Unmet Hearing Health Care Needs: The Beaver Dam Offspring Study

Scott D. Nash, MS, Karen J. Cruickshanks, PhD, Guan-Hua Huang, PhD, Barbara E. K. Klein, MD, MPH, Ronald Klein, MD, MPH, F. Javier Nieto, MD, PhD, and Theodore S. Tweed, MS

Objectives. We evaluated the use of hearing health care services (hearing testing and hearing aids) by adults aged 21 to 84 years.

Methods. Hearing was tested and medical and hearing health histories were obtained as part of the Beaver Dam Offspring Study between 2005 and 2008 (n = 3285, mean age = 49 years).

Results. Of the cohort, 34% (55% of participants aged ≥ 70 years) had a hearing test in the past 5 years. In multivariate modeling, older age, male gender, occupation, occupational noise, and having talked with a doctor about a hearing problem were independently associated with having had a hearing test in the past 5 years. Hearing aid use was low among participants with a moderate to severe hearing impairment (22.5%) and among participants with a hearing handicap (8.6%), as determined by the Hearing Handicap Inventory.

Conclusions. Data support the need for improvement in hearing health care. Hearing aids' effectiveness is limited if patients do not acquire them or do not use them once acquired. Future research should focus on developing effective strategies for moving patients from diagnosis to treatment. (*Am J Public Health.* 2013;103:1134–1139. doi:10.2105/AJPH.2012.301031)

Hearing impairment is one of the most frequent chronic conditions in adults in the United States, with epidemiological prevalence estimates reaching 90% in the oldest adults.[1] Hearing impairment is often accompanied by poorer quality of life and is associated with a range of comorbidities including cognitive dysfunction and depression.[2–5] Despite the potential consequences, hearing impairments are often undiagnosed and untreated, and many adults who know they have hearing impairments do not acquire hearing aids.[6,7] As the US population ages, hearing health care needs and hearing loss–related morbidity will be an increasing burden on the nation's public health infrastructure.

A research working group organized by the National Institutes of Health and the National Institute of Deafness and Communication Disorders recently developed a research agenda addressing issues of accessibility of hearing health care.[8] Recommendations included the need to identify factors that influence a patient's access to hearing health care and factors that influence a patient's perceived need and motivation for seeking out hearing health care. Our objective was to determine the prevalence of previous hearing testing and current hearing aid use in a large cohort of adults and to assess characteristics associated with hearing health care use in the general population.

METHODS

Participants in the Beaver Dam Offspring Study (BOSS) were the adult offspring of the participants in the prospective population-based Epidemiology of Hearing Loss Study.[1] Eligibility criteria and participation data for the BOSS have previously been published.[9] Data collection occurred between 2005 and 2008. The 3285 participants ranged in age from 21 to 84 years (mean age = 49 years), 45% of the cohort was male, and the majority of participants were non-Hispanic White. A total of 3130 participants had questionnaire data on hearing testing; of these, 2790 had an audiometric exam.

The hearing examination included otoscopy, tympanometry, pure-tone air- and bone-conduction audiometry, and 2 word recognition tasks. Consistent with guidelines of the American Speech-Language-Hearing Association, we conducted audiometric testing in a sound-treated booth (Industrial Acoustics Company, New York, NY) using a clinical audiometer (GSI-61; Grason-Stadler, Eden Prairie, MN) with earphones (TDH-50P; Telephonics, Farmingdale, NY) or insert earphones (E-A-Rtone 3A; Cabot Safety Corp., Indianapolis, IN).[10] The clinical audiometer was calibrated every 6 months according to American National Standards Institute standards, and calibration checks were performed daily.[11] We routinely measured ambient noise levels throughout the study to ensure testing conditions remained within these standards.[12]

Air conduction thresholds were determined for each ear at 0.5, 1, 2, 3, 4, 6, and 8 kilohertz, and we calculated a 4-threshold (0.5, 1, 2, and 4 kHz) pure-tone average (PTA) for each ear. We defined a mild hearing impairment as PTA greater than 25-decibel hearing level (HL) and less than or equal to 40-decibel HL in either ear (worse ear) and a moderate to severe hearing impairment as PTA greater than 40-decibel HL in either ear (worse ear). We defined bilateral hearing impairment as PTA greater than 25-decibel HL in both ears and unilateral hearing impairment as PTA greater than 25-decibel HL in only 1 ear.

