Hearing Threshold Levels at Age 70 Years (65–74 Years) in the Unscreened Older Adult Population of the United States, 1959–1962 and 1999–2006

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Objectives: To provide hearing threshold percentiles from unscreened older adults for creating new Annex B reference standards.

Design: Percentiles are calculated, and 95% confidence intervals for medians from two U.S. surveys are compared graphically.

Results: Median thresholds are lower (better) in the 1999–2006 National Health and Nutrition Examination Survey for men across all frequencies except 1 kHz. Results for women are similar; however, there is more overlap in confidence intervals across frequencies.

Conclusions: The prevalence of hearing impairment in older adults, age 70 years (65–74 years), is lower in 1999–2006 compared with 1959–1962, consistent with our earlier findings for younger adults.

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INTRODUCTION

We recently calculated and published percentile distributions of hearing threshold levels, by age and sex, from the National Health and Nutrition Examination Survey (NHANES), 1999–2004 (Hoffman et al. 2010). Our primary goal was to offer these new reference data as a possible replacement for Annex B, a long-standing reference for age-related hearing loss in both international (ISO-1999, 1990) and national (ANSI S3. 44-1996) standards.

Annex B is based on much older data from the U.S. National Health Examination Survey (NHES) collected in 1959–1962 (Glorig & Roberts 1965). These hearing threshold data were unscreened; in particular, there was no exclusion of subjects in the sample based on otologic or noise exposure history. For tabular presentation in Annex B, the adult U.S. population was divided into four 10-year age groups by sex: age 30 years (25–34 years), age 40 years (35–44 years), age 50 years (45–54 years), and age 60 years (55–64 years). Our recent article used the same four age by sex groupings, but the ISO revision committee has since decided to include hearing reference percentile data for men and women at age 70 years (65–74 years) in the forthcoming update to Annex B.

The purpose of this brief report is to provide the required additional information for older adults at age 70 years (65–74 years), on the basis of the same methods, and to display in the same distributional format, as in our earlier article (Hoffman et al. 2010).

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MATERIALS AND METHODS

The NHANES is an ongoing complex, multistage, stratified, cluster sample design health examination survey conducted by the U.S. National Center for Health Statistics (NCHS). Details of sampling, audiometry, and statistical analysis are identical to those described in Hoffman et al. (2010) except as detailed later.

In 1999–2004, audiometric data were collected for adults aged 20–69 years, while older adults (>70 years) were sampled in 2005 and 2006. To estimate thresholds for men and women aged 65–74 years, we combined data from 472 subjects aged 65–69 years from NHANES 1999–2004 and 252 subjects aged 70–74 years from NHANES 2005–2006. Although there were far more subjects in the 65–69-year-old group, they did not disproportionately influence the final threshold distributions, because of the use of sample weights, as described later. Altogether, the total sample size was 724 for age 70 years (65–74 years) in NHANES 1999–2006. For comparison purposes, audiometric data from the much earlier NHES, 1959–1962, the source of the current Annex B, were also analyzed using the same methodology. In the NHES sample, 564 subjects aged 70 years (65–74 years) completed the audiometric examination.

To combine the data across this span of years, 1999–2006, to produce estimates for adult men and women age 70 years (65–74), we followed guidelines supplied by the NCHS NHANES Web Tutorial as shown in *Task 2: When and How to Construct Weights When Combining Survey Cycles*. Data collected in 1999–2000 were based on population estimates developed by the U.S. Census Bureau before the Year 2000 Decennial Census counts became available, but sample weights beginning with the 2-year NHANES cycle of 2001–2002 and beyond (through 2010) are based on population estimates that incorporate the Year 2000 Census counts. In combining across this span of years, we followed NCHS guidelines, employing their special 4-year sample weights to bridge the two different reference populations for 1999–2002, and then used the national weights for 2003–2004 and 2005–2006, as outlined on the NCHS website (2010).

