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Kids Nowadays Hear Better Than We Did: Declining Prevalence of Hearing Loss in US Youth, 1966–2010

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Objectives/Hypothesis: To investigate factors associated with hearing impairment (HI) in adolescent youths during the period 1966–2010.

Study Design: Cross-sectional analyses of US sociodemographic, health, and audiometric data spanning 5 decades.

Methods: Subjects were youths aged 12 to 17 years who participated in the National Health Examination Survey (NHES Cycle 3, 1966–1970; n = 6,768) and youths aged 12 to 19 years in the Third National Health and Nutrition Examination Survey (NHANES III, 1988–1994; n = 3,057) and NHANES (2005–2010; n = 4,374). HI prevalence was defined by pure-tone average (PTA) ≥ 20 dB HL for speech frequencies (0.5, 1, 2, and 4 kHz) and high frequencies (3, 4, and 6 kHz). Multivariable logistic models were used to estimate the odds ratio (OR) and 95% confidence interval (CI).

Results: Overall speech-frequency HI prevalence was 10.6% (95% CI: 9.7%-11.6%) in NHES, 3.9% (95% CI: 2.8%-5.5%) in NHANES III, and 4.5% (95% CI: 3.7%–5.4%) in NHANES 2005 to 2010. The corresponding high-frequency HI prevalences were 32.8% (95% CI: 30.8%-34.9%), 7.3% (95% CI: 5.9%-9.0%), and 7.9% (95% CI: 6.8%-9.2%). After adjusting for sociodemographic factors, overall high-frequency HI was increased twofold for males and cigarette smoking. Other significant risk factors in NHANES 2005 to 2010 included very low birth weight, history of ear infections/otitis media, ear tubes, fair/poor general health, and firearms use.

Conclusions: HI declined considerably between 1966 to 1970 and 1988 to 1994, with no additional decline between 1988 to 1994 and 2005 to 2010. Otitis media history was a significant HI risk factor each period, whereas very low birth weight emerged as an important risk factor after survival chances improved. Reductions in smoking, job-related noise, and firearms use may partially explain the reduction in high-frequency HI. Loud music exposure may have increased, but does not account for HI differences.

Key Words: Hearing impairment, pediatric population, low birth weight, ear infections, ear tubes, noise exposure, loud music, cigarette smoking.

Level of Evidence: NA

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INTRODUCTION

Since at least the 1960s, clinicians have worried about the risk of hearing loss from nonoccupational noise in daily life, especially amplified music.[1,2] In the 1970s, concern focused on live music at concerts and discotheques[3,4]; for most listeners, exposure was episodic and relatively brief. In recent decades, portable music players (PMPs) (including the Walkman, Discman, iPod, and

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smart phone) allow users, including children, to listen to loud music for many hours each day. Daily exposures for the most enthusiastic listeners can be both loud (above 90 dBA [A-weighted decibel scale])[5,6] and long (16% of students listened more than 3 hr/d),[7] exceeding the 85 dBA time-weighted average level that would, for occupational exposure, require enrollment in a hearing conservation program.[8]

If hazardous recreational exposure to loud music has been increasing, one might expect a parallel increase in the population prevalence of hearing loss. Previous analyses of audiometric surveys of US adults have shown that hearing thresholds, especially in higher frequencies, have actually improved since 1960.[9–11] Possible reasons include loss of manufacturing jobs and greater use of hearing protection in noisy workplaces. However, PMP use begins in childhood; effects of excessive exposure might best be seen in surveys of older children and adolescents, for whom occupational noise exposure might not be an important risk factor. But exposure to loud music is not the only risk factor that may have changed during those decades.

Many risk factors for hearing loss in adults could also predict hearing loss in children and adolescents. These include demographic variables (male sex, increasing age, white race, and low socioeconomic status [SES]),[11] nonoccupational noise other than music (especially gunfire),[12,13] occupational noise, smoking,[13] and head injury.[14] The prevalence of some of these risk factors could have changed since the 1960s. For example, child labor in noisy jobs may be less common.

Other risk factors are especially important for children: otitis media (OM) (including surgical treatment such as ventilating tubes), meningitis, viral infections (measles, mumps, rubella, cytomegalovirus), congenital hereditary hearing loss, and perinatal illness.[15,16] Management of OM has evolved considerably since the 1950s with the introduction of middle ear ventilating tubes[17] and progressively more potent oral antibiotics (e.g., ampicillin and amoxicillin), which could have reduced the incidence of hearing loss from OM.[18,19]

Premature very low birth weight (<1,500 g) infants and other low birth weight (<2500 g) infants born preterm or growth retarded *in utero* often require prolonged stays in neonatal intensive care units (NICUs); predictors of hearing loss in NICU graduates include sepsis, prolonged intubation and ventilation, oxygen therapy, acidosis, and brain bleeding or infarction.[20,21] Improved management of these infants has led to increased survival since the 1970s both within the United States and abroad, which in turn may have led to increased prevalence of hearing loss in children.[22–24]

Individual measles, mumps, and rubella vaccines were first licensed in 1963, 1967, and 1969, respectively. Measles was by far the disease with the greatest incidence, and measles cases fell from 500,000 per year to well below 100,000 cases following vaccine introduction.[25] The advent of the mumps–measles–rubella vaccine in 1971 nearly eliminated hearing loss from these viruses.[26] Vaccines against two major bacterial causes of meningitis (*Haemophilus influenzae* type B vaccine in 1987 and the conjugate vaccine against meningococcus in 2005) should have reduced the incidence of meningitic hearing loss.[27,28]

Some risk factor changes (increased exposure to loud music, more surviving premature infants) may have led to more hearing loss in children and adolescents, whereas others (antibiotics, immunization) may have led to less hearing loss. Has the prevalence of hearing impairment of children changed in recent decades? To address this question, we analyzed three cross-sectional, nationally representative health surveys that included home interviews and audiometric exams for American youths between the ages 12 to 17 years (or 12 to 19 years) between 1966 and 2010.

MATERIALS AND METHODS

Subjects and Datasets

Since 1960, the US National Center for Health Statistics has conducted three nationally representative audiometric surveys of American youths that included thresholds for both ears, at frequencies of 0.5, 1, 2, 3, 4, 6, and 8 kHz. Cycle 3 of the National Health Examination Survey (NHES 1966–1970) enrolled 6,768 or 90.1% of the targeted youth sample between 12 to 17 years of age. The National Health and Nutrition Examination Surveys (NHANES) in both 1988 to 1994 and 2005 to 2010 achieved an 83% response rate for youths aged 12 to 19 years participating in health exams; however, 154 and 353 youths, respectively, were excluded from subsequent analyses due to incomplete ascertainment of audiometric thresholds. Hence, NHANES III 1988 to 1994 obtained complete audiometric thresholds for 3,057 or 78.6% of the targeted sample, and NHANES 2005 to 2010 obtained audiometric thresholds for 4,374 or 77.3% of the targeted sample of 12- to 19-year-olds. These complex, multistage, stratified, cluster-sample surveys were designed to assess the health status of the civilian, noninstitutionalized US population by a health-related household questionnaire, medical examinations, physiological measurements, and laboratory tests. The surveys were conducted with institutional review board approval and written consent of all participants (or parent/guardian as appropriate). All three surveys collected basic sociodemographic data (age, sex, race/ethnicity, family income, and parental education), but other risk factor questions differed among these surveys.

