Prevalence of Adult Unilateral Hearing Loss and Hearing Aid Use in the United States

Justin S. Golub, MD, MS; Frank R. Lin, MD, PhD; Lawrence R. Lustig, MD; Anil K. Lalwani, MD

Objective: The prevalence of unilateral hearing loss (UHL) in adults has not been well characterized. The objectives of this study are to determine the prevalence of UHL in U.S. adults and its treatment with hearing aids using a nationally representative study.

Study Design: Cross-sectional national epidemiologic study (n = 6,242).

Methods: Subjects ≥ 18 years old with audiometric testing in the 2005 to 2006, 2009 to 2010, and 2011 to 2012 cycles of the National Health and Nutrition Examination Study were included. UHL was defined as normal hearing (< 25 decibels hearing level [dB HL] pure tone average [PTA]) in one ear and at least mild hearing loss (> 25 dB HL PTA) in the other ear. Hearing aid usage was defined by at least 5 hours per week (2005–2006) or at least seldom (2009-2012) use. Sampling weights were utilized to ensure generalizability to the U.S. population.

Results: The overall prevalence of UHL in adult Americans was 7.2% (95% confidence interval 6.1%–8.6%), with 5.7% (4.8%–6.7%) having mild and 1.5% (0.1%–2.1%) with moderate-or-worse UHL; nearly one-third of the latter reported trouble hearing. The prevalence of hearing aid usage in those with UHL was 2.0% (0.6%–6.7%). Of those with mild UHL, 1.4% (0.2%–8.0%) used hearing aids. Of those with moderate UHL, 4.2% (0.1%–22%) used hearing aids. Among those with UHL and also at least moderate subjective difficulty hearing, only 11% wore hearing aids.

Conclusion: UHL is common among U.S. adults. Hearing aid usage is very low, even when there is perceived handicap. Public health education is needed to increase awareness of and auditory rehabilitation for UHL.

Key Words: Prevalence, unilateral hearing loss, NHANES.

Level of Evidence: 2.

INTRODUCTION

A series of recent studies have rigorously characterized the epidemiology of adult hearing loss. This includes its prevalence1,2 and the prevalence of its treatment.3,4 These important, basic reports have influenced policy recommendations on how we deliver hearing healthcare in the United States5,6 and also form the basis of future studies.

Age-related hearing loss, which is bilateral and the most common form of adult hearing loss, has been found to be associated with other morbid conditions of aging. These include dementia,7–12 falls,13,14 and even possibly early mortality.15 In contrast, the associations and consequences of unilateral hearing loss (UHL) in adults are unknown. In children, UHL has been associated with cognitive impairment and poor school performance. For example, children with UHL have been found to score 6.3 points lower on IQ (intelligence quotient) tests16 and have more failing grades in school.17 This raises the possibility that UHL in adults may also have significant consequences.

A necessary first step in studying adult UHL is to understand its prevalence. Previously, UHL epidemiologic studies have focused primarily on children. In one report, approximately 14% of 12 to 19 year olds were found to have UHL.18 However, due to the high rate of conductive causes of pediatric hearing loss, such as otitis media with effusion, the prevalence is likely quite different in adults. A definitive study on the prevalence of adult UHL is lacking.

An impediment to the study of UHL in adults is the absence of a consensus on the definition of UHL. Numerous definitions have been used, including ≥ 30 decibels hearing level (dB HL),19,20 ≥ 40 dB HL,21,22 or ≥ 45 dB23,24 in the worse ear. These definitions are restrictive.
right pure tone average threshold (in dB HL) was calculated for abnormalities. We acknowledge this is an imperfect method for not possible to know the reason for tympanometric or otoscopic panometry. Because a physician did not perform otoscopy, it is

<table>
<thead>
<tr>
<th>Number of U.S. Adults with UHL</th>
<th>Prevalence of UHL, % of U.S. Adult Population (CI)</th>
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</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td>Mild (25–40 dB HL)</td>
</tr>
<tr>
<td>18–19</td>
<td>91,455</td>
</tr>
<tr>
<td>20–29</td>
<td>373,544</td>
</tr>
<tr>
<td>30–39</td>
<td>751,259</td>
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<tr>
<td>40–49</td>
<td>1,538,420</td>
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<td>50–59</td>
<td>3,959,996</td>
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<td>60–69</td>
<td>4,214,765</td>
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<tr>
<td>70–79</td>
<td>2,398,052</td>
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<tr>
<td>80+</td>
<td>896,867</td>
</tr>
<tr>
<td>Total</td>
<td>14,222,159</td>
</tr>
</tbody>
</table>

and may miss individuals with only a mild UHL. Not surprisingly, varying definitions of UHL result in widely varying prevalence estimates. Furthermore, these studies using more restrictive definitions generally did not subcategorize into grades of severity.

