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ORIGINAL RESEARCH

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Cerumen impaction: Prevalence and associated factors in the United States population

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Abstract

Objective: To examine the prevalence of cerumen impaction in a nationally representative sample of the US population and the association of cerumen impaction with sociodemographic factors, hearing loss, and tinnitus.

Methods: The cohort included 14,230 individuals aged ≥12 years who completed otoscopy and audiometry in NHANES (2005–2016). Cerumen impaction (partial/complete) was determined by otoscopy. Hearing level was defined by speech-frequency pure-tone average (PTA). Multivariable regression analysis was performed to identify factors associated with cerumen impaction.

Results: The prevalence of any cerumen impaction was 18.6% [95% CI: 17.3%–19.9%] among individuals ≥12 years and 32.4% [29.9%–35.1%] among those ≥70 years. The prevalence of bilateral partial and complete cerumen impaction was 6.3% [5.6%–7.1%] and 1.2% [1.0%–1.9%], respectively. Any cerumen impaction was associated with male sex (OR 1.77 [1.5–2.1]), identifying as Black race (vs. Caucasian, OR: 1.78 [1.5–2.9]), lower level of education (OR: 0.84 [0.71–0.98]), and older age (OR: 1.02 [1.01–1.03]). After adjusting for sociodemographic and clinical factors, complete impaction was associated with increased PTA (right ear: $\beta = 4.1$ dB [2.4–5.8 dB], left ear: $\beta = 1.9$ dB [0.46–3.4 dB]), but not with tinnitus.

Conclusions: Cerumen impaction is highly prevalent in the US population, especially among older adults, and has disproportionate sociodemographic impacts. Complete impaction is associated with a small, statistically significant elevation in PTA, but there is no association with tinnitus. These findings emphasize the need to implement and disseminate best practices for ear hygiene and cerumen management broadly and equitably.

Level of Evidence: 2B

KEYWORDS

CDC, cerumen, cerumen impaction, earwax, National Health and nutrition examination survey, NHANES, otology, prevalence

1 | INTRODUCTION

Cerumen is a universal part of the human experience. It is a naturally occurring substance formed in the cartilaginous portion of the external auditory canal (EAC) that serves to lubricate, clean, and protect the ear.[1] Any impairment in the innate self-cleaning mechanisms in the EAC can lead to excessive accumulation of cerumen, termed cerumen impaction, which is thought to cause aural fullness, pain, itching, and hearing loss.[2,3] The treatment of cerumen impaction is commonplace to many otolaryngology and primary care practices and represents a considerable healthcare burden. Annually, cerumen accounts for 12 million medical office visits[4] and cerumen removal is the third most billed procedure by otolaryngologists.[5] To guide evidence-based practice, the AAO-HNSF published a Clinical Practice Guideline (CPG) on cerumen impaction in 2008, with a subsequent update in 2017.[6] Reflecting the ongoing relevance of cerumen and cerumen impaction, the recommendations and resources provided in the CPG are the second most downloaded products from AAO-HNSF, with over 130,000 views since 2016.[1]

Despite evidence of significant healthcare utilization, few have explored the epidemiology of cerumen impaction and its key associations. A report based on a national sample of US adults from the National Health and Nutrition Examination Survey (NHANES) in 1999–2002 demonstrated the prevalence of cerumen impaction at 10%–12%. However, this report included only adults aged 20–69 years without adolescent or older adult populations. While prior studies have identified several factors associated with a higher burden of cerumen such as older age and individuals with intellectual disabilities, there is currently limited knowledge regarding other demographic or clinical factors that may play a role.[7–9] Similarly, despite hearing loss and tinnitus being frequently cited symptoms of cerumen impaction, the supporting data is not as established. Investigations into the audiometric impact of cerumen have demonstrated an elevation in pure tone thresholds with increasing levels of EAC occlusion,[7] but the extent of this effect remains disputed as identical levels of occlusion have resulted in anywhere from a 5 to 40 dB hearing loss.[10,11] The relationship between tinnitus and cerumen is even more ambiguous, with no primary data to support an association.[12,13] Greater clarification of these relationships can guide the clinical work-up of patients who present with these symptoms.

In this study, we aimed to estimate the prevalence of cerumen impaction and identify associated demographic and clinical factors in a national sample of US population aged 12 years and older. Additionally, to inform clinical practice and counseling, we aimed to quantify the association of cerumen impaction with tinnitus and audiometrically measured hearing loss.