Hearing Components

The surveys included otoscopic examination (by a pediatrician in the NHES 1966–1970, by health technicians in the later surveys) and air-conduction pure-tone audiometric testing conducted by trained health technicians. NHES 1966 to 1970 and NHANES III 1988 to 1994 used manual audiometry, whereas NHANES 2005 to 2010 thresholds were obtained using a specially programmed microprocessor (automatic) audiometer, Interacoustics (Middelfart, Denmark) model AD226. Thresholds in all three surveys were obtained using a modified Hughson-Westlake procedure.[29] Supra-aural TDH-39 earphones (Telephonics, Farmingdale, NY) were used in the NHES 1966 to 1970 and NHANES 2005 to 2010, whereas the NHANES 1988 to 1994 used supra-aural TDH-49/50 earphones (Telephonics). The NHANES 2005 to 2010 also used insert phones (ER-3A; Etymotic Research, Inc., Elk Grove Village, IL) in cases of marked asymmetry or if ear canal collapse was suspected.

In all three surveys, audiometry was conducted in acoustically treated rooms. For the NHES 1966 to 1970, rooms were

treated to comply with the maximum background noise standard specified by the American Standards Association (ASA) 1960 criteria.[30] Roberts and Ahuja reported the performance of the room in attenuating external noise was determined by acoustical surveys conducted periodically under normal test conditions with twice-daily checks by the technicians, weekly sound pressure level calibration, and approximate monthly checking of all the field equipment by the acoustics laboratory; the measurements obtained and further analysis of the audiometric data showed no evidence of masking from external noise throughout the test frequency range.[31] For the 1988 to 1994 and 2005 to 2010 NHANES, more stringent background noise standards were applied.[32–35] Because the NHES 1966 to 1970 allowed more ambient noise, low-frequency thresholds, especially at 0.5 kHz, could have been slightly elevated.

Some of the audiometry in the NHES 1966 to 1970, like all audiometry in the United States until 1964, used the ASA Z24.5-1951 calibration standard,[36] based on hearing surveys done in the 1930s. Roberts and Ahuja reported that thresholds in the NHES 1966 to 1970 obtained from audiometers calibrated to the 1951 standard were corrected to account for the differences in calibration standards and recorded according to the newer American National Standards Institute (ANSI) S3.6-1969 standard.[37] Thus, audiograms from all three surveys are comparable in terms of calibration to International Organization for Standardization (ISO)-R389 1964 and the current ISO-389-1 1998 or ANSI S3.6-2004.[38–40]

Audiometric Classification

In previous articles[9–11] we reported the prevalence of hearing impairment defined as pure-tone average threshold > 25 dB HL; this is a common—albeit arbitrary—criterion for mild hearing loss in adults. For this article, we selected a cutoff of ≥20 dB HL for two reasons. First, many audiologists (for example, Downs[41]) have shown that children with speech frequency thresholds <25 dB HL have deficits in language acquisition and academic achievement. Equally important, the prevalence of threshold averages >25 dB HL is very low in children and adolescents; a slight reduction of criterion level yields many more cases and thus more statistical power to examine both trends over time and associations with risk factors. The ≥ 20 dB HL criterion was also used by the Gates Foundation and the World Health Organization's (WHO) Global Burden of Disease (GBD) project[42] to define mild hearing loss. We report prevalence for two pure-tone averages: 0.5, 1, 2, and 4 kHz (speech frequencies) and 3, 4, and 6 kHz (the high frequencies most susceptible to noise-induced hearing loss).

Following the WHO and GBD definitions, the degree of hearing loss in this article was categorized based on better-ear, speech frequency PTA: 1) mild hearing impairment (HI) (20 dB HL ≤ PTA < 35 dB HL), 2) moderate HI (35 dB HL ≤ PTA < 50 dB HL), 3) moderately severe HI (50 dB HL ≤ PTA < 65 dB HL), and 4) severe or profound HI or deaf (PTA ≥ 65 dB HL).

Sociodemographic and Health-Related Components

SES was estimated differently across surveys; annual family income categories were used in the NHES 1966 to 1970 and NHANES 1988 to 1994, but poverty-to-income ratio categories were used in the NHANES 2005 to 2010. However, our income groups were calibrated to include approximately the same proportion of families across the time period. Although we had access to educational levels of parents, the proportion in the population who completed high school (or college) changed markedly over time and was therefore a much less stable SES characteristic. In the NHES 1966 to 1970, African American or black race was not oversampled, nor was Hispanic ethnicity ascertained, unlike the NHANES 1988 to 1994 and 2005 to 2010. Other characteristics, such as birth weight, were available for youths in the NHES 1966 to 1970 and NHANES 2005 to 2010, but not in the NHANES 1988 to 1994.

The NHES 1966 to 1970 household questionnaire included only a few questions on hearing and medical conditions known to affect hearing.[37] In the NHANES 2005 to 2010, household questionnaire items were more extensive and included questions about subjective hearing loss, hearing aid use, tinnitus, last time hearing was tested, and both occupational and nonoccupational noise exposure.[43]

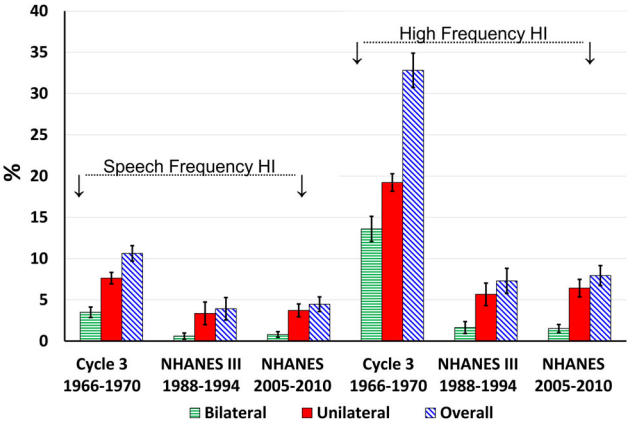

Fig. 1. Bilateral, unilateral, and overall prevalence (%) of speech-frequency and high-frequency hearing impairment (HI) in three national health examination surveys, 1966–2010. Error bars show 95% confidence intervals. NHANES = National Health and Nutrition Examination Survey. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Statistical Analysis

Prevalence is presented along with 95% CIs. The statistical programs SAS version 9.2 (SAS Institute, Inc., Cary, NC) and SUDAAN (Research Triangle Institute, Research Triangle, NC) were used to assemble the data and to account for the complex survey design in the analysis. Population estimates for medians and percentiles were weighted using the NHANES examination sample weights to produce nationally representative estimates. The NHANES examination sample weights incorporate the differential probabilities of selection and include adjustments for oversampling of selected populations, noncoverage (the potential problem that some groups in the population do not appear in the sampling frame), and nonresponse. Standard errors were estimated using SUDAAN by Taylor series linearization.

For the bar chart (Fig. 1) and in all the tables, we have included 95% CIs. A quick glance at Figure 1 and comparisons within and across tables will reveal which comparisons are statistically significant, because nonoverlap of 95% CIs is a strong indication of statistical significance beyond the nominal $P < .05$ criterion; for example, if two CIs just touch, the estimate of statistical significance, or P value, is about 0.01.[44] As CIs move further apart, P values become smaller and the statistical significance becomes greater. When 95% CIs do overlap by as much as half the length of one CI arm, then the P value is approximately .05; this result has been shown to be robust and sufficiently accurate when samples sizes are 10 or greater and

TABLE I.
Speech-Frequency HI* of Youths in Three US Hearing Exam Surveys, 1966–2010.