As in our earlier article (Hoffman et al. 2010), we defined "better ear" (BE) on a frequency by frequency basis. Thus, the BE threshold at each frequency is simply the threshold of the ear with the lower threshold. We considered a measured threshold of "x" dB hearing level (HL), assessed in 5 dB HL steps, ranging from −10 dB HL to +120 dB HL, to be the midpoint of the interval $x - 2.5$ to $x + 2.5$ dB HL. This midpoint convention allows percentiles estimated by linear interpolation to correspond closely and without bias to those

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TABLE 1. Proposed new Annex B (right side); better-ear percentile distribution of hearing threshold levels according to frequency for age 70 years (65–74 years) by gender, based on the U.S. National Health and Nutrition Examination Survey (NHANES), 1999–2006; the percentile distribution (left side) from the source of the current Annex B, the U.S. National Health Examination Survey (NHES), 1959–1962, is provided for comparison

	Hearing Threshold Level (dB HL)									
	NHES, 1959–1962 (Age 70 Years) Percentiles					NHANES, 1999–2006 (Age 70 Years) Percentiles				
Frequency (Hz)	5	10	50	90	95	5	10	50	90	95
Men										
500	7	8	19	41	51	1	4	15	28	35
1000	1	2	15	43	58	3	4	14	31	39
2000	4	8	26	60	68	4	6	21	54	61
3000	15	20	49	72	80	10	13	37	66	72
4000	18	23	54	77	83	15	20	49	73	80
6000	30	36	67	92	97	20	26	56	84	93
8000	—	—	—	—	—	23	30	60	86	93
Women										
500	7	9	21	41	59	2	5	17	32	44
1000	1	3	15	35	51	1	3	13	33	37
2000	2	5	20	45	59	2	4	17	35	40
3000	7	10	26	53	64	5	8	20	42	47
4000	9	11	28	60	68	7	10	27	48	54
6000	19	23	44	74	83	14	17	37	61	66
8000	—	—	—	—	—	11	16	48	74	81

estimated by simply counting cases or by using the grouped data method (Dobie 2006). All estimated threshold percentiles are rounded to the nearest integer.

RESULTS

Estimates of BE hearing threshold percentiles for men and women aged 70 years (65–74 years) are shown in Table 1 for NHES, 1959–1962, and for NHANES, 1999–2006. No hearing thresholds were obtained at 8 kHz in 1959–1962. All of the percentile values are the same (four values) or higher (worse) for the NHES, 1959–1962, data compared with the recent data from NHANES, 1999–2006, with the exception of two values at 1 kHz, the 5th and 10th percentiles for men, which were only 2 dB HL lower.

Figures 1 and 2 depict 95% confidence intervals (CIs) for BE median thresholds at age 70 years (65–74 years). The medians, which are shown in the table but not in the figures, lie midway between the upper and lower confidence limits. For both Figure 1A (NHES, 1959–1962) and Figure 1B (NHANES, 1999–2006), the CIs overlap for men and women only at 0.5 and 1 kHz; at frequencies of 2, 3, 4, and 6 kHz, men have worse (higher) thresholds compared with women. The differences between the BE median hearing thresholds of men and women averaged across the high-frequency range (3, 4, and 6 kHz) were determined to be 24.0 dB HL in NHES, 1959–1962, and 19.3 dB HL in NHANES, 1999–2006, by calculating the mean of the median differences (found in Table 1).

Median hearing levels from the two time periods are contrasted separately for men (Fig. 2A) and women (Fig. 2B). For men, only at 1 kHz is there considerable overlap in the CIs. BE median hearing levels are better by an average of 7.4 dB HL across the remaining frequencies. For women,