Tests of word recognition in quiet (WRQ) and in competing message (WRCM) used the Northwestern University Auditory Test Number 6.[13] For WRQ, a 25-word list was administered at 36-decibel HL above the individual's threshold at 2 kilohertz in the better ear (using a single female voice). For WRCM, a second list was administered with a single male talker added at 8-decibel HL below the speaker's level at 2 kilohertz in the same ear. We defined poor WRQ and WRCM as less than 80% for WRQ and less than 70% for WRCM.[14]

We administered an extensive questionnaire to collect data on demographics, education

level, household income level, longest held job, insurance status, home ownership and location, hearing-related medical history, and occupational noise exposure. Before the hearing exam, participants were asked about their last hearing test, use of a hearing aid, self-rated hearing ability, and whether they had ever seen a medical doctor about a hearing or ear problem in the past 5 years. Participants completed the Hearing Handicap Inventory for the Elderly Screening Version (age ≥ 65 years) or the Hearing Handicap Inventory for Adults Screening Version (age < 65 years).[15–17] We defined a hearing handicap (mild to severe) as a score of greater than 8 on either test[18,19] and a positive history of occupational noise exposure as a self-report of ever holding a full-time job that required speaking in a raised voice or louder to be heard when within 2 feet from another person.[1,20]

We used the χ^2 test for comparisons between participant characteristics and hearing testing. Multivariate logistic regression was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) and to examine the associations between participant characteristics and having had a hearing test within the past 5 years and hearing aid use. Because participants in BOSS were recruited from families, we reran final multivariate models using general estimating equation (GEE) models, which allowed for the determination of whether familial correlation was having an effect on the results of this study. We performed all analyses using SAS version 9.2 (SAS Institute, Cary, NC).

RESULTS

Hearing health care data were available for 95.3% of the BOSS cohort. Characteristics of the study population with hearing health care data are given in Table 1. Of the 3130 people in the BOSS cohort with hearing health care data, 1069 (34.2%) had a hearing test in the past 5 years (Table 2). More than 9% of the cohort reported never having had a hearing test. Among participants aged 21 to 69 years and aged 70 years and older, 33.6% and 54.7%, respectively, had a hearing test in the past 5 years. In unadjusted models, age (OR = 1.16; 95% CI = 1.11, 1.21; per 5 years of age) and male gender (OR = 2.56; 95% CI = 2.20, 2.98) were associated with increased odds of hearing testing.

Variables Associated with Obtaining Hearing Test

In separate models controlling for age and gender, lower education level (OR = 1.86; 95% CI = 1.53, 2.25; ≤ 12 years vs ≥ 16 years); lower income level (OR = 1.45; 95% CI = 1.14, 1.84; $30 000–$49 999 vs ≥ $100 000); working in production, operation, or labor occupations (OR = 2.83; 95% CI = 2.36, 3.40); occupational noise exposure (OR = 1.64; 95% CI = 1.40, 1.93); and having talked with a doctor about a hearing or ear problem in the past 5 years (OR = 3.31; 95% CI = 2.75, 3.99) were associated with increased odds of hearing testing in the past 5 years. Marital status, health insurance status, home ownership, and home location were not associated with having had a hearing test (data not shown).

In the multivariate model, older age; male gender; production, operation, or labor occupations; occupational noise exposure; and having talked with a doctor about a hearing problem in the past 5 years remained statistically significant (Table 3). When we ran the multivariate model with income instead of education, income was also not statistically significant and model fit was very similar (data not shown). Accounting for the familial correlation in a general estimating equation model, the results were also similar (data not shown). Results were similar by age group; however, the association between occupational noise and hearing testing was statistically significant only in the youngest age group (21–44 years). Results were similar for men and women for all variables except for longest held job, where the associations for women (OR = 4.81; 95% CI = 3.26, 7.10) and men (OR = 2.04; 95% CI = 1.56, 2.66) were statistically significantly different ($P = .005$).

Among participants reporting occupational noise at their current job, the odds of hearing testing increased with the amount of time that job was noisy (OR = 1.61; 95% CI = 1.35, 1.93; per 25% increase). However, among participants with jobs that were noisy 100% of the time (n = 81), only 77.8% had a hearing test in the past 5 years.