Surveys	No HI	Unilateral HI	Bilateral (BE) HI			
	BE: PTA < 20 dB HL, WE: PTA < 20 dB HL	BE: PTA < 20 dB HL, WE: PTA ≥ 20 dB HL	Mild: 20 ≤ PTA < 35 dB HL	Moderate: 35 ≤ PTA < 50 dB HL	Moderately Severe: 50 ≤ PTA < 65 dB HL	Severe, Profound, or Deaf: PTA ≥ 65 dB HL†
NHES Cycle 3 (1966–1970), Wtd % (95% CI)‡	89.38 (88.40-90.29)	7.39 (6.76-8.07)	2.37 (2.02-2.78)	0.73 (0.50-1.07)	0.11 (0.06-0.20)	0.02 (0.00-0.09)
Aged 12–17 years, population	20,282,539	1,675,873	538,000	165,777	25,234	4,568
NHANES III (1988–1994), Wtd % (95% CI)‡	96.08 (94.50-97.21)	3.34 (2.24-4.96)	0.29 (0.13-0.67)	0.22 (0.06-0.81)	0.00 (0.00-0.00)	0.07 (0.01-0.38)
Aged 12–19 years, population	26,193,971	910,996	79,834	60,341	0	18,525
NHANES (2005–2010), Wtd % (95% CI)‡	95.54 (94.56-96.23)	3.69 (3.00-4.54)	0.68 (0.42-1.10)	0.07 (0.02-0.22)	0.015 (0.013-0.017)	0.004 (0.001-0.031)
Aged 12–19 years, population	29,682,569	1,147,861	211,513	21,914	4,528	1,284

*HI is defined by air-conduction audiometry and the PTA of four threshold values (0.5, 1, 2, and 4 kHz) in each ear separately.
†The NHES did not attempt to measure hearing threshold levels that exceeded 75 dB hearing level.[28]
‡Weighted (Wtd) % is the nationally weighted prevalence percent estimate; population corresponds to estimated number of US youths by hearing status within each survey period.
BE = better ear; CI = confidence interval; HI = hearing impairment; NHANES = National Health and Nutrition Examination Survey; NHES = National Health Examination Survey; PTA = pure-tone average; WE = worse ear.

the width of the two CIs do not differ by more than a factor of 2.[44] In this report, we relied on the more conservative nonoverlapping confidence intervals criterion because multiple such comparisons are made. In reporting and displaying medians and percentiles of thresholds, we adopted the interval midpoint estimate as opposed to the upper limit estimate generated by some statistical programs (including SUDAAN), which has been described earlier.[9]

Associations of hearing loss prevalence with risk factors were tested with an α level of .05 for statistical significance with SAS and SUDAAN statistical packages using logistic regression models that were: 1) unadjusted, 2) adjusted only for demographic factors (age, sex, race/ethnicity, and family income), or 3) multivariable, adjusting for all risk factors displayed.

RESULTS

Trends in Hearing Impairment

In the 1966 to 1970 survey, 89.4% of youths were free of speech-frequency HI (Table I). This nonimpaired percentage grew to about 96% in the 1988 to 1994 and 2005 to 2010 surveys. The prevalence of unilateral HI dropped from 7.4% in the 1966 to 1970 survey to less than half that amount in the later surveys. Bilateral HI of different severity levels showed similar patterns. The 95% CIs for the 1966 to 1970 survey did not overlap those for the later surveys, indicating that the decrease in all levels of speech-frequency HI after the 1966 to 1970 survey was statistically significant (one exception was "severe, profound, or deaf," where the numbers of affected individuals was relatively small, reducing statistical power). Comparing the 1988 to 1994 survey to the 2005 to 2010 survey data, all CIs overlapped, indicating the likelihood of no significant change.

High-frequency HI declined even more dramatically than speech frequency HI after the NHES Cycle 3 1966 to 1970 survey (Fig. 1) for bilateral, unilateral, and overall HI (sum of unilateral and bilateral). Again, 95% CIs for the NHES Cycle 3 1966 to 1970 survey did not overlap those for the later surveys, whereas the two later NHANES surveys had overlapping CIs.

Figure 2 shows the changes in threshold distributions between the 1966 to 1970 and 2005 to 2010 surveys for both boys and girls, and both better and worse ears, in audiometric format; the 10th, 50th, and 90th percentiles are displayed. For frequencies up to 2 kHz, the differences are very small—always less than 5 dB—over this 40-year span. For these lower frequencies, the most noticeable changes are for better ears at 0.5 kHz and 1 kHz, where 10th percentile thresholds were better in the 2005 to 2010 survey. These 10th percentile thresholds were better than 0 dB HL; the lower thresholds in the 2005 to 2010 survey could have been attributable to the less strict ambient noise requirements in the 1966 to 1970 survey. The small differences in better ear and lack of differences for worse ear, low frequency percentiles in Figure 2 provide empirical evidence that methodological differences between the two surveys were not responsible for the speech-frequency HI differences shown in Figure 1.

From 3 kHz to 8 kHz, hearing levels were markedly worse in the 1966 to 1970 survey than in the 2005 to 2010 survey. The differences were largest at 6 kHz, at the 90th percentile, and for worse ears. If calibration differences had been responsible for threshold differences across surveys, those differences would have been similar at all percentiles and for both better and worse ears. The audiometric patterns for the 1966 to 1970 survey are all notched (showing better thresholds at 8 kHz than in the 3–6 kHz region), which is suggestive of noise-induced hearing loss (NIHL). They are also more deeply notched

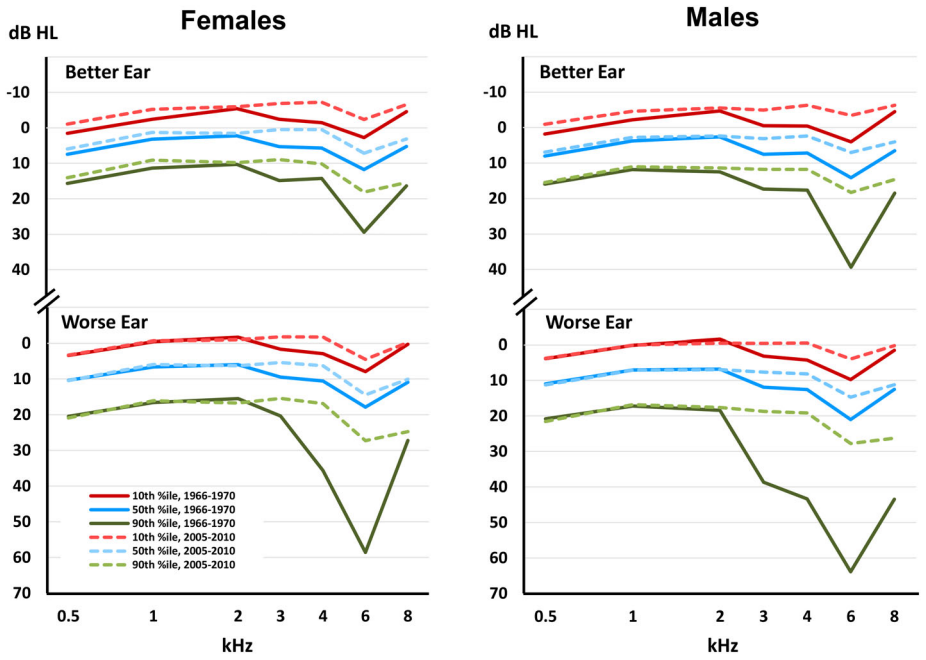

Fig. 2. Hearing threshold percentiles (10th, 50th, and 90th) for NHES Cycle 3, 1966–1970 (solid lines) and NHANES 2005–2010 (dashed lines) by sex and better versus worse ear. NHANES = National Health and Nutrition Examination Survey; NHES = National Health Examination Survey. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

in the 1966 to 1970 survey than in the 2005 to 2010 survey, suggesting more noise-induced hearing loss in the earlier survey.