2 | METHODS

2.1 | Study population

The study cohort was comprised of 14,230 participants in the NHANES aged 12 years and older. NHANES is a comprehensive collection of questionnaires and physical examinations designed to investigate the health status of US adults and children. Data were combined from five cycles, years 2005 through 2016 (excluding cycle 2013–2014 with no available audiometry data). Study of the de-identified publicly available dataset was deemed exempt by the University of Minnesota Institutional Review Board (#00015174).

2.2 | Primary outcome: Cerumen impaction

Prior to audiometric assessment, trained NHANES examiners performed bilateral otoscopic examination to assess for physical abnormalities of each ear canal (e.g., collapsing canal, cerumen) or tympanic membrane (e.g., perforation).[14] Excessive cerumen, hereby referred to as partial impaction, was defined as significant accumulation of cerumen such that less than half of the tympanic membrane can be seen as it was partially (but not completely) blocked by cerumen. Complete cerumen impaction was defined as accumulation of cerumen blocking any visualization of the tympanic membrane. These definitions are supported by the NHANES 2018 Policy and Procedures manual which gives photo examples of each definition to guide reviewers.[14] The main outcome "any cerumen impaction" was defined as having partial or complete cerumen impaction in either ear. The reported prevalence values refer to point prevalence or the proportion at one point in time.

2.3 | Covariates

As part of an otologic symptom questionnaire, the presence of tinnitus was assessed with the question "in the past 12 months have you been bothered by ringing, roaring, or buzzing in your ears or head that lasts for five minutes or more?" Air conduction audiometry assessments were conducted based on established NHANES protocols.[14] Ear-specific (left and right) speech frequency pure tone average (PTA) was calculated from the thresholds at 500, 1000, 2000, and 4000 Hz.

Covariates of interest were selected based on relevance to social determinants of health and otologic health. Covariates included sex (binary); race/ethnicity (grouped as non-Hispanic white, non-Hispanic Black, Hispanic (Mexican American or other Hispanic), or Asian); education level (<12th grade, high school graduate, some college or more); household income (<$20,000; $20,000–$44,999; $45,000–$74,999; ≥$75,000/unknown); and insurance (none; private health plan; Medicare; Medicaid; unknown). Medical history variables included diabetes (DM) (self-reported diagnosis and/or current use of insulin or other diabetic medications), hypertension (HTN) (self-reported diagnosis and/or current use of anti-hypertensive medications), cardiovascular disease (congestive heart failure, coronary artery disease, angina pectoris, or myocardial infarction), stroke (self-reported), smoking status (current, former, and never), and hearing aid use (self-reported). Body mass index (BMI) was categorized into the five World Health Organization (WHO) weight classes (underweight BMI <18.5 kg/m^2; normal weight 18.5–24.9 kg/m^2; overweight 25–29.9 kg/m^2; obesity class I 30–34.9 kg/m^2; obesity class II 35–

39.9 kg/m^2; obesity class III >40 kg/m^2).[14,15] History of occupational noise exposure, recreational noise exposure, and hearing protection use were included in multivariable regression models for outcomes assessing hearing loss and tinnitus. These variables were defined as binary variables as in prior study.[16,17]

A history of hearing protection use was missing in a subset of the cohort ($n = 1890$, 13.3%). Additional analysis was performed to investigate sociodemographic factors associated with the missingness of hearing protection use. This analysis found hearing protection use data were more likely to be missing among younger, female (vs. male), Asian (vs. White) participants, and participants with higher education and private insurance (vs. Medicare).

Sensitivity analysis showed that there were no significant changes in results or effect size with and without hearing protection use as a covariate.

2.4 | Statistical analysis

The complete dataset underwent sample weighting according to the established National Center for Health Statistics guidelines to yield results generalizable to the US population. Unweighted data are exclusively reported in Table 1 providing descriptive statistics for the study cohort. Pearson χ^2 test and Student *t*-test were used to compare baseline characteristics for categorical and continuous variables, respectively. Univariable and multivariable logistic regression analyses were used to identify factors associated with cerumen impaction. Multivariable regression models adjusted for age, sex, race/ethnicity, education, income, insurance, smoking status, BMI, DM, and HTN. In multivariable regression analysis assessing the association of cerumen impaction with hearing loss and tinnitus, occupational/recreational noise exposure, and hearing protection were added as covariates when they were significantly associated with the outcomes of hearing loss and tinnitus. Collinearity diagnostics were performed for all explanatory variables, using a cutoff variance inflation factor (VIF); a measure of the amount of multicollinearity in regression analysis of >2.5 as problematic correlation among variables a priori. A history of stroke and cardiovascular disease were excluded from the analysis due to their VIF values >2.5. Subsequent collinearity diagnostics performed after exclusion of stroke and cardiovascular disease history showed no evidence of collinearity among covariates. Linear regression analysis was used to examine the association between cerumen impaction and PTA, separated by ears. Logistic regression analysis was used to assess the association between various levels of cerumen impaction (unilateral partial, bilateral partial, unilateral complete, and bilateral complete impaction) and tinnitus. Statistical significance was set at $p < .05$, two-tailed. Analyses were conducted with Stata (version 16.1; StataCorp, College Station, TX).