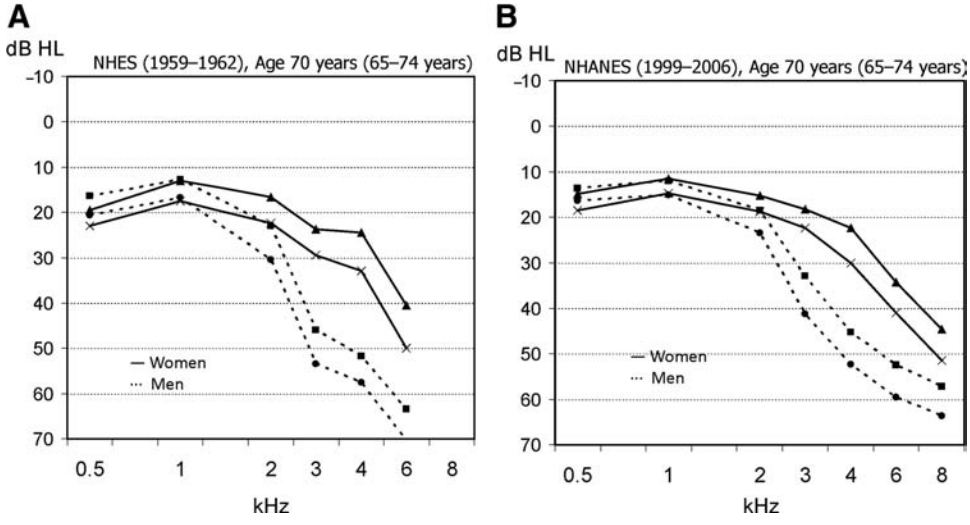

Fig. 1. The 95% confidence intervals (CIs) for better ear medians are shown in audiometric format (threshold in dB HL vs. frequency in kHz) for comparison of women vs. men at age 70 years (65–74 years). The solid curves represent women and the dashed curves represent men, based on (A) National Health Examination Survey (NHES), 1959–1962, and (B) National Health and Nutrition Examination Survey (NHANES), 1999–2006, respectively. The markings on each curve (triangle, square, circle, or "×") represent the lower or upper 95% CI threshold values at specific pure-tone frequencies of 0.5, 1, 2, 3, 4, 6, or 8 kHz.

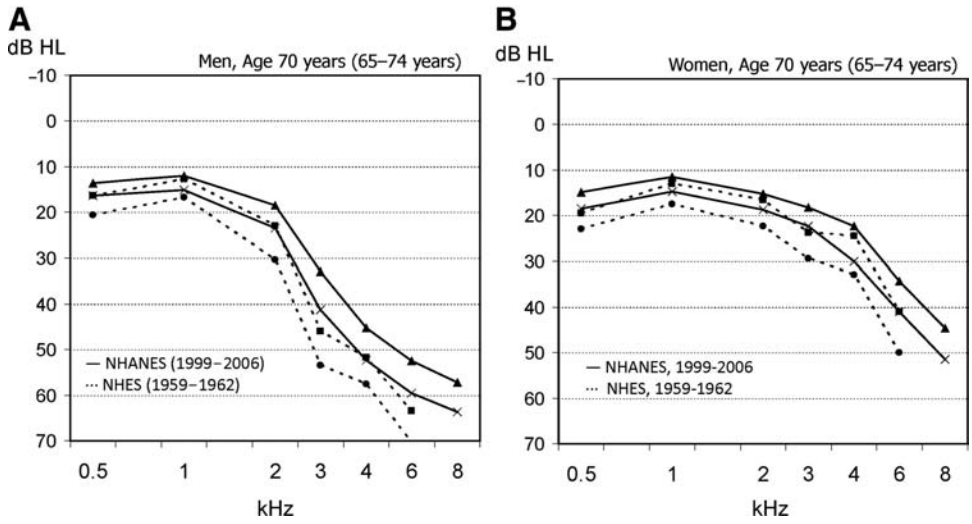

Fig. 2. The 95% confidence intervals (CIs) for better ear medians are shown in audiometric format (threshold in dB HL vs. frequency in kHz) for (A) men and (B) women shown separately at age 70 years (65–74 years). The solid curves represent National Health and Nutrition Examination Survey (NHANES), 1999–2006, and the dashed curves represent National Health Examination Survey (NHES) I, 1959–1962. The markings on each curve (triangle, square, circle, or "×") represent the lower or upper 95% CI threshold values at specific pure-tone frequencies of 0.5, 1, 2, 3, 4, 6, or 8 kHz.

there is greater overlap in the CIs and the amount of shift is smaller for women, averaging 5.0 dB HL across all frequencies except 1 kHz.

We also performed an analysis of the risk of BE hearing impairment, defined by the pure-tone average of thresholds across the four frequencies 0.5, 1, 2, and 4 kHz > 25 dB HL, comparing the 1999–2006 NHANES data for adults aged 70 years to the reference population from the NHES, 1959–1962. Using the BE pure-tone average, the odds ratios were 0.59 (95% CI: 0.41, 0.87; $p < 0.01$) for men and 0.57 (95% CI: 0.38, 0.87; $p < 0.01$) for women. The prevalence of hearing impairment based on the BE four-frequency average was 58.9% for men, 39.4% for women, and 48.1% for both sexes combined in NHES. The prevalence of hearing impairment improved to 46.0% for men, 27.2% for women, and 36.0% for both sexes combined in NHANES. This translates into a 25% drop (improvement) for both sexes combined in the prevalence of hearing impairment for older adults aged 70 years (65–74 years) examined in NHANES 1999–2006.