Demographic Characteristics

Speech-frequency HI (unilateral and overall) was more prevalent in boys than in girls in the 1966 to 1970 survey (nonoverlapping CIs, Table II), but there was no significant sex difference in the 1988 to 1994 or 2005 to 2010 surveys (overlapping CIs, Tables III and IV). Table II also shows that although white youths had less overall speech-frequency HI in the 1966 to 1970 survey, that difference was not apparent in the 1988 to 1994 or 2005 to 2010 surveys. The decline in speech-frequency HI prevalence after the 1966 to 1970 survey is not accounted for by subsequent demographic changes in race/ethnicity in the United States. As shown in Tables II, III and IV, the decline in HI prevalence occurred across all racial/ethnic groups. In addition, low family income and low parental educational level were associated with increased HI (unilateral, bilateral, and overall) in the 1966-1970 survey, but not in the 2005 to 2010 survey.

Similar patterns for high frequencies were observed: male sex, low family income, and low educational level were associated with high frequency HI in the 1966 to 1970 survey, but not in the 1988 to 1994 or the 2005 to 2010 surveys. Demographic findings for the 1988 to 1994 survey were like those for the 2005 to 2010 survey. Only the highest parental education level (completion of college) was associated with less speech-frequency HI (bilateral only) and high-frequency HI (bilateral and overall).

Together, these findings point to adolescent health disparities based on sex, race, and SES that appear to have lessened since the 1966 to 1970 survey. Note that these were all bivariate analyses; the relative importance of each of these demographic variables is evaluated in the multivariable analyses.

Multivariable Analysis

Table V compares the 1966 to 1970 and 2005 to 2010 surveys with respect to demographic and other risk factors for bilateral (better ear) speech-frequency HI. For each survey, there are three columns showing ORs that are unadjusted, adjusted for demographic variables, and adjusted for all variables tabulated, respectively. For 1966 to 1970, significant associations were observed in fully adjusted analyses for male sex; low family income; history of earaches, myringotomy, or more than one episode of otorrhea; cigarette smoking; and less-than-excellent health.

For the 2005 to 2010 survey, although prevalence of bilateral speech-frequency HI was higher for males and for youths with low family income, CIs for these variables overlapped in fully adjusted analyses. Because the ORs for these variables were similar in both surveys, the lack of statistical significance is likely related to the smaller sample size and wider CIs in the NHANES 2005 to 2010. Significant fully adjusted associations in this time period included history of ear pressure equalization or tympanostomy tubes and use of firearms; neither of these variables was ascertained in the 1966 to 1970 survey. Finally, there was a strong dose-related effect of low and very low birth weight on speech-frequency HI (the lower the birth weight, the higher the prevalence of HI); this association was absent in the 1966 to 1970 survey.

Table VI shows similar findings for fully adjusted analyses of bilateral (better ear) high-frequency HI. In both

TABLE II.
Prevalence of Speech-Frequency and High-Frequency HI Among US Youths Aged 12–17 Years, NHES Cycle 3, 1966–1970