Hearing Aid Use

Use of hearing health care (hearing testing, ever use of a hearing aid, or current use of

TABLE 1—Select Characteristics of Participants With Hearing Health Care Data: Beaver Dam Offspring Study, 2005–2008

Characteristic	No. (%)
Male	1451 (46.4)
Age group, y	
21–34	178 (5.7)
35–44	891 (28.5)
45–54	1183 (37.8)
55–64	668 (21.3)
65–84	210 (6.7)
Education, y	
≤ 12	946 (30.4)
13–15	1052 (33.8)
≥ 16	1111 (35.7)
Income, US$	
≥ 100 000	671 (22.2)
50 000–99 999	1375 (45.6)
30 000–49 999	603 (20.0)
< 30 000	369 (12.2)
Longest held job	
Management, technical, service	2248 (75.1)
Production, operation, labor	744 (24.9)
Occupational noise exposure	
No	2104 (67.5)
Yes	1015 (32.5)
Married	
No	811 (26.0)
Yes	2303 (74.0)
Talked with a doctor about a hearing problem in past 5 y	
No	2426 (78.4)
Yes	670 (21.6)
Home location	
City or town	2169 (69.6)
Country	947 (30.4)
Home owner	
No	434 (13.9)
Yes	2681 (86.1)
Health insurance	
No	166 (5.3)
Yes	2960 (94.7)

Note. The sample size was n = 3130. Variable counts may not sum to 3130 because of missing data.

TABLE 2—Prevalence of Hearing Testing in the Past 5 Years by Age and Gender: Beaver Dam Offspring Study, 2003–2005

	All		Female		Male	
Age, Years	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)
21–34	178	25.3 (18.9, 31.7)	105	16.2 (9.1, 23.2)	73	38.4 (27.2, 49.5)
35–44	891	27.8 (24.9, 30.8)	484	18.2 (14.7, 21.6)	407	39.3 (34.6, 44.1)
45–54	1183	33.7 (31.0, 36.4)	628	23.7 (20.4, 27.1)	555	45.0 (40.9, 49.2)
55–64	668	40.3 (36.6, 44.0)	354	31.6 (26.8, 36.5)	314	50.0 (44.5, 55.5)
65–84	210	51.4 (44.7, 58.2)	108	41.7 (32.4, 51.0)	102	61.8 (52.3, 71.2)
All	3130	34.2 (32.5, 35.8)	1679	24.5 (22.4, 26.5)	1451	45.3 (42.8, 47.9)

Note. CI = confidence interval.

hearing aid) was low (Table 4). The prevalence of current hearing aid use among those with mild and moderate to severe hearing impairment was 3.9% and 22.5%, respectively. Among participants with hearing impairment (mild–severe) aged 21 to 69 years (n = 358), 10.3% were currently using a hearing aid, and 11.6% of hearing-impaired adults aged 70 years and older (n = 43) were currently using a hearing aid. Current hearing aid use was higher among those with bilateral hearing impairment than among those with unilateral hearing impairment (19.8% vs 1.9%). Participants with poor performance on either WRQ or WRCM had a low prevalence of hearing aid use (current use = 6.9% and 2.1%, respectively). Among those with a hearing handicap or who self-reported hearing problems, hearing testing and hearing aid use were also low. Hearing aid use was low in all age groups; for example, among those who self-reported a hearing loss (n = 1458), the prevalence of current hearing aid use was 1.4% (n = 5) among those aged 21 to 44 years, 1.4% (n = 8) among those aged 45 to 54 years, and 8.1% (n = 41) among those aged 55 to 84 years. Of those who reported ever using a hearing aid, 41.3% were not current users (at the time of the examination), suggesting that adherence to hearing aid use was also low in this cohort.

In a multivariate model controlling for age and gender, we found that worse-ear PTA (OR = 1.24; 95% CI = 1.15, 1.34; per 5 dB), WRCM (OR = 0.89; 95% CI = 0.80, 0.99; per 5%), and hearing handicap score (OR = 1.31; 95% CI = 1.22, 1.41; per 2 points) were all independently associated with current hearing aid use. Socioeconomic status and occupational variables were not associated with hearing aid use (data not shown). Results were similar when we used WRQ instead of WRCM and when we used hearing aid ever-use instead of current hearing aid use (data not shown).

