loss in PsA would be helpful in identifying the most appropriate therapeutic interventions for the treatment of hearing impairment in this population.

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