	Sample No.	Population-Weighted %*	Speech-Frequency HI, % (95% CI)†			High-Frequency HI, % (95% CI)‡		
			Overall§	Unilateral§	Bilateral§	Overall§	Unilateral§	Bilateral§
Total (1966–1970)	6,768	100.0	10.6 (9.7-11.6)	7.4 (6.8-8.1)	3.2 (2.7-3.9)	32.8 (30.8-34.9)	19.2 (18.2-20.3)	13.6 (12.1-5.2)
Sex								
Male	3,545	50.6	13.0 (11.6-14.6)	9.1 (8.0-10.4)	3.9 (3.2-4.7)	40.7 (37.8-43.7)	23.4 (21.5-25.4)	17.3 (15.5-19.2)
Female	3,223	49.4	8.2 (7.4-9.1)	5.6 (5.0-6.3)	2.6 (2.0-3.3)	24.7 (22.6-27.0)	14.9 (13.6-16.4)	9.8 (8.3-11.6)
Age, yr								
12-13	2,398	35.1	11.0 (9.7-12.5)	7.0 (6.0-8.2)	3.9 (3.1-5.0)	30.8 (28.3-33.4)	17.8 (16.5-19.1)	13.1 (11.2-15.2)
14-15	2,320	33.5	11.1 (9.8-12.5)	8.1 (6.8-9.5)	3.0 (2.3-4.0)	33.2 (30.7-35.7)	19.8 (18.0-21.7)	13.4 (11.5-15.5)
16-17	2,050	31.4	9.8 (8.3-11.4)	7.1 (6.1-8.2)	2.7 (1.9-3.8)	34.7 (31.7-37.8)	20.3 (18.1-22.6)	14.4 (12.8-16.2)
Race								
White	5,735	86.2	10.1 (9.2-11.2)	7.1 (6.4-7.8)	3.1 (2.5-3.8)	32.5 (30.3-34.7)	19.1 (18.1-20.1)	13.4 (11.7-15.2)
Black	999	13.3	13.4 (11.4-15.6)	9.1 (7.3-11.4)	4.3 (3.3-5.4)	35.3 (30.7-40.3)	20.0 (16.2-24.5)	15.3 (13.2-17.7)
Other	34	0.5	18.4 (11.5-28.2)	15.2 (7.2-29.3)	3.2 (0.4-23.6)	28.9 (17.9-43.2)	21.4 (13.8-31.6)	7.5 (2.3-21.8)
Family income								
<$3,000	817	11.8	15.0 (12.9-17.3)	9.7 (7.8-12.0)	5.3 (3.7-7.5)	39.0 (35.0-43.3)	17.9 (15.7-20.3)	21.2 (18.0-24.7)
$3,000–$4,999	946	13.5	13.8 (11.2-17.0)	8.4 (6.9-10.2)	5.4 (3.7-8.0)	38.6 (34.5-42.9)	21.8 (18.3-25.7)	16.9 (14.5-19.5)
$5,000–$6,999	1,085	15.5	10.2 (8.4-12.4)	7.3 (5.8-9.2)	2.9 (2.1-4.0)	34.5 (29.5-39.8)	21.4 (18.4-24.7)	13.1 (10.5-16.2)
$7,000–$9,999	1,555	22.8	10.7 (9.0-12.5)	7.4 (6.1-9.0)	3.3 (2.3-4.6)	32.4 (28.9-36.1)	19.8 (17.8-21.4)	12.7 (10.4-15.3)
$10,000–$14,000	1,277	19.3	8.1 (6.8-9.7)	6.4 (5.4-7.6)	1.7 (1.2-2.5)	28.4 (26.7-30.3)	18.5 (16.7-20.3)	10.0 (8.2-12.1)
≥$15,000	652	10.7	5.6 (4.2-7.4)	4.3 (2.9-6.3)	1.3 (0.7-2.3)	25.2 (20.4-30.7)	16.0 (12.9-19.8)	9.2 (6.9-12.2)
Education of parent with highest education								
<High school	2,522	36.1	14.4 (13.4-15.4)	9.7 (8.8-10.6)	4.7 (3.7-6.0)	38.8 (35.5-42.3)	20.6 (18.5-23.0)	18.2 (16.4-20.2)
High school	2,491	36.3	10.2 (8.7-11.9)	7.5 (6.4-8.8)	2.7 (2.0-3.7)	32.0 (29.8-34.3)	19.8 (18.6-21.1)	12.2 (10.3-14.5)
Some college	736	11.4	5.5 (3.6-8.1)	3.6 (2.2-5.8)	1.9 (1.0-3.6)	25.2 (20.9-30.0)	16.6 (14.4-19.1)	8.6 (5.5-13.1)
≥College	903	14.5	6.3 (4.8-8.3)	4.4 (3.3-6.0)	1.9 (1.2-2.9)	25.1 (22.2-28.3)	16.0 (13.8-18.5)	9.1 (7.5-11.0)
Birth weight, g								
<1,500	31	0.4	15.9 (6.6-33.6)	12.2 (4.8-27.6)	3.7 (0.4-26.3)	39.4 (24.2-56.9)	16.1 (6.8-33.4)	23.3 (10.2-45.0)
1,500–2,499	528	7.8	10.3 (8.2-12.9)	7.3 (5.3-10.1)	3.0 (1.7-5.1)	33.0 (29.5-36.8)	19.4 (17.5-21.5)	13.6 (10.7-17.2)
2,500–2,999	1,250	18.7	10.0 (8.4-12.0)	6.7 (5.4-8.4)	3.3 (2.2-4.9)	31.0 (27.8-34.4)	17.9 (15.5-20.7)	13.1 (11.3-15.1)
3,000–3,999	2,789	41.1	9.8 (8.8-10.9)	7.0 (6.3-7.9)	2.8 (2.1-3.7)	31.5 (28.5-34.6)	19.1 (17.5-20.9)	12.3 (10.5-14.5)
≥4,000	402	6.0	12.2 (9.1-16.1)	8.5 (6.3-11.4)	3.7 (2.1-6.4)	36.0 (29.6-42.9)	20.2 (14.9-26.9)	15.7 (12.0-20.4)
Missing	1,768	26.0	12.0 (10.2-14.0)	8.1 (6.7-9.8)	3.8 (3.0-4.9)	35.3 (31.4-39.5)	20.0 (17.8-22.4)	23.3 (10.2-45.0)
Ever had asthma								
No	6,304	93.8	10.7 (9.7-11.7)	7.4 (6.7-8.1)	3.3 (2.8-4.0)	32.1 (30.2-34.1)	18.9 (17.9-19.8)	13.3 (11.8-14.8)
Yes	391	6.0	9.2 (6.4-13.1)	7.5 (5.2-10.7)	1.7 (0.6-4.8)	41.2 (34.7-48.2)	23.1 (18.1-29.0)	18.2 (13.9-23.4)
Earache in past year (parent report)								
No	5,693	84.9	9.5 (8.5-10.7)	7.0 (6.3-7.8)	2.6 (2.1-3.1)	31.9 (29.8-34.1)	19.1 (17.9-20.4)	12.8 (11.3-14.5)
Yes	1,029	15.1	16.4 (13.9-19.2)	9.6 (7.3-12.5)	6.9 (5.2-8.9)	37.1 (33.5-40.9)	19.5 (17.2-22.2)	17.6 (15.1-20.4)
How often had earache past year (youth report)								
Not at all	5,356	79.6	9.5 (8.5-10.6)	6.9 (6.2-7.7)	2.6 (2.1-3.3)	32.0 (29.8-34.3)	19.2 (18.0-20.5)	12.8 (11.3-14.5)
Not very often	1,278	19.0	14.1 (12.6-15.6)	9.1 (8.1-10.3)	4.9 (3.9-6.3)	35.4 (32.7-38.2)	19.3 (17.4-21.4)	16.1 (13.8-18.6)
Quite often	98	1.4	27.8 (18.8-38.9)	12.3 (7.9-18.5)	15.5 (8.9-25.7)	45.6 (33.6-58.1)	19.4 (13.2-27.8)	26.1 (18.1-36.2)
Ears drums opened or lanced (parent report)								
No	6,524	96.5	10.0 (9.1-10.9)	7.0 (6.4-7.7)	2.9 (2.5-2.2)	32.3 (30.2-34.4)	19.0 (17.9-20.1)	13.3 (11.9-14.9)
Yes, once	143	2.0	27.7 (20.2-36.7)	18.7 (12.9-26.2)	9.0 (5.1-9.6)	45.1 (36.0-54.5)	26.8 (19.5-35.6)	18.4 (12.5-26.1)
Yes, > once	60	0.9	35.6 (24.9-48.0)	17.9 (10.3-29.2)	17.7 (9.1-30.5)	53.3 (38.6-67.4)	25.3 (14.1-41.0)	28.0 (16.5-43.4)
Running ear or discharge (parent report)								
No	6,137	90.2	9.4 (8.5-10.3)	6.6 (6.0-7.3)	2.8 (2.3-3.2)	31.5 (29.4-33.8)	18.9 (17.8-20.1)	12.6 (11.2-14.3)
Yes, once	202	3.1	15.7 (9.8-24.3)	12.4 (7.6-19.5)	3.3 (1.3-8.2)	30.6 (23.8-38.5)	17.6 (12.8-23.7)	13.0 (8.1-20.1)
Yes, > once	377	5.9	25.4 (20.0-31.7)	16.1 (12.0-21.4)	9.3 (6.9-12.4)	51.0 (45.3-56.7)	25.0 (20.8-29.6)	26.0 (22.4-30.0)

(Continues)