Among participants who had not had a hearing test in the past 5 years, had never used a hearing aid, and had available audiometric data (n = 1876), 8.7% (n = 164) had a mild to severe hearing impairment. In those younger than 55 years, 5.8% (n = 83) had a hearing loss; in those aged 55 years and older, 18.0% (n = 81) had a hearing loss yet had not had a hearing test in the past 5 years. Among those who had seen a doctor about a hearing or ear problem, 50.5% (n = 297) had not had a hearing test in the past 5 years; of these, 9.4% (n = 28; < 55 years, 5.9%; ≥ 55 years, 19.2%) had a mild to severe hearing impairment.

DISCUSSION

The magnitude of the unmet need for hearing health care in this large adult cohort was considerable. Only half of the participants aged 65 years and older had a hearing test in the past 5 years, and nearly 9% (n = 164) of those without a hearing test had a hearing impairment determined audiometrically at the

TABLE 3—Multivariate Odds Ratios for Hearing Testing in the Past 5 Years by Age Group for Select Characteristics: Beaver Dam Offspring Study, 2003–2005

Characteristic	All (n = 2939), OR (95% CI)	21–44 y (n = 1013), OR (95% CI)	45–54 y (n = 1126), OR (95% CI)	55–84 y (n = 800), OR (95% CI)
Age, 5 y	1.16 (1.11, 1.21)	0.99 (0.84, 1.18)	1.22 (0.95, 1.56)	1.24 (1.07, 1.43)
Male	2.19 (1.83, 2.62)	2.39 (1.73, 3.29)	2.21 (1.65, 2.96)	2.07 (1.48, 2.90)
Education, y				
≥ 16 (Ref)	1.00	1.00	1.00	1.00
13–15	1.18 (0.96, 1.47)	1.12 (0.77, 1.62)	1.28 (0.90, 1.83)	1.09 (0.72, 1.63)
≤ 12	1.17 (0.93, 1.48)	0.85 (0.54, 1.32)	1.25 (0.86, 1.83)	1.41 (0.92, 2.16)
Longest held job				
Management, technical, service (Ref)	1.00	1.00	1.00	1.00
Production, operation, labor	2.79 (2.25, 3.47)	2.54 (1.72, 3.75)	3.18 (2.25, 4.49)	2.77 (1.82, 4.21)
Occupational noise exposure	1.29 (1.07, 1.54)	1.91 (1.38, 2.65)	1.14 (0.85, 1.53)	0.97 (0.68, 1.36)
Talked with doctor about hearing problem past 5 y	3.57 (2.93, 4.36)	2.68 (1.87, 3.85)	4.46 (3.22, 6.19)	3.73 (2.61, 5.34)

Note. CI = confidence interval; OR = odds ratio.

TABLE 4—Hearing Health Care Use among Participants with Various Hearing Impairment Outcomes: Beaver Dam Offspring Study, 2003–2005

Variable	No.	Hearing Test Last 5 Years, No. (%)	Ever Aid Use, No. (%)	Current Aid Use, No. (%)
Mild hearing impairment (PTA > 25 and ≤ 40 dB HL)	259	123 (48.1)	24 (9.3)	10 (3.9)
Moderate to severe hearing impairment (PTA > 40 dB HL)	142	102 (72.3)	49 (34.5)	32 (22.5)
Unilateral hearing loss (PTA > 25 dB HL)	209	96 (46.2)	15 (7.2)	4 (1.9)
Bilateral hearing loss (PTA > 25 dB HL)	192	129 (68.3)	58 (30.2)	38 (19.8)
Word recognition (Quiet) < 80%	260	105 (41.3)	26 (10.0)	18 (6.9)
Word recognition (CM) < 70%	1806	621 (35.0)	70 (3.9)	37 (2.1)
Hearing handicap	545	265 (49.8)	75 (13.8)	47 (8.6)
Self-reported hearing loss	1458	619 (43.5)	90 (6.2)	54 (3.7)
Self-rated hearing: fair, poor	516	283 (56.7)	79 (15.3)	47 (9.1)
Talked to a doctor about hearing problem	697	360 (53.7)	61 (8.8)	37 (5.3)

Note. CM = competing message; HL = hearing loss; PTA = pure-tone average. Percentages may not match exactly because of a small amount of missing hearing health care data.

time of the exam. Hearing aid use was low among those with moderate to severe hearing impairment (22.5%) and among those who self-identified as either having a hearing problem (3.7%) or having problems in their daily life owing to their hearing (8.6%). Of those participants who had reported ever using a hearing aid, 41.3% were not currently using one, suggesting poor adherence to treatment.