3 | RESULTS

Unweighted cohort characteristics are presented in Table 1. After accounting for sampling weights,[15] the overall US prevalence of any cerumen impaction was estimated to be 18.6% (95% CI: 17.4–19.9) for those ≥12 years and 32.4% (29.9%–35.1%) for older adults (≥ 70 years). Figure 1. summarizes the prevalence of partial and complete impaction for individual and bilateral ears. In all analyzed subgroups, the prevalence of partial cerumen impaction was higher than that of complete cerumen impaction for both unilateral and bilateral states. There was no significant difference between right and left ears for either level of impaction.

Factors associated with cerumen impaction are presented in Table 2. In univariable analyses, any cerumen impaction was significantly associated with older age, male sex, Black race, lower education, lower income, having Medicare/Medicaid insurance, and history of smoking, DM, and HTN. In the multivariable model, factors independently associated with any cerumen impaction were age, sex, race, education, and insurance status. Older age was associated with higher odds of cerumen impaction, with a 20% increased likelihood of impaction per decade of age (OR: 1.02 [1.01–1.03]). Male participants were 1.8 times more likely to have cerumen impaction than female participants (OR 1.77 [1.53–2.05]). Black participants were 1.8 times more likely to have cerumen impaction than white participants (OR: 1.78 [1.53–2.89]). Participants with less than a high school education were 1.2 times more likely to have cerumen impaction than participants with some college education or more (OR 1.16 [1.02–1.29]). The participants enrolled in Medicare and Medicaid insurance were 1.4 times (OR: 1.42 [1.11–1.82]) and 1.3 times (OR: 1.34 [1.09–1.64]) more likely to have cerumen impaction than counterparts with private insurance. Medical factors, including DM and HTN, were not associated with cerumen impaction in the multivariable model. Hearing aid use was not associated with cerumen impaction in univariable or multivariable models.

In multivariable analysis, individuals with complete impaction were found to have 4.10 dB (2.37–5.83) higher PTA in the right ear and 1.93 dB (0.46–3.38) higher PTA in the left ear compared to individuals with no impaction (Table 3). When analyzed against the PTA in no impaction states, partial cerumen impaction did not significantly affect PTA (Figure 2.). Clinical significance of the elevated PTA in this range is unclear. In multivariable analyses to assess the relationship between cerumen impaction and tinnitus (Table 4), neither unilateral nor bilateral partial or complete cerumen impaction were associated with the presence of tinnitus.

4 | DISCUSSION

In a nationally representative sample of the US population, we observed an 18.6% prevalence of any cerumen impaction among individuals ≥12 years and 32.4% prevalence among adults ≥70 years. Partial impaction was approximately five times more common than complete impaction, in both unilateral and bilateral conditions, with no significant difference between ears. Cerumen impaction was significantly associated with older age, male sex, Black race, public insurance, and lower education, suggesting a link between cerumen impaction and social determinants of health.

Our study demonstrated high prevalence of cerumen impaction in the United States, especially among older adults. The estimated

TABLE 1 Unweighted sample characteristics by Cerumen impaction in US adults ($N = 14,230$).