TABLE II.
Continued

	Sample No.	Population-Weighted %*	Speech-Frequency HI, % (95% CI)†			High-Frequency HI, % (95% CI)‡		
			Overall§	Unilateral§	Bilateral§	Overall§	Unilateral§	Bilateral§
Ever smoked cigarettes								
No	3,651	53.8	10.3 (9.1-11.7)	7.0 (6.1-8.0)	3.4 (2.7-4.2)	31.0 (28.9-33.2)	18.9 (17.6-20.3)	12.1 (10.7-13.6)
Yes	3,064	45.9	10.8 (9.6-12.2)	7.8 (6.9-8.7)	3.1 (2.5-3.8)	34.8 (32.2-37.5)	19.6 (18.0-21.2)	15.2 (13.3-17.4)
Packs smoked per day currently								
Nonsmoker	5,708	84.6	10.1 (9.1-11.2)	7.0 (6.3-7.8)	3.1 (2.5-3.8)	31.6 (29.5-33.9)	19.1 (18.2-20.1)	12.5 (10.9-14.3)
<1 pack/day	837	12.2	13.3 (11.4-15.5)	9.2 (7.6-11.1)	4.1 (3.1-5.5)	38.6 (35.1-42.4)	20.0 (17.1-23.3)	18.6 (16.9-20.5)
≥1 pack/day	127	1.9	15.5 (11.5-20.6)	11.2 (6.8-17.8)	4.3 (2.6-7.0)	49.9 (40.5-59.4)	20.9 (14.2-29.7)	29.0 (22.2-36.9)
Body mass index								
Underweight (<18.5)	2,016	29.5	11.7 (10.0-13.7)	8.1 (6.7-9.8)	3.6 (2.9-4.5)	33.9 (30.7-37.3)	19.9 (18.3-21.6)	14.0 (12.0-16.4)
Normal (18.5–24.9)	4,098	61.1	10.0 (8.9-11.1)	6.9 (6.1-7.8)	3.1 (2.4-4.0)	31.9 (29.7-34.2)	18.8 (17.3-20.4)	13.1 (11.6-14.7)
Overweight (25.0–29.9)	513	7.4	10.8 (7.9-14.5)	7.8 (5.2-11.5)	3.0 (1.9-4.6)	35.9 (32.4-39.6)	21.6 (17.8-25.9)	14.3 (10.9-18.5)
Obese (≥30)	141	2.0	13.7 (8.4-21.6)	9.7 (4.8-18.6)	4.0 (1.9-8.5)	33.7 (25.5-43.0)	13.7 (8.7-20.8)	20.0 (14.3-27.4)
Nutritional appraisal (NHES physician exam)								
Underweight	142	1.9	10.5 (6.5-16.4)	6.6 (3.6-11.8)	3.9 (1.9-8.1)	33.2 (23.8-44.1)	17.9 (11.9-21.6)	15.3 (9.7-23.2)
Normal	5,910	87.5	10.5 (9.4-11.7)	7.3 (6.5-8.3)	3.2 (2.6-3.9)	32.7 (30.6-35.0)	19.4 (18.2-20.4)	13.3 (11.9-14.8)
Moderately obese	592	8.8	11.6 (8.5-15.6)	8.2 (5.5-12.0)	3.5 (2.2-5.3)	33.0 (29.9-36.3)	18.2 (14.5-25.9)	14.8 (12.3-17.8)
Very obese	120	1.7	11.0 (6.9-17.3)	7.2 (3.2-15.3)	3.9 (2.0-7.6)	33.9 (25.8-43.1)	15.7 (9.8-24.2)	18.2 (12.2-26.4)
Listened to radio (hours per day)								
No	1,044	15.1	13.5 (11.2-16.1)	8.7 (7.4-10.2)	4.7 (3.2-6.9)	38.6 (34.6-42.7)	20.8 (18.7-23.0)	17.8 (15.0-21.1)
<1 hour	1,618	23.8	9.9 (8.5-11.6)	7.1 (5.9-8.6)	2.8 (2.0-3.9)	31.6 (28.9-34.5)	19.3 (17.0-21.7)	12.3 (10.4-14.5)
1 to < 4 hours	3,228	47.7	9.7 (8.6-10.9)	6.9 (6.1-7.8)	2.8 (2.1-3.9)	31.5 (29.5-33.6)	19.1 (17.7-20.7)	12.4 (10.9-13.9)
≥4 hours	803	12.2	11.3 (8.8-14.3)	7.8 (6.0-10.0)	3.5 (2.2-5.4)	33.6 (29.0-38.6)	18.2 (15.4-21.4)	15.4 (11.7-20.0)
Ever unconscious (parent report)								
No	6,143	90.8	10.5 (9.5-11.5)	7.2 (6.6-7.9)	3.3 (2.7-3.9)	32.4 (30.3-34.6)	19.1 (18.0-20.2)	13.3 (11.8-15.0)
Yes, ≤ 1 hour	475	7.0	10.8 (8.9-13.1)	8.8 (6.9-11.2)	2.0 (1.2-3.3)	33.6 (28.4-39.3)	19.4 (14.8-25.1)	14.2 (11.3-17.7)
Yes, 2 hours to < 1 day	68	1.0	14.2 (7.7-24.9)	9.6 (4.1-20.9)	4.6 (1.7-11.9)	43.7 (31.1-57.1)	21.7 (14.3-30.6)	21.9 (14.2-32.3)
Yes, ≥ 1 day	25	0.4	18.1 (6.8-40.2)	9.6 (2.4-31.2)	8.5 (1.8-31.5)	55.9 (31.1-78.0)	27.1 (10.5-54.1)	28.8 (11.2-56.5)

*Population-weighted percent is the subgroup percentage for each characteristic, based on the US youth population, aged 12 to 17 years, 1966–1970.

†Speech-frequency hearing impairment is defined by PTA of thresholds at 0.5, 1, 2, and 4 kHz ≥ 20 dB HL.

‡High-frequency HI is defined by PTA of thresholds at 3, 4, and 6 kHz ≥ 20 dB HL.

§Overall HI is the sum of bilateral (better ear) and unilateral HI, also known as HI in either one or both ears. Unilateral HI is defined by the PTA of thresholds (either speech or high frequencies) ≥ 20 dB HL in one ear but <20 dB HL in the other ear. Bilateral HI is defined by the PTA of thresholds (either speech or high frequencies) ≥ 20 dB HL in both ears.

CI = confidence interval; HI = hearing impairment; PTA = pure-tone average.

surveys, males had significantly more high-frequency HI. Low family income was associated with HI in the 1966 to 1970 survey; the ORs for this variable were similar in both surveys, but the CI did not exclude 1.0 in the 2005 to 2010 survey. Low birth weight was significant in both surveys (< 1,500 g in the 1966–1970 survey, < 3,000 g in the 2005–2010 survey), but ORs were much higher in the 2005 to 2010 survey. Additional significant associations in the 1966 to 1970 survey included history of asthma, otorrhea (more than once), smoking, elevated body mass index (BMI), and less-than-excellent health. Surprisingly, listening to the radio was associated with less high-frequency HI in the 1966 to 1970 survey. For the 2005 to 2010 survey, elevated ORs for high-frequency HI were seen for history of smoking or ear tubes, elevated BMI, and a history of nonoccupational exposure to steady loud noise or music for 5 or more hours per week.

Multivariable analyses of unilateral HI for the 1966 to 1970 and the 2005 to 2010 surveys are available in the supporting information (see Supporting Tables I and II in the online version of this article). In general, the fully adjusted analyses were consistent with the findings described above. Male sex and low family income in the 1966 to 1970 survey, low birth weight and current elevated BMI in the 2005 to 2010 survey, and questions related to OM (both surveys) were statistically significant predictors of HI. Nonoccupational noise or music was not associated with unilateral high-frequency HI in the 2005-2010 survey, in contrast to that variable's association with bilateral high-frequency HI.

TABLE III.
Prevalence of Speech-Frequency and High-Frequency HI Among US Youths Aged 12–19 Years, NHANES III, 1988–1994