Although the prevalence of hearing testing in the past 5 years in BOSS was low (33.6% in adults aged 20 to 69 years and 54.7% in adults aged 70 years and older), it did meet the hearing examination goals set by Healthy People 2020 (31.5% and 42.4%, respectively) and was somewhat higher than 2003–2004 national estimates from the National Health and Nutrition Examination Survey (29% and 39%).[21] However, these rates of hearing testing did not necessarily translate into high rates of hearing aid use because the prevalence of current hearing aid use in BOSS in those aged 70 years and older (12%) was lower than national data (19%) and did not meet the Healthy People 2020 goal (32%).[21,22] The low use of hearing aids in this cohort appeared to be within the range of previous reports from US studies (5.5% in the Framingham Heart Study [age range = 57–89 years] to 14.6% in the Epidemiology of Hearing Loss Study [age range = 48–92 years]).[6,23] Hearing aid use is similarly low in health care systems in Europe, the United Kingdom, and Australia, where hearing aids are provided by the government or are covered by insurance.[24–28] Therefore, cost itself does not appear to explain the low rate of hearing aid use in the United States.

Occupational status and the presence of noise in the workplace were important correlates of hearing testing. Those working in production, operation, or labor occupations were more likely to have had a hearing test than those working in other occupations, probably because of the link between these occupations and noise exposure. The association between occupation and hearing testing was more pronounced in women than in men, possibly owing to a lack of awareness about the importance of hearing health care for women in the general population. Hearing testing increased with amount of noise exposure in the workplace, suggesting that exposure rules requiring yearly testing implemented by the Occupational Safety and Health Administration may be an important determinant of testing.[29] Among older participants, who were more likely to be retired, the association between occupational noise and hearing testing was not statistically significant. Among workers reporting noisy occupational conditions 100% of the time, 22% had not received a hearing test in the past 5 years. Although noncompliance with noise regulations in industry has been documented, these data should be interpreted cautiously because actual workplace noise levels were not measured, and participants may have been working in specific occupations not required to have yearly testing.[30]

Several recent reports have discussed the important role primary care physicians can play in initiating hearing health care for their patients.[31,32] In this study, participants who had talked to a doctor about a hearing problem were more likely to have had a hearing test in the past 5 years. This physician interaction may have directly led to an increased use of hearing health care. In a study of US primary care physicians (n = 95), 73% reported screening their Medicare-eligible patients if they suspected a problem or if their patients complained about hearing difficulties.[31] Furthermore, more than 80% responded that they routinely referred these patients with hearing difficulties to an audiologist. Despite these trends, in our study a large percentage (50.5%) of those who had talked to their doctor about a hearing problem had not had a hearing test in the past 5 years. Although some patients may not have needed hearing testing to diagnose and treat the hearing problem, some may possibly have benefitted from referrals for hearing testing. In addition, others seeing primary care practitioners for unrelated health problems may have had undetected hearing impairment.

Recent publications have reported that much is likely to be gained by earlier detection of hearing impairment in adults through hearing screening.[33,34] Indeed, self-perception of hearing quality has been shown to be a predictor of hearing aid acquisition.[7,35] In this study, hearing handicap was associated with hearing aid use even after controlling for measured hearing level and ability to discriminate words in noise. Despite this, it is too early to advocate for comprehensive screening programs because effective treatment options are not yet available. According to recent

clinical guidelines by the US Preventive Task Force, research is still needed to determine the health benefits of hearing screening.[36] Although observational studies and randomized controlled trials have shown that hearing aids can have an impact on quality of life, a large majority of people do not acquire a hearing aid after being told they have a hearing loss, and adherence to hearing aids as a treatment is low.[6,7,37–41] In this study, hearing aid use was low among participants who self-reported a hearing loss, even among those in the oldest age group. Reasons for not seeking treatment are complex and may include the inconvenience of wearing a hearing aid, pervasive social stigma surrounding hearing loss and hearing aids, or knowledge of others' negative experiences.[7] A comprehensive approach that may entail educating patients and their spouses about the potential improvement in quality of life that can come with aural rehabilitation, providing training and support for hearing aid use, and introducing patients to alternative therapies including assisted listening devices and communication programs may improve utilization rates.[33,42] At a population level, public health interventions should include educating the public and destigmatizing hearing loss and hearing aids. Once effective approaches have been developed to help patients make the transition from knowledge to treatment to improved health and quality of life, then a focus on screening may be warranted.