		Any cerumen impaction		
	Overall $N = 14,230$	Yes	No	*p*-value
Age, year, average (SD)	39 (21.8)	43.7 (23.8)	37.8 (21.0)	<.001
Sex, male, *n* (%)	7150 (50.3)	1729 (57.3)	5421 (48.4)	
Race, *n* (%)				<.001
White	5104 (35.9)	1050 (34.8)	4054 (36.2)	
Black	3510 (24.7)	945 (31.3)	2565 (22.9)	
Hispanic	3981 (28.0)	753 (24.9)	3228 (28.8)	
Asian	1074 (7.5)	166 (5.5)	908 (8.1)	
Other	561 (3.9)	106 (3.5)	455 (4.0)	
Education, *n* (%)				<.001
Less than high school	2275 (16.0)	585 (19.4)	1690 (15.1)	
High school graduate	2178 (15.3)	542 (17.9)	1636 (14.6)	
Some college or more	5, 372 (37.7)	1056 (35.0)	4, 316 (38.5)	
Refused/do not know	4405 (31.0)	837 (27.7)	3, 568 (31.8)	
Income, *n* (%)				<.001
<20k	3043 (21.4)	722 (23.9)	2321 (20.7)	
20–44.9k	4036 (28.3)	915 (30.3)	3121 (27.8)	
45–74.9k	2645 (18.6)	550 (18.2)	2095 (18.7)	
>75k	3400 (23.9)	612 (20.3)	2788 (24.9)	
Refused/do not know/unsure	1106 (7.8)	221 (7.3)	885 (7.9)	
Insurance, *n* (%)				<.001
None	2764 (19.4)	528 (17.5)	2236 (19.9)	
Private	6051 (42.5)	1089 (36.0)	4962 (44.3)	
Medicare	2062 (14.5)	655 (21.7)	1407 (12.6)	
Medicaid	1850 (13.0)	461 (15.3)	1389 (12.4)	
Unknown	1503 (10.6)	287 (9.5)	1216 (10.8)	
Smoking, *n* (%)				<.001
Never	5557 (39.1)	1157 (38.3)	4400 (39.3)	
Former	2377 (16.7)	581 (19.2)	1796 (16.0)	
Current	1884 (13.2)	445 (14.8)	1439 (12.8)	
Unknown	4412 (31.0)	837 (27.7)	3575 (31.9)	
BMI, *n* (avg; SD)				.405
Normal	5021 (35.3)	1, 045 (34.6)	3, 976 (35.5)	
Underweight	726 (5.1)	149 (4.9)	577 (5.15)	
Overweight	3959 (27.8)	836 (27.7)	3123 (27.9)	
Obesity class I	2438 (17.1)	536 (17.8)	1902 (17.0)	
Obesity class II	1117 (7.9)	247 (8.2)	870 (7.8)	
Obesity class III	841 (5.9)	171 (5.7)	670 (6.0)	
Diabetes, *n* (%)				<.001
Non-diabetic	12,843 (90.3)	2633 (87.2)	10,210 (91.1)	
Diabetic	1387 (9.7)	387 (12.8)	1000 (8.9)	
Hypertension, *n* (%)				<.001
No	8602 (60.5)	1704 (56.4)	6898 (61.5)	
Yes	3417 (24.0)	882 (29.2)	2535 (22.6)	
Unknown	2211 (15.5)	434 (14.4)	1777 (15.9)	

TABLE 1 (Continued)

	Overall $N = 14{,}230$	Any cerumen impaction		*p*-value
		Yes	No	
Cardiovascular disease, *n* (%)				<.001
No	9012 (63.3)	1896 (62.8)	7116 (63.5)	
Yes	814 (5.7)	287 (9.5)	527 (4.7)	
Unknown	4404 (31.0)	837 (27.7)	3567 (31.8)	
Stroke, *n* (%)				<.001
No	9449 (66.4)	2062 (68.3)	7387 (65.9)	
Yes	369 (2.6)	119 (3.9)	250 (2.2)	
Unknown	4412 (31.0)	839 (27.8)	3573 (31.9)	
Hearing aid use, *n* (%)				.081
No	14,111 (99.2)	2987 (98.9)	11,124 (99.2)	
Yes	119 (0.8)	33 (1.1)	86 (0.8)	

Note: Any cerumen impaction includes participants classified as excessive impaction or complete impaction.
Abbreviations: BMI, body mass index; SD, standard deviation.