	Sample No.	Population-Weighted %‡	Speech-Frequency HI, % (95% CI)*			High-Frequency HI, % (95% CI)†		
			Overall§	Unilateral§	Bilateral§	Overall§	Unilateral§	Bilateral§
Total, 1988–1994	3,057	100.0	3.9 (2.8-5.5)	3.3 (2.2-5.0)	0.6 (0.3-1.1)	7.3 (5.9-9.0)	5.7 (4.5-7.2)	1.6 (1.1-2.5)
Sex								
Male	1,433	50.7	3.4 (2.2-5.4)	3.0 (1.8-5.0)	0.4 (0.2-1.1)	9.5 (7.3-12.1)	7.3 (5.3-9.9)	2.2 (1.2-3.9)
Female	1,624	49.3	4.5 (2.7-7.2)	3.7 (2.1-6.5)	0.8 (0.3-2.0)	5.1 (3.4-7.7)	4.0 (2.4-6.4)	1.1 (0.5-2.3)
Age, yr								
12–13	824	25.0	4.1 (2.3-7.1)	3.8 (2.2-6.4)	0.3 (0.1-1.7)	7.9 (5.5-11.3)	6.2 (4.2-9.1)	1.7 (0.8-3.9)
14–15	751	26.0	3.7 (2.1-6.6)	3.0 (1.7-5.4)	0.7 (0.2-2.3)	5.5 (3.4-8.8)	4.6 (2.7-7.6)	0.9 (0.4-2.0)
16–17	798	25.8	4.4 (2.4-8.1)	3.6 (1.7-7.6)	0.8 (0.4-1.5)	8.9 (6.3-12.4)	7.0 (4.5-10.8)	1.8 (1.0-3.4)
18–19	684	23.2	3.4 (1.8-6.4)	3.0 (1.5-6.1)	0.4 (0.1-1.4)	7.0 (4.8-10.0)	4.8 (3.2-7.2)	2.1 (1.0-4.6)
Race/ethnicity								
NH white	791	66.0	4.1 (2.6-6.4)	3.7 (2.2-6.1)	0.4 (0.1-1.3)	7.1 (5.2-9.7)	5.7 (4.0-8.1)	1.4 (0.7-2.7)
NH black	1,083	15.3	3.4 (2.4-4.8)	3.0 (2.1-4.2)	0.4 (0.2-0.9)	5.7 (4.5-7.1)	4.1 (3.1-5.4)	1.5 (0.9-2.7)
Hispanic	1,126	13.8	3.3 (1.6-6.6)	2.9 (1.3-6.2)	0.5 (0.2-0.9)	8.9 (5.6-14.0)	6.7 (4.1-10.6)	2.3 (0.8-6.2)
NH other	57	4.9	5.1 (2.3-10.9)	1.3 (0.2-9.5)	3.8 (1.7-8.1)	10.9 (5.0-22.0)	7.1 (2.2-20.6)	3.8 (1.7-8.1)
Family income								
<$9,000	516	10.0	4.0 (1.8-9.2)	2.7 (0.9-8.0)	1.3 (0.3-4.8)	10.2 (6.2-16.3)	7.6 (4.1-13.9)	2.6 (1.0-6.6)
$9,000–$14,999	494	11.8	5.0 (2.7-9.2)	4.4 (2.3-8.3)	0.6 (0.1-3.2)	7.3 (4.8-11.0)	4.8 (2.6-8.8)	2.5 (1.1-5.5)
$15,000–$24,999	577	15.9	2.2 (1.2-3.8)	2.1 (1.1-3.7)	0.1 (0.03-0.3)	7.5 (4.1-13.5)	6.1 (3.1-11.7)	1.4 (0.4-4.4)
$25,000–$39,999	519	18.5	4.8 (2.5-8.8)	3.7 (1.8-7.5)	1.1 (0.3-4.3)	8.8 (5.8-13.1)	7.2 (4.6-11.3)	1.6 (0.6-4.4)
$40,000–$49,000	296	13.6	4.0 (1.3-12.2)	3.9 (1.2-12.3)	0.1 (0.01-0.7)	7.0 (3.1-14.8)	6.0 (2.5-13.4)	1.0 (0.3-3.6)
≥$50,000	365	22.6	3.6 (1.8-7.0)	3.3 (1.6-6.8)	0.3 (0.04-1.9)	5.5 (3.2-9.2)	4.0 (2.1-7.6)	1.5 (0.5-4.2)
Education, highest grade completed by family reference person								
<High school	1,279	25.8	5.6 (4.0-7.7)	4.0 (2.4-6.5)	1.6 (0.8-3.5)	9.4 (7.0-12.5)	6.9 (5.0-9.6)	2.4 (1.4-4.2)
High school	976	34.1	3.6 (1.6-8.2)	3.4 (1.4-8.1)	0.2 (0.1-1.1)	8.4 (5.6-12.4)	6.7 (4.2-10.6)	1.7 (0.8-3.5)
Some college	485	21.4	2.4 (1.2-4.8)	2.0 (0.9-4.4)	0.4 (0.1-1.7)	7.1 (4.7-10.6)	5.1 (3.2-8.0)	2.0 (0.9-4.7)
≥College	317	18.7	4.0 (1.7-8.8)	4.0 (1.7-8.8)	—	2.7 (1.1-6.5)	2.7 (1.1-6.5)	—
Had earache in past week								
No	2,903	95.3	3.6 (2.6-5.1)	3.1 (2.1-4.7)	0.5 (0.3-1.0)	6.9 (5.6-8.6)	5.2 (4.1-6.7)	1.7 (1.1-2.6)
Yes, one ear	94	2.9	9.1 (1.7-36.9)	9.0 (1.6-37.1)	0.1 (0.02-0.9)	15.6 (6.4-33.4)	15.0 (6.0-33.0)	0.6 (0.2-1.9)
Yes, both ears	27	0.9	1.8 (0.4-7.9)	1.1 (0.1-8.1)	0.7 (0.1-5.3)	1.8 (0.4-7.9)	1.1 (0.1-8.1)	0.7 (0.1-5.3)
Now have ear tube in either ear								
No	2,985	97.3	3.4 (2.3-5.0)	3.0 (1.9-4.7)	0.4 (0.2-0.9)	6.8 (5.4-8.5)	5.2 (4.0-6.7)	1.6 (1.0-2.7)
Yes	35	1.6	26.7 (7.1-63.3)	22.2 (6.0-55.9)	4.5 (1.0-18.7)	29.7 (12.6-55.2)	24.2 (11.3-44.5)	5.4 (1.4-18.7)
Ever had an ear infection or earache (parent report for youth aged 12–16 years)								
No	920	36.2	2.6 (1.4-4.9)	1.9 (1.1-3.1)	0.8 (0.2-2.5)	6.6 (4.6-9.4)	5.7 (3.8-8.5)	0.9 (0.4-2.2)
Yes	1,050	63.8	5.1 (3.0-8.4)	4.3 (2.5-7.5)	0.7 (0.2-2.4)	7.3 (5.0-10.6)	5.3 (3.5-8.0)	2.0 (1.1-3.7)
How often had an ear infection or earache (parent report for youth aged 12–16 years)								
No ear infections	920	36.3	2.6 (1.4-4.9)	1.9 (1.1-3.1)	0.8 (0.2-2.5)	6.6 (4.6-9.4)	5.7 (3.8-8.5)	0.9 (0.4-2.2)
1–2 times	408	18.3	2.3 (1.1-4.6)	1.5 (0.7-3.4)	0.8 (0.2-3.7)	4.9 (2.5-9.3)	2.3 (1.2-4.3)	2.6 (0.9-7.6)
3–5 times	317	20.6	3.5 (1.4-8.5)	2.9 (1.0-8.0)	0.6 (0.1-3.2)	7.6 (4.4-12.7)	5.8 (3.2-10.2)	1.7 (0.7-4.2)
≥6 times	318	24.8	8.5 (4.7-15.0)	7.6 (4.1-13.9)	0.9 (0.2-3.1)	9.0 (4.9-16.1)	7.3 (3.7-13.9)	1.8 (0.8-4.0)
Ever had ear tubes inserted (parent report for youth aged 12–16 years)								
No ear infections	920	37.6	2.6 (1.4-4.9)	1.9 (1.1-3.1)	0.8 (0.2-2.5)	6.6 (4.6-9.4)	5.7 (3.8-8.5)	0.9 (0.4-2.2)
No	864	54.8	3.1 (1.7-5.5)	2.4 (1.2-4.7)	0.7 (0.2-2.4)	5.7 (3.8-8.5)	3.7 (2.3-5.7)	2.0 (1.0-4.2)
Yes	90	7.6	21.7 (10.7-39.1)	20.2 (9.9-36.8)	1.6 (0.3-7.9)	21.6 (10.8-38.4)	18.8 (8.9-35.6)	2.7 (1.2-5.8)
Ever smoked 100 or more cigarettes in lifetime (self-reported by youth aged 12–19 years)								
No	2,675	79.9	3.8 (2.5-5.7)	3.4 (2.2-5.3)	0.4 (0.2-0.8)	7.0 (5.5-8.9)	5.9 (4.5-7.6)	1.2 (0.7-2.0)
Yes	319	18.7	4.6 (2.3-9.0)	3.2 (1.4-7.2)	1.4 (0.5-4.2)	9.1 (6.0-13.7)	5.0 (2.7-9.2)	4.1 (2.1-8.0)

(Continues)