DISCUSSION

As expected, hearing thresholds of older adults aged 70 years (65–74 years) are higher (worse) than those of younger adults in both the NHES and the NHANES (see Tables 1 and 2 in Hoffman et al. 2010). In our earlier article, we cited reference standards for subjects in the NHES, 1959–1962, at age 30 years (25–34 years), 40 years (35–44 years), 50 years (45–54 years), and 60 years (55–64 years), which were originally calculated by Johnson (1978) and corrected by Clark and Bohl (1992). However, in this report, we derived the reference standards for subjects aged 70 years (65–74 years) from the original audiometric threshold data of the NHES, 1959–1962, as these results were not available in the literature. The data shown in this report in both surveys indicate that men at age 70 years have higher BE median thresholds than women, especially above 1 kHz. There seems to be a narrowing of sex differences over time: the male–female differences in BE median thresholds in the high frequencies of 3, 4, and 6 kHz are about 5 dB smaller in the more recent NHANES 1999–2006 (see Table 1).

For both men and women aged 70 years, median thresholds above 1 kHz are better in the more recent survey, as previously shown for younger adults (Hoffman et al. 2010). Possible reasons for this improvement, as discussed in the previous article, include less occupational noise exposure, less smoking, and perhaps better control of diabetes and other cardiovascular risk factors. The apparent improvement at 0.5 kHz may be in part artifactual, attributable to less stringent audiometric ambient noise standards in 1959.

The provision of updated reference standards for an unscreened population at age 70 years based on NHANES, 1999–2006, is important for several reasons. With increasing lifespan and the aging of the "baby boom" generation in the United States, the number of individuals with sensory impairments (especially hearing loss) will increase the need for medical services (Dillon et al. 2010). A recent study by Hickson et al. (2010) of community-living adults aged 62–88 years demonstrated the functional problems that hearing loss can cause in normal activities, such as driving. Moderate-to-severe hearing impairment was associated with significantly poorer performance while driving an automobile with complex auditory or visual distracters, when compared with similarly aged subjects with normal or mild hearing loss. Unfortunately, many older adults have not had recent hearing tests and do not know if their hearing is impaired. A study of patients aged 65 years and older in a University of Pittsburgh Internal Medicine Residency Program reviewed medical history records (Shaffer and Day 2010) and found screening data for hearing assessments are much more often missing (82%) than are records for cognitive screening (68%), vision screening (60%), or depression screening (43%).

The American Speech–Language–Hearing Association (ASHA 1997) recommends that adults older than 50 years should complete a limited audiometric screening test and a self-assessment hearing disability questionnaire at least every 3 years. In contrast, the U.S. Preventive Services Task Force (USPSTF 1996) recommends routine and periodic hearing screening be performed on adults aged 65 years or older without endorsing any of several quick and easy assessment methods. The USPSTF is currently reviewing the topic of hearing screening; more detailed or specific recommendations may be forthcoming soon. There is an objective in Healthy People 2010 (2004) to track the percent of adults (and older adults) with hearing examinations in the past 5

years to increase awareness of the potential hearing health benefit. Although hearing impairment is common in older adults (36% prevalence for adults aged 65–74 years old in NHANES 1999–2006, as noted in the Results section), because of the typically gradual onset of hearing loss with aging, it may be unnoticed. Whatever screening method is chosen, early detection can lead to referral for a follow-up audiological examination and management of hearing loss, including hearing aids and an improved quality of life (Johnson et al. 2009). The threshold percentiles provided in this report could be used to inform patients how their hearing thresholds compare to population reference values.

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The authors prepared this report in their roles as U.S. Federal employees, except for one (R.A.D.), who is a member of the faculties of The University of Texas Health Science Center at San Antonio and the University of California at Davis and also has a private consulting practice in otology. The authors have no other financial or potential conflicts of interest to declare.

The views expressed are solely those of the authors and do not necessarily represent the agencies or institutions for which they work.

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