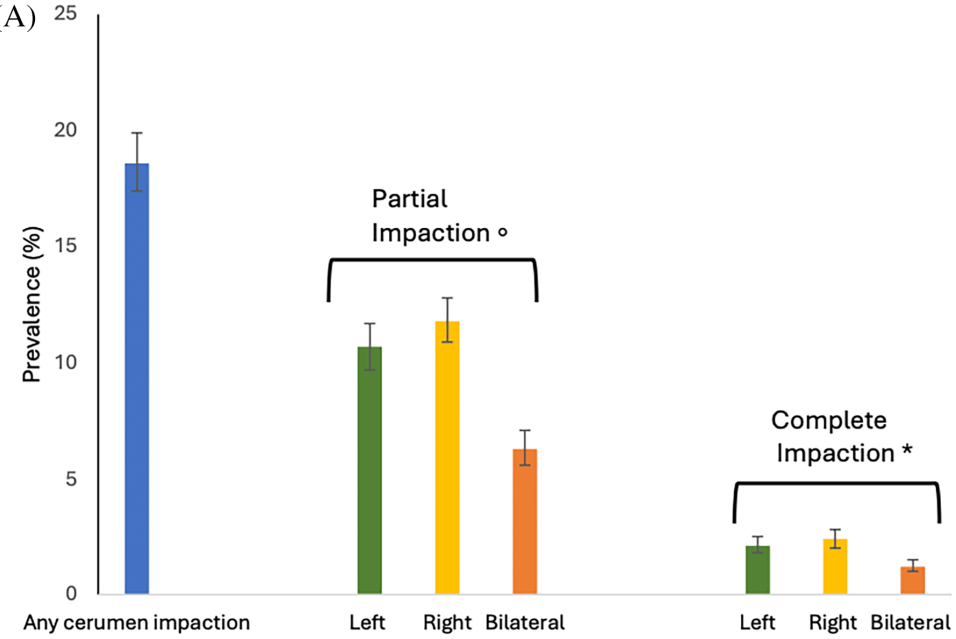
prevalence was greater than reports from prior studies based on communities of specific regions in the United States ranging from 5% to 8%.[7,12] One prior study based on analysis of NHANES cohorts from 1999 to 2002 reported a 10%–12% prevalence. The prevalence difference between the study of prior NHANES cohorts and the current study is likely due to the addition of older adults in our cohort who were found to have significantly higher likelihood of any cerumen impaction. The prevalence of cerumen impaction in our cohort limiting age to 20–69 years as in the prior study showed no substantial changes in prevalence in this age group over time. Older adults tend to have higher prevalence of cerumen impaction due to multiple factors such as changes in ear canal shape, increased hair growth, and decreased self-cleaning ability of the ear. Addressing cerumen impaction, especially among older adults has clinical implications for optimizing their hearing thresholds and reducing associated symptoms.[6,8] Routine monitoring and appropriate cerumen cleaning should be offered when necessary.

We observed several sociodemographic patterns regarding cerumen impaction. Within our dataset, males were twice as likely to have cerumen impaction as compared to females. This is consistent with the findings of community-based studies and aligns with the theory that the larger, coarser hair found at the external auditory meatus in men impairs the egress of wax.[18,19] Similar changes to the meatal hair also occur with aging as above.[3] Our findings reinforce the downstream effects of these physiologic changes, as each decade of age corresponded with a 20% increased likelihood of cerumen impaction. Analysis of additional demographic factors revealed significant differences in cerumen impaction by race, education, and insurance status. The increased likelihood of cerumen impaction observed in Black participants is likely multifactorial. The genetic origin of cerumen phenotype is well-established, with the wet (vs. dry) phenotype more frequently observed in those of African ancestry.[20] Presumably, the force required for canal skin to extrude wet cerumen with its characteristic "sticky" quality is greater than the force required for the "flaky" dry wax,[21] increasing risk of cerumen impaction. There may also be different culturally influenced ear-cleaning practices.[22]

Patterns of healthcare engagement may underpin some of our observations. Compared to Caucasians, Black Americans have lower rates of ambulatory care usage and lower overall healthcare expenditure.[23] A similar pattern is seen in Americans of lower socioeconomic status (SES), as individuals of low SES use substantially less ambulatory and preventative care than high-SES patients.[22–24] These patterns of healthcare utilization may partially account for the increased likelihood of cerumen impaction in participants with lesser education or those enrolled in public insurance (Medicare or Medicaid), both independent markers of lower SES. As seen in other medical conditions, reduced engagement in ambulatory services limits health literacy, preventative care, and treatment of precursor conditions (e.g., excessive cerumen).[22–24] The identification of higher-risk populations can guide future education efforts and ultimately improve health equity and access to care for cerumen impaction. Fortunately, there are over-the-counter and low-cost treatment options for cerumen that offer safe and realistic tools for at-home management, eliminating many of the barriers to care faced with other health conditions. There should be efforts to increase the general knowledge of and recommendations regarding such options. In conjunction with a CPG, the AAO-HNS has published plain language guidelines for cerumen impaction which could be purposefully disseminated among populations and regions with a high density of at-risk persons.[1] Interestingly, there was no significant association between hearing aid use and cerumen impaction in this cohort. Hearing aid use itself may increase the likelihood of cerumen dislocation into the medial canal by causing canal blockage. On the other hand, hearing aid users are likely routinely seen by hearing care professionals and may have their cerumen debrided more often. Given the limited data in this study on hearing aid use and debridement pattern, we are unable to make a conclusion on the impact of hearing aid use on cerumen impaction.