Herein, we report on the prevalence of UHL using an all-inclusive definition of UHL that includes all categories of severity, beginning with mild, utilizing a large and nationally representative epidemiologic cohort. We additionally report on the use of hearing aids in individuals with UHL.

MATERIALS AND METHODS

The National Health and Nutrition Examination Study (NHANES) is a biannual cross-sectional study designed to be representative of the United States population. The study includes interviews, physical examinations, and specialty tests. Audiometry is included in select NHANES cycles. Pure tone audiometry across octave frequencies 500 to 4000 Hz is performed in dedicated sound-isolated rooms by trained examiners. Subjects aged 18 years and over with audiometric testing in the 2005 to 2006, 2009 to 2010, and 2011 to 2012 cycles of NHANES were included (n = 6,242). This represented the most recent audiometry available at the time of this writing. United States population estimates from the 2016 census were used to estimate absolute numbers of people with hearing loss.

Only air conduction (not bone conduction) audiometry is performed in NHANES. As a screen to attempt to identify subjects who might have UHL due to a conductive abnormality, versus a sensorineural abnormality, we performed an additional analysis eliminating subjects with tympanometric or otoscopic abnormalities. This included impacted cerumen, the presence of a tympanostomy tube, any other otoscopic abnormality, as well as a flat (compliance < 0.2) or negative peak (< –150) on tympanometry. Because a physician did not perform otoscopy, it is not possible to know the reason for tympanometric or otoscopic abnormalities. We acknowledge this is an imperfect method for identifying possible conductive loss.

The absolute value of the difference between the left and right pure tone average threshold (in dB HL) was calculated for each frequency. This dB HL difference was then plotted over frequency among those with hearing loss in one ear, and normal hearing loss in the other ear on the four-frequency pure tone average.

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complex sample design of NHANES and was performed in accordance with guidelines of the National Center for Health Statistics. Differences between categorical variables were assessed with the chi-squared test. Differences between continuous variables were assessed with the paired t-test. Multivariable logistic regression was used to identify demographic predictors of UHL. We controlled for predictors by including them as covariates in the model. This included age, gender, and race. Significance was considered at the P < 0.05 level. Data analysis was performed in Stata 15.0 (StataCorp LLC, College Station, TX).

RESULTS

The overall prevalence of UHL in the U.S. adult population was 7.2% (95% confidence interval [CI] = 6.1–8.6). The prevalence of those with mild and moderate-or-worse UHL was 5.7% (4.8–6.7) and 1.5% (1.1–2.1), respectively (Table I). The mild UHL category included some individuals with near-symmetric hearing for which one ear is just better than 25 dB and one ear is just worse than 25 dB. If a more stringent definition of UHL is used that also requires at least a 10-dB pure tone average asymmetry, then the prevalence of mild UHL was 2.2% (1.6–2.9) and the overall UHL prevalence was 3.7% (3.0–4.6). (The prevalence of moderate-or-worse UHL is unaffected because all individuals with moderate-or-worse UHL have at least a 10 dB asymmetry.)

NHANES only performed air conduction pure tone audiometry. Thus, it is not possible to directly distinguish sensorineural from conductive hearing loss. If subjects with any tympanometric or otoscopic abnormality were eliminated, the overall prevalence of UHL was 4.7% (95% CI = 4.0–5.5). Similarly eliminating subjects with any tympanometric/otoscopic abnormalities but using the more stringent definition of UHL, requiring an additional 10 dB pure tone asymmetry, the overall prevalence of UHL was 2.0% (95% CI = 1.7–2.5).

Among those with UHL, hearing was more asymmetric at higher frequency (Fig. 1). The mean absolute value of the difference between the left and right pure tone average was 13.4 dB HL (95% CI = 12.0–14.8) at 500 Hz. This rose to 19.2 dB HL (95% CI = 17.7–20.8) at 4,000 Hz before falling to 17.8 dB HL (95% CI = 16.3–19.3) at 8,000 Hz. There was a significant difference in the difference in hearing threshold between 500 Hz and 8,000 Hz (P < 0.001).

UHL peaked at 60 to 69 years old (Table I). Males were significantly more likely to have UHL compared to females (9.1% of males vs. 5.5% of females; P < 0.01). Males were also significantly more likely to have mild UHL compared to females (7.4% of males vs. 4.1% of females; P = 0.001); however, there was no significance difference between genders for moderate-or-worse UHL (P = 0.90) (Table II). Whereas whites and other/multiple races seemed to have a higher prevalence of UHL, there was no significant association between race and presence of UHL (P = 0.557) (Table III).