This investigation into the use of hearing health care used a large population for whom hearing endpoints were measured using standardized protocols in a well-controlled environment. An extensive questionnaire allowed for a thorough determination of the characteristics of those who seek hearing health care. However, this cohort was made up of mostly non-Hispanic Whites, and so prevalence estimates may not be applicable to Americans in other ethnic/racial groups who are often less likely to receive medical care. Nonetheless, given the known disparities in health care access between Whites and disadvantaged minorities, the data from BOSS participants may represent a best-case scenario. Participants in BOSS were the offspring of participants in the Epidemiology of Hearing Loss Study; therefore, these participants may have been more likely to seek hearing-related care than other populations. However, hearing aid usage estimates in BOSS were similar to those in other demographically similar cohorts and national averages. Furthermore, in statistical modeling, results were similar when accounting for family structure, suggesting a negligible familial effect on associations.

The use of hearing health care, namely hearing testing and hearing aid use, was low in this general population of adults. Factors associated with increased hearing health care use included older age, male gender, occupation, and occupational noise. Hearing aid use was low among those who self-reported hearing problems and among those with audiometrically defined moderate to severe hearing impairment. This study's results address some of the research recommendations made by the National Institutes of Health and the National Institute of Deafness and Communication Disorders working group. These recommendations are important because they are aimed at finding ways to improve accessibility to hearing health care, including hearing aids. Although hearing aids are an important component of hearing health care, their effectiveness is limited if patients do not acquire them, or do not use them once acquired, as appears to be the case. Developing effective strategies for moving patients from diagnosis to treatment should be a focus of future research. ■

About the Authors

Scott D. Nash, Karen J. Cruickshanks, and F. Javier Nieto are with the Department of Population Health Sciences, University of Wisconsin School of Medicine and Public Health, Madison. Karen J. Cruickshanks is also with the Department of Ophthalmology and Visual Sciences, University of Wisconsin School of Medicine and Public Health. Guan-Hua Huang is with the Institute of Statistics, National Chiao Tung University, Hsinchu, Taiwan. Barbara E. K. Klein and Ronald Klein are with the Department of Ophthalmology and Visual Sciences, University of Wisconsin School of Medicine and Public Health. Theodore S. Tweed is with the Department of Communicative Disorders, University of Wisconsin, Madison.

Correspondence should be sent to Scott D. Nash, MS, Department of Population Health Sciences, University of Wisconsin School of Medicine and Public Health, 610 North Walnut Street, Room 1036 WARF, Madison, WI 53726 (e-mail: snash@wisc.edu). *Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.*

This article was accepted August 4, 2012.

Contributors

S. D. Nash designed and performed the analyses, led the interpretation of the results, and led the writing of the article. K. J. Cruickshanks conceptualized the study, participated in the acquisition of participants and data, provided advice on the analysis and interpretation of data, and contributed to the writing of the article. G.-H. Huang and F. J Nieto provided advice on the analysis and interpretation of data and contributed to the writing of the article. B. E. K. Klein and R. Klein were involved in the acquisition of participants and data, provided advice on the analyses and interpretation of results, and contributed to the writing of the article. T. S. Tweed provided advice on data collection and quality and contributed to the writing of the article. All authors approved the final version of the article.

Acknowledgments

This project was supported by the National Institute on Aging, National Eye Institute, and National Institute on Deafness and Other Communication Disorders (grant R01AG021917).

Note. The content is solely the responsibility of the authors and does not necessarily reflect the official views of the National Institute on Aging, the National Eye Institute, the National Institute on Deafness and Other Communication Disorders or the National Institutes of Health.

Human Participant Protection

Beaver Dam Offspring Study methods were approved by the University of Wisconsin Madison Internal Review Board, and all participants provided informed consent.

References

1. Cruickshanks KJ, Wiley TL, Tweed TS, et al. Prevalence of hearing loss in older adults in Beaver Dam, Wisconsin: the Epidemiology of Hearing Loss Study. *Am J Epidemiol.* 1998;148(9):879–886.