Our findings suggest that complete cerumen impaction can increase hearing thresholds. The clinical significance of increased

(A)



(B)

	Prevalence of Cerumen Impaction (%) [95% CI]		
	Age ≥ 12 years	Age ≥ 20 years	Age ≥ 65 years
Any cerumen impaction	18.6 [17.3-19.9]	19.1 [17.7-20.6]	31.0 [28.3-33.8]
Partial Impaction			
Left	10.7 [9.7-11.7]	10.7 [9.6-11.9]	17.2 [14.9-19.8]
Right	11.8 [10.9-12.8]	12.0 [10.9-13.3]	19.8 [17.7-22.1]
Bilateral	6.3 [5.6-7.1]	6.4 [5.5-7.3]	9.7 [8.0-11.8]
Complete Impaction			
Left	2.1 [1.8-2.5]	2.3 [1.9-2.7]	2.8 [2.0-3.8]
Right	2.4 [2.0-2.8]	2.6 [2.2-3.1]	3.4 [2.5-4.7]
Bilateral	1.2 [1.0-1.5]	1.3 [1.0-1.7]	1.1 [0.7-1.7]

Any cerumen impaction includes diagnosis of both partial and complete impaction.
∘ cerumen obstructing >50% of view of tympanic membrane on otoscopy.
* cerumen completely blocking view of tympanic membrane on otoscopy.

FIGURE 1 (A) and (B) Prevalence of cerumen impaction in the United States. Any cerumen impaction includes diagnosis of both partial and complete impaction. (∘cerumen obstructing >50% of view of tympanic membrane on otoscopy. *cerumen completely blocking view of tympanic membrane on otoscopy.)

hearing thresholds in range of 1.93–4.10 dB is unclear. Prior studies have observed sound intensity difference as low as 4 dB may be noticeable to individuals with normal hearing.[25,26] Partial impaction had no significant impact on hearing thresholds, aligning with prior studies in which hearing changes occurred when cerumen involved at least 80% of the cross-sectional area of the ear canal.[27] Contrary to what is frequently reported by patients and in non-primary sourced literature, after adjusting for relevant factors there was no association between the presence of tinnitus and cerumen impaction. This finding emphasizes the importance of clinical investigation of the cause of

TABLE 2 Univariable and multivariable logistic regression analyses examining factors associated with any cerumen impaction.