Most people with UHL stated that their hearing, subjectively, was excellent or good (56%). Over a quarter stated they had a little trouble (28%). About 17% stated they had moderate-or-worse trouble. Among subjects with mild UHL, nearly two-thirds (63%) stated their hearing subjectively was excellent or good. A quarter (25%) stated they had a little trouble. About 13% stated they had moderate-or-worse trouble. Among subjects with moderate-or-worse UHL, nearly a third (31%) stated their hearing subjectively was excellent or good. Over a third (38%) stated they had a little trouble. Nearly a third (31%) stated they had moderate-or-worse trouble.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Number of U.S. Adults with UHL</th>
<th>Prevalence of UHL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mild (25–40 dB HL)</td>
<td>Moderate or Worse (≥ 41 dB HL)</td>
</tr>
<tr>
<td>Male</td>
<td>8,729,475</td>
<td>2,020,350</td>
</tr>
<tr>
<td>Female</td>
<td>5,125,823</td>
<td>1,761,212</td>
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<tr>
<td></td>
<td>Mild (25–40 dB HL)</td>
<td>Moderate or Worse (≥ 41 dB HL)</td>
</tr>
<tr>
<td>Male</td>
<td>7.4% (5.8–9.3)</td>
<td>1.7% (1.1–2.7)</td>
</tr>
<tr>
<td>Female</td>
<td>4.1% (3.1–5.3)</td>
<td>1.4% (1.1–1.8)</td>
</tr>
</tbody>
</table>

*Percentages represent percent within each gender with a certain category of hearing loss.
†95% confidence interval.
The prevalence of hearing aid use among those with UHL was low at 2.0% (95% CI = 0.6–6.7). Usage remained low at 4.2% (95% CI = 0.1–22), even among those with moderate-or-worse UHL. Because of the low prevalence of treatment, we could not perform any additional analyses stratified by demographic groups (Table IV).

The prevalence of hearing aid usage remained low if only those with perceived difficulty hearing were analyzed. Among those with UHL and subjectively moderate-or-worse trouble hearing, only 11% wore a hearing aid.

In logistic regression modeling, age was found to be a significant predictor of UHL. For every 1-year increase in age, the odds of UHL increased 1.04 (95% CI = 1.03, 1.04; P < 0.001) times. For every 10-year increase in age, the odds of UHL therefore increased 1.46 times. Additional adjustment for gender and race did not affect the strength of this association. Gender was also a significant predictor of UHL. Males had 1.15, 1.71; P = 0.001) times the odds of UHL compared to females, adjusting for race and age. Race/ethnicity was not significantly associated with UHL (P = 0.43) (Table V). Removing subjects with tympanometric or otoscopic abnormality had no effect on the regression analysis results.

**DISCUSSION**

The prevalence of UHL among adults was high at 7.2% overall, or 18 million Americans. The prevalence of moderate-or-worse UHL was also high at 1.5%, or 3.8 million Americans. The latter figure is important because it may approximate the number who, if counseled appropriately, would consider a hearing aid. This study used the NHANES database, which is designed to be representative of the U.S. population. It is thus ideally suited for establishing disease prevalence, including absolute numbers of affected individuals.

We defined UHL in the most literal sense as normal hearing in one ear and abnormal hearing in the other ear. This used the widely accepted cutoff for adult hearing loss of 25 dB HL, which is also endorsed by the WHO. Consistent with prior epidemiologic research employing large national datasets, hearing was defined by the four-frequency pure tone average. Some individuals may have nearly symmetric hearing, for which one ear is just below 25 dB and one ear is just above. To account for this, we performed an additional analysis with a stricter definition of UHL, additionally requiring at least a 10 dB difference between ears. Even with this more stringent definition of UHL, requiring at least a 10 dB asymmetry, the overall prevalence of UHL was 3.7%, or 9 million Americans.

It was not possible to distinguish conductive from sensorineural UHL because NHANES does not include bone conduction audiometry. However, the majority of individuals with UHL had normal tympanograms and otoscopy, suggesting a primarily sensorineural etiology.

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**TABLE III.**


<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Number of U.S. Adults with UHL</th>
<th>Prevalence of UHL, % of Each Race/Ethic Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mild (25–40 dB HL)</td>
<td>Moderate or Worse (≥ 41 dB HL)</td>
</tr>
<tr>
<td>Mexican American</td>
<td>745,009</td>
<td>270,977</td>
</tr>
<tr>
<td>Other Hispanic</td>
<td>606,189</td>
<td>189,958</td>
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<tr>
<td>White (Non-Hispanic)</td>
<td>10,209,166</td>
<td>2,541,989</td>
</tr>
<tr>
<td>Black (Non-Hispanic)</td>
<td>1,141,441</td>
<td>391,993</td>
</tr>
<tr>
<td>Other/Multiple</td>
<td>1,215,237</td>
<td>392,191</td>
</tr>
</tbody>
</table>

*Percentages represent percent within each race/ethnicity with a certain category of hearing loss. Primary sampling unit design did not allow confidence interval computation for individual race/ethnicities.

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**TABLE IV.**


<table>
<thead>
<tr>
<th>Number of U.S. Adults Using Hearing Aids for UHL</th>
<th>Prevalence of Hearing Aid Use Among Those with UHL, % (CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild (25–40 dB HL)</td>
<td>Moderate or Worse (≥ 41 dB HL)</td>
</tr>
<tr>
<td>201,642</td>
<td>161,485</td>
</tr>
</tbody>
</table>

4% (0.2–8.0) 4.2% (0.1–22%) 2.0% (0.6–6.7%)

*95% CI.

dB HL = decibels hearing level; UHL = unilateral hearing loss, defined by at least mild hearing loss in one ear, and normal hearing loss in the other ear on the four-frequency pure tone average.
Among those with UHL, hearing was more asymmetric at higher frequencies. This suggests that most cases of UHL were due to one of the numerous pathologies that cause a high-frequency hearing loss. The greatest asymmetry was at 4,000 Hz, suggesting noise-induced hearing loss as a major etiology. Likewise, conditions that cause a flat- or low-frequency asymmetric hearing loss, such as Meniere's disease (low-frequency sensorineural hearing loss) or conductive etiologies (flat- or low-frequency hearing loss) likely cause a minority of UHL.

The number of U.S. adults with bilateral hearing loss, which overwhelmingly includes age-related hearing loss (ARHL, or presbycusis), is a staggering 38 million.1 This is approximately two times higher than the UHL prevalence of 18 million in our study. When using a more stringent definition of UHL requiring at least a 10 dB difference between two ears, ARHL is approximately four times more common than UHL. Considering that ARHL is a universally recognized phenomenon, it is surprising that UHL is remotely close in prevalence. Although ARHL continues to rise with age (exponentially until a plateau approaching 100% is reached), UHL peaked at 60 to 69 years old. This is due to the fact that, as individuals with UHL grow older, they will inevitably develop presbycusis in their better ear. At this point, they would no longer be classified as having UHL.

In children, UHL is related to lower performance in school and on intelligence tests.16,17 Although the implications of UHL in adults is not well studied, recent data show poorer cognitive function in adults with bilateral HL.7–12 Given the minimal risk of hearing aid use, but the potential benefit, we recommend public health education about the importance of testing for and treating UHL in adults.

Age and gender were both found to be significant demographic predictors of UHL. Males versus females, as well as a 10-year increase in age, were both found to have 1.4 times the odds of UHL. Hearing loss becomes more asymmetric with aging35; thus, it is not surprising that UHL increases in prevalence with age. This relationship is slightly attenuated by the fact that UHL drops in the final decades as bilateral hearing loss (i.e., presbycusis) becomes near universal. An explanation for increased UHL in males is unclear. It is plausible, but speculative, that this may be from environmental or occupational noise exposure. There was no association between race/ethnicity and UHL.

This study has limitations. The prevalence data are at least 5 years old, representing the most recent NHANES cohort with audiometric data in our study population. (The absolute numbers of affected U.S. adults, however, were computed using 2016 census population estimates.) Although the prevalence of UHL is unlikely to have dramatically changed in this time period, it is conceivable that the prevalence of hearing aid use may have changed with improving technology.

Future studies should assess whether adult UHL is associated with other conditions, such as dementia, depression, falls, and loneliness. Given that both UHL in children16,17 and bilateral hearing loss in adults7–12 are associated with worse neurocognitive states, we hypothesize a similar association for UHL in adults.

CONCLUSION

UHL is common in American adults. Hearing aid usage is very low, even when a handicap is perceived. As
the importance of adult-onset hearing loss among the
medical, scientific, political, and general community
grows, it is necessary to study the epidemiology and
relative impact of different hearing loss subtypes, including
UHL.

Acknowledgment
We thank Adele M. Goman, PhD, for her assistance in com-
puting absolute population counts and Jessica Galatito,
AuD for her expertise in interpretation of tympanometry.

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