2. Dalton DS, Cruickshanks KJ, Klein BEK, Klein R, Wiley TL, Nondahl DM. The impact of hearing loss on quality of life in older adults. *Gerontologist.* 2003;43(5):661–668.

3. Uhlmann RF, Larson EB, Rees TS, Koepsell TD, Duckert LG. Relationship of hearing impairment to dementia and cognitive dysfunction in older adults. *JAMA.* 1989;261(13):1916–1919.

4. Strawbridge WJ, Wallhagen MI, Sherma SJ, Kaplan GA. Negative consequences of hearing impairment in old age: a longitudinal analysis. *Gerontologist.* 2000;40(3):320–326.

5. Nachtegaal J, Smit JH, Smits C, et al. The association between hearing status and psychosocial health before the age of 70 years: results from an Internet-based national survey on hearing. *Ear Hear.* 2009;30(3):302–312.

6. Popelka MM, Cruickshanks KJ, Wiley TL, Tweed TS, Klein BEK, Klein R. Low prevalence of hearing aid use among older adults with hearing loss: the Epidemiology of Hearing Loss Study. *J Am Geriatr Soc.* 1998;46(9):1075–1078.

7. Fischer ME, Cruickshanks KJ, Wiley TL, Klein BEK, Klein R, Tweed TS. Determinants of hearing aid acquisition in older adults. *Am J Public Health.* 2011;101(8):1449–1455.

8. Donahue A, Dubno JR, Beck L. Guest editorial: accessible and affordable hearing health care for adults with mild to moderate hearing loss. *Ear Hear.* 2010;31(1):2–6.

9. Nash SD, Cruickshanks KJ, Klein R, et al. The prevalence of hearing impairment and associated risk factors: the Beaver Dam Offspring Study. *Arch Otolaryngol Head Neck Surg.* 2011;137(5):432–439.

10. American Speech-Language-Hearing Association. *Guidelines for Manual Pure-Tone Threshold Audiometry.* Washington, DC: American Speech-Language-Hearing Association; 1987: 297–301.

11. American National Standards Institute. *Specifications for Audiometers.* ANSI S3.6-2004. New York, NY: American National Standards Institute; 2004.

12. American National Standards Institute. *Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms.* ANSI/ASA S3.1–1999 (R2008). New York, NY: American National Standards Institute; 1999.

13. Wilson RH, Zizz CA, Shanks JE, Causey GD. Normative data in quiet, broadband noise, and competing message for Northwestern University Auditory Test Number 6 by a female speaker. *J Speech Hear Disord.* 1990;55(4):771–778.

14. Wilson RH, Noe CM, Cruickshanks KJ, Wiley TL, Nondahl DM. Prevalence and degree of hearing loss among males in the Beaver Dam cohort: a comparison of veterans and nonveterans. *J Rehabil Res Dev.* 2010;47 (6):505–520.

15. Ventry IM, Weinstein BE. Identification of elderly people with hearing problems. *ASHA.* 1983;25(7): 37–42.

16. Newman CW, Weinstein BE, Jacobsen GP, Hug GA. The Hearing Handicap Inventory for Adults: psychometric adequacy and audiometric correlates. *Ear Hear.* 1990;11(6):430–433.

17. Newman CW, Weinstein BE, Jacobson GP, Hug GA. Test-retest reliability of the Hearing Handicap Inventory for Adults. *Ear Hear.* 1991;12(5):355–357.

18. Newman CW, Jacobson, Hug GA, Weinstein BE, Malinoff RL. Practical method for quantifying hearing aid benefit in older adults. *J Am Acad Audiol.* 1991;2(2):70–75.

19. American Speech-Language-Hearing Association. *Guidelines for Audiologic Screening.* Rockville, MD: ASHA; 1997.

20. Talbott E, Helmkamp J, Matthews K, Kuller L, Cottington E, Redmond G. Occupational noise exposure, noise-induced hearing loss, and the epidemiology of high blood pressure. *Am J Epidemiol.* 1985;121(4):501–514.

21. Healthy People 2020. *Hearing and Other Sensory or Communication Disorders.* Washington, DC: US Department of Health and Human Services. Available at: http://www.healthypeople.gov/2020/topicsobjectives2020/objectiveslist.aspx?topicid=20. Accessed May 10, 2012.