	Univariable		Multivariable	
	Odds ratio (95% CI)	*p*-value	Odds ratio (95% CI)[a]	*p*-value
Age	1.02 (1.01–1.02)**	<.001	1.02 (1.01–1.02)	<.001
Sex[b]	0.60 (0.53–0.69)**	<.001	0.57 (0.49–0.65)	<.001
Race				
White	Ref		Ref	
Black	1.65 (1.43–1.89)**	<.001	1.79 (1.53–2.09)**	<.001
Hispanic	1.01 (0.88–1.1.6)	.835	1.15 (0.98–1.34)	.085
Asian	0.81 (0.66–0.98)*	.034	0.94 (0.76–1.17)	.590
Others	0.99 (0.76–1.30)	.938	1.04 (0.77–1.41)	.786
Education				
Less than high school	Ref		Ref	
High school graduate	0.87 (0.69–1.09)	.222	0.97 (0.76–1.24)	.797
Some college or more	0.65 (0.56–0.75)**	<.001	0.84 (0.72–0.98)*	.032
Refused/do not know	0.62 (0.52–0.74)**	<.001	0.53 (0.12–2.41)	.408
Income				
<20k	Ref		Ref	
20–44.9k	0.94 (0.78–1.14)	.551	1.05 (0.85–1.31)	.628
45–74.9k	0.84 (0.66–1.05)	.129	1.02 (0.78–1.33)	.892
>75k	0.70 (0.59–0.84)**	<.001	0.97 (0.77–1.21)	.774
Refused/do not know/unsure	0.87 (0.67–1.12)	.270	0.97 (0.76–1.24)	.819
Insurance				
Private	Ref		Ref	
None	0.90 (0.76–1.07)	.239	1.01 (0.84–1.22)	.927
Medicare	2.08 (1.73–2.50)**	<.001	1.40 (1.10–1.78)**	.007
Medicaid	1.42 (1.19–1.70)**	<.001	1.33 (1.08–1.63)**	.008
Unknown	0.98 (0.79–1.20)	.811	0.99 (0.81–1.20)	.889
Smoking				
Never	Ref		0.94 (0.79–1.13)	.528
Current	1.21 (0.99–1.47)	.066	0.31 (0.04–2.61)	.277
Former	1.24 (1.07–1.45)**	.006	1.06 (0.88–1.29)	.541
BMI				
Normal	Ref		1.22 (0.89–1.68)	.215
Underweight	1.10 (0.83–1.48)	.471	0.88 (0.72–1.09)	.238
Overweight	1.03 (0.85–1.26)	.726	0.88 (0.74–1.04)	.142
Obesity class I	1.05 (0.90–1.24)	.528	0.90 (0.70–1.14)	.366
Obesity class II	1.02 (0.81–1.29)	.863	0.92 (0.69–1.23)	.567
Obesity class III	1.01 (0.77–1.32)	.961	1.28 (0.74–2.21)	.375
Diabetes	1.54 (1.31–1.81)**	<.001	1.07 (0.88–1.31)	.480
Hypertension	1.15 (1.06–1.24)**	<.001	0.97 (0.80–1.18)	.771
Cardiovascular disease	0.98 (0.91–1.05)	.533	1.16 (0.93–1.31)	.189
Stroke	0.94 (0.87–1.01)	.095	1.03 (0.81–1.31)	.789
Hearing aid use	1.41 (0.78–2.54)	.257	1.06 (0.59–1.92)	.844

Note: Crude unadjusted model.

Abbreviations: CI, confidence interval; Ref, reference.

[a]Multivariable regression analysis was adjusted for associated variables (age, sex, race, education, income, insurance, smoking status, BMI, diabetes mellitus, hypertension, cardiovascular disease, stroke history).

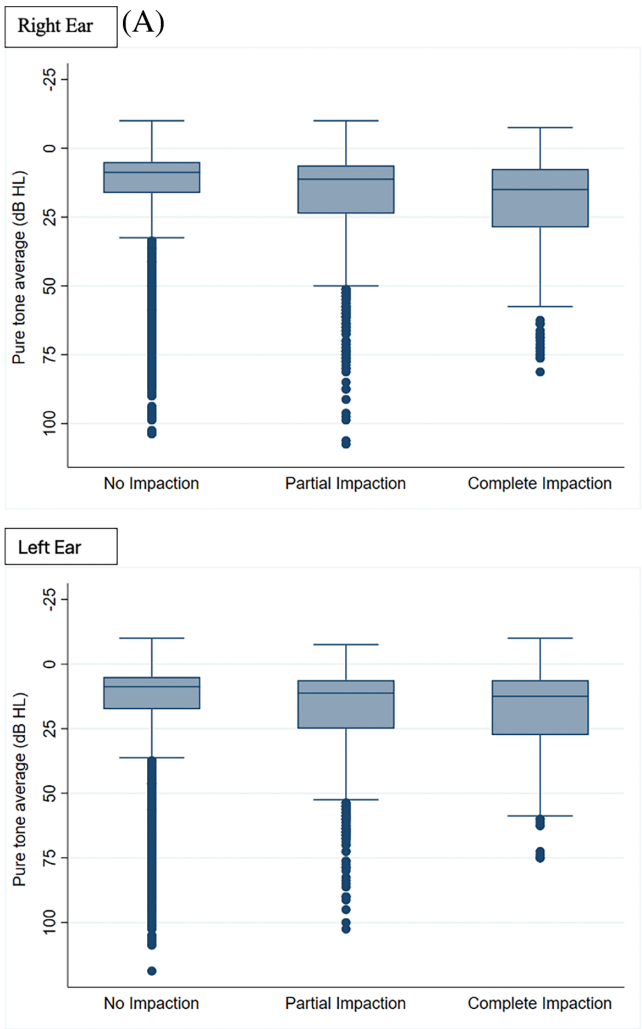
[b]Male as a reference group.

*$p < .05$; **$p < .01$.