TABLE III.
Continued

	Sample No.	Population-Weighted %‡	Speech-Frequency HI, % (95% CI)*			High-Frequency HI, % (95% CI)†		
			Overall§	Unilateral§	Bilateral§	Overall§	Unilateral§	Bilateral§
No. of cigarettes smoked per day currently (self-reported by youth aged 12–19 years)								
Never smoked or former smoker	2,744	86.0	3.8 (2.5-5.7)	3.4 (2.2-5.1)	0.4 (0.1-0.9)	7.0 (5.5-8.9)	5.8 (4.5-7.6)	1.2 (0.7-2.0)
<10 cigarettes	99	3.3	3.9 (1.3-10.8)	1.9 (0.5-7.4)	2.0 (0.4-0.3)	12.0 (6.0-22.5)	5.3 (1.9-14.4)	6.7 (2.4-16.9)
≥10 cigarettes	211	10.5	5.7 (2.8-11.3)	3.8 (1.5-9.2)	1.9 (0.8-4.4)	9.6 (5.7-15.7)	5.9 (2.9-11.8)	3.7 (1.5-8.7)
Body mass index								
Underweight (<18.5)	463	16.3	2.6 (1.0-6.7)	2.2 (0.7-6.4)	0.5 (0.1-2.9)	3.6 (2.1-6.2)	1.9 (0.8-4.2)	1.7 (0.8-3.8)
Normal (18.5–24.9)	1,821	62.9	4.6 (3.0-7.1)	3.9 (2.3-6.5)	0.7 (0.3-1.4)	7.9 (6.1-10.2)	6.1 (4.5-8.4)	1.8 (1.0-3.0)
Overweight (25.0–29.9)	461	12.9	2.5 (1.3-4.5)	2.3 (1.2-4.4)	0.2 (0.1-0.4)	10.1 (6.5-15.3)	8.8 (5.6-13.7)	1.3 (0.5-3.0)
Obese (≥30)	280	7.1	4.0 (1.4-11.2)	3.5 (1.0-11.0)	0.6 (0.2-1.7)	6.1 (3.5-10.4)	5.1 (2.7-9.4)	1.1 (0.5-2.3)
Health status (NHANES physician report)								
Excellent	2,051	69.2	4.3 (2.8-6.6)	3.7 (2.2-6.1)	0.6 (0.3-1.2)	7.2 (5.7-9.0)	5.3 (4.0-7.0)	1.8 (1.1-3.0)
Very good	491	16.0	1.5 (0.6-4.1)	0.9 (0.5-1.8)	0.6 (0.1-3.5)	8.8 (4.6-16.0)	7.5 (3.9-13.9)	1.2 (0.4-4.1)
Good	350	11.2	5.2 (2.1-12.4)	5.0 (2.0-12.2)	0.2 (0.1-0.6)	7.1 (4.7-10.6)	6.2 (3.8-10.0)	0.9 (0.4-1.9)
Fair/poor	25	0.7	7.1 (1.7-25.4)	3.7 (0.5-24.2)	3.4 (0.6-16.3)	8.9 (2.5-26.7)	5.5 (1.2-22.0)	3.4 (0.6-16.3)
Exposed to very loud noise past 24 hours								
No	2,765	90.6	3.7 (2.6-5.1)	3.2 (2.1-4.7)	0.5 (0.3-1.0)	6.8 (5.4-8.6)	5.2 (4.0-6.7)	1.6 (1.0-2.5)
Yes	260	8.4	4.9 (1.8-12.4)	4.7 (1.7-12.4)	0.2 (0.1-0.6)	10.7 (5.9-18.7)	8.7 (4.4-16.5)	2.0 (0.6-6.9)
Exposed to very loud noise within past 24 hours and how many hours ago did the noise end								
Not exposed	2,765	90.6	3.7 (2.6-5.1)	3.2 (2.1-4.7)	0.5 (0.3-1.0)	6.8 (5.4-8.6)	5.2 (4.0-6.7)	1.6 (1.0-2.5)
Yes, ≥ 12 hours ago	101	3.9	8.8 (2.8-24.4)	8.7 (2.7-24.4)	0.1 (0.01-0.5)	13.9 (6.1-28.6)	10.6 (4.0-25.6)	3.2 (0.7-14.5)
Yes, 5–11 hours ago	51	1.7	2.7 (0.4-17.6)	2.7 (0.4-17.6)	-	11.3 (2.6-37.9)	10.0 (2.0-37.5)	1.3 (0.2-9.2)
Yes, < 5 hours ago	105	2.7	0.7 (0.2-2.3)	0.3 (0.04-2.0)	0.4 (0.1-1.8)	6.1 (3.1-12.0)	5.4 (2.5-11.1)	0.7 (0.1-3.4)
Listened to music with headphones within past 24 hours and how many hours ago did you stop listening								
No	2,585	85.6	3.7 (2.6-5.3)	3.2 (2.1-4.9)	0.5 (0.3-1.1)	7.0 (5.6-8.8)	5.5 (4.2-7.1)	1.6 (1.0-2.4)
Yes, ≥ 12 hours ago	187	5.4	4.2 (1.2-13.6)	3.8 (1.0-13.8)	0.4 (0.1-1.3)	7.9 (3.1-18.8)	4.4 (1.3-13.7)	3.5 (0.8-14.5)
Yes, 5–11 hours ago	92	3.7	4.6 (0.7-26.1)	4.5 (0.6-26.5)	0.1 (0.02-0.9)	8.8 (2.7-25.1)	8.8 (2.7-25.1)	—
Yes, < 5 hours ago	158	5.3	3.6 (1.3-9.6)	3.2 (1.1-9.2)	0.4 (0.1-2.2)	6.0 (3.5-13.8)	5.1 (2.1-12.1)	0.9 (0.3-2.6)

*Speech-frequency HI is defined by PTA of thresholds at 0.5, 1, 2, and 4 kHz ≥ 20 dB HL.
†High-frequency HI is defined by PTA of thresholds at 3, 4, and 6 kHz ≥ 20 dB HL.
‡Population-weighted percent is the subgroup percentage for each characteristic, based on the US youth population aged 12 to 19 years, 1988–1994.
§Overall HI is the sum of bilateral (better ear) and unilateral HI, also known as HI in either one or both ears. Unilateral HI is defined by the PTA of thresholds (either speech or high frequencies) ≥ 20 dB HL in one ear, but <20 dB HL in the other ear. Bilateral HI is defined by the PTA of thresholds (either speech or high frequencies) ≥ 20 dB HL in both ears.
CI = confidence interval; HI = hearing impairment; NH = non-Hispanic ; NHANES = National Health and Nutrition Examination Survey; PTA = pure-tone average.

DISCUSSION

US youths in the 2005 to 2010 survey had a lower prevalence of HI and better high-frequency pure-tone thresholds, compared to youths in the late 1960s. Readers born between 1948 and 1958 (now in their 60s) could have been subjects in the 1966 to 1970 survey and can say, "Kids nowadays hear better than we did." This improvement after 1970 was already apparent in the 1988 to 1994 survey, and is consistent with our findings for US adults[9,10] and other reports.[45] Thresholds at 0.5 kHz were slightly better in the 2005 to 2010 survey, but only at the 10th percentile, where some youths had thresholds <0 dB HL; this probably reflects the looser ambient noise requirements in the 1966 to 1970 survey rather than a genuine difference in hearing ability. These improvements in the hearing of US youth after the 1966 to 1970 survey cannot be attributed to intersurvey changes in audiometric procedures (because they affected high frequencies selectively) or calibration (because they affected the most susceptible youths and worse ears selectively).

We found no significant differences in HI prevalence when comparing the 1988 to 1994 and 2005 to 2010 surveys. In contrast, Shargorodsky et al. also used NHANES data but reported increasing prevalence in this time frame.[46] Their analyses are not directly comparable to ours because 1) they examined only the 2005 to 2006 data instead of the full 2005 to 2010 dataset, 2) the frequencies they chose to examine were different, 3) their cutoffs for