22. Lin FR, Thorpe R, Gordon-Salant S, Ferrucci L. Hearing loss prevalence and risk factors among older adults in the United States. *J Gerontol A Biol Sci Med Sci.* 2011;66(5):582–590.

23. Mościcki EK, Elkins EF, Baum HM, McNamara PM. Hearing loss in the elderly: an epidemiologic study of the Framingham heart study cohort. *Ear Hear.* 1985;6(4): 184–190.

24. Plath P. Problems in fitting hearing aids in the elderly. *Acta Otolaryngol Suppl.* 1990;111(476):278–280.

25. Gussekloo J, de Bont LEA, von Faber M, et al. Auditory rehabilitation of older people from the general population—the Leiden 85-plus study. *Br J Gen Pract.* 2003;53(492):536–540.

26. Karlsson AK, Rosenhall U. Aural rehabilitation in the elderly: supply of hearing aids related to measured need and self-assessed hearing problems. *Scand Audiol.* 1998;27(3):153–160.

27. Davis AC. The prevalence of hearing impairment and reported hearing disability among adults in Great Britain. *Int J Epidemiol.* 1989;18(4):911–917.

28. Gopinath B, Schneider J, Hartley D, et al. Incidence and predictors of hearing aid use and ownership among older adults with hearing loss. *Ann Epidemiol.* 2011;21 (7):497–506.

29. Occupational Safety & Health Administration. Occupational safety & health standards: standard 1910.95, occupational noise exposure. Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9735. Accessed May 10, 2012.

30. Reilly MJ, Rosenman KD, Kalinowski DJ. Occupational noise-induced hearing loss surveillance in Michigan. *J Occup Environ Med.* 1998;40(8):667–674.

31. Johnson CE, Danhauer JL, Koch LL, Celani KE, Lopez IP, Williams VA. Hearing and balance screening and referrals for Medicare patients: a national survey of primary care physicians. *J Am Acad Audiol.* 2008;19 (2):171–190.

32. Yueh B, Shapiro N, MacLean CH, Shekelle PG. Screening and management of adult hearing loss in primary care: scientific review. *JAMA.* 2003;289(15):1976–1985.

33. Pronk M, Kramer SE, Davis AC, et al. Interventions following hearing screening in adults: a systematic descriptive review. *Int J Audiol.* 2011;50(9):594–609.

34. Smith PA, Davis A, Pronk M, et al. Adult hearing screening: what comes next? *Int J Audiol.* 2011;50 (9):610–612.

35. Palmer CV, Solodar HS, Hurley WR, Byrne DC, Williams KO. Self-perception of hearing ability as a strong predictor of hearing aid purchase. *J Am Acad Audiol.* 2009;20(6):341–347.

36. Chou R, Dana T, Bougatsos C, Fleming C, Beil T. Screening adults aged 50 years or older for hearing loss: a review of the evidence for the US Preventive Services Task Force. *Ann Intern Med.* 2011;154(5):347–355.

37. Yueh B, Collins MP, Souza PE, et al. Long-term effectiveness of screening for hearing loss: the screening for auditory impairment—which hearing assessment test (SAI-WHAT) randomized trial. *J Am Geriatr Soc.* 2010;58(3):427–434.

38. Chisolm TH, Johnson CE, Danhauer JL, et al. A systematic review of health-related quality of life and hearing aids: final report of the American Academy of Audiology task force on the health-related quality of life benefits of amplification in adults. *J Am Acad Audiol.* 2007;18(2):151–183.

39. Mulrow CD, Aguilar C, Endicott JE, et al. Quality-of-life changes and hearing impairment: a randomized trial. *Ann Intern Med.* 1990;113(3):188–194.

40. Mulrow CD, Tuley MR, Aguilar C. Sustained benefits of hearing aids. *J Speech Hear Res.* 1992;35 (6):1402–1405.

41. Jerger J, Chmiel R, Florin E, Pirozzolo F, Wilson N. Comparison of conventional amplification and an assistive listening device in elderly persons. *Ear Hear.* 1996;17(6):490–504.

42. Laplante-Lévesque A, Hickson L, Worrall L. Rehabilitation of older adults with hearing impairment: A critical review. *J Aging Health.* 2010;22(2):143–153.