TABLE 3 Multivariable linear regression analysis between PTA[a] and cerumen impaction.[b]

	Right		Left	
Cerumen impaction	**Beta-coefficient (95% CI)**	***p*-value**	**Beta-coefficient (95% CI)**	***p*-value**
Partial impaction	0.94 (−0.08 to 1.96)	.071	0.21 (−0.72 to 1.15)	.653
Complete impaction	4.34 (2.65–6.03)**	<.001	2.73 (0.66–4.79)*	.010

[a]PTA = pure tone average, calculated from thresholds at 500, 1000, 2000, and 4000 Hz.
[b]Model adjusted by all relevant variables (age, gender, race, education, income, insurance, smoking status, BMI, diabetes mellitus, hypertension, cardiovascular disease, stroke history).
*$p < .05$; **$p < .01$.



(B)

	Left ear-PTA	std dev	Right ear- PTA	std dev
No impaction	13.31	13.97	12.95	12.38
Partial impaction	17.44	16.48	17.11	16.78
Complete impaction	18.85	17.05	20.75	18.2

FIGURE 2 (A) and (B). Box plot of right and left ear PTA at different levels of impaction.

tinnitus, particularly when it is bothersome or asymmetric, rather than concluding that observed cerumen is the source.[28]

There are limitations to our study. As a cross-sectional study, we were unable to examine temporal relationships between cerumen impaction and variables of interest. The definition of cerumen impaction used in prior literature varies, thus limiting precise comparisons. In attempts to overcome this, cerumen impaction was exclusively based on the degree of tympanic membrane view obstruction. Cerumen impaction was assessed using otoscopy by non-clinicians and microscopic exams were unavailable. The detailed examination of cerumen (e.g., depth, location) was not possible in this study. While standardized protocols were employed as described in the procedure protocol ratings of cerumen impaction as partial or complete may be dependent on the rater.[14] The presence or absence of symptoms related to excessive cerumen was not considered in our diagnostic criteria (e.g., otalgia, aural fullness, decreased hearing). Thus, our prevalence data directly reflects the number of Americans afflicted with cerumen impaction. From our clinical experience, we suspect that a significant number of individuals seek medical care for such symptoms but have otoscopy findings that would not qualify as cerumen impaction (>50% obstruction of TM view). As such, our 18.6% prevalence of cerumen impaction likely underestimates the percentage of Americans who may utilize healthcare resources for cerumen disimpaction.

As a result of sourcing our data from a national database we can control for some but not all confounding variables. Objective information regarding the presence of ear canal pathologies (e.g., canal size, canal osteoma, and exostoses) that may contribute to cerumen impaction is not available. Additionally, given the paucity of published literature investigating environmental and physiologic factors related to cerumen burden, our analysis may have excluded confounding variables that are currently unknown. We also could not control for all variables associated with hearing loss or tinnitus due to limited availability (e.g., exposure to ototoxic medication or chemicals, surgical-associated hearing loss, and medical history causing hearing loss). We were able to incorporate hearing protection use and loud noise exposure (both occupational and recreational) into this analysis. The missing data on hearing protection use in a subset of our cohort was associated with sociodemographic factors and may represent a potential source of bias. We could not account for individual hygiene

TABLE 4 Multivariable logistic regression analysis assessing the association between cerumen impaction and tinnitus.[a]

	Partial Cerumen impaction		Complete Cerumen impaction	
	Odds ratio (95% CI)	*p*-value	Odds ratio (95% CI)	*p*-value
No impaction	Ref		Ref	
Unilateral	0.98 [0.72–1.34]	.895	0.64 [0.39–1.07]	.087
Bilateral	0.91 [0.69–1.20]	.505	0.92 [0.54–1.56]	.747

[a]Model adjusted by all relevant variables (PTA from better hearing ear, age, gender, race, education, income, insurance, smoking status, BMI, diabetes mellitus, hypertension, cardiovascular disease, stroke history).

practices or in-ear device usage other than hearing aids, and bone conduction thresholds were not available to differentiate conductive from sensorineural hearing loss.

5 | CONCLUSION

Cerumen impaction is highly prevalent in the US population, especially among older adults. Cerumen impaction is associated with hearing loss and disproportionately impacts individuals based on social determinants of health and SES, particularly minority race, lower education, and public insurance. Improving education on best practices for aural hygiene and cerumen management for higher-risk populations may increase engagement with safe and effective tools for at-home treatment. We also must improve access to the resources provided in the AAO-HNS CPGs and ensure they are utilized in ambulatory and emergency care practices.

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CONFLICT OF INTEREST STATEMENT

Dr. Adams served on a medical advisory council to Advanced Bionics, independent of this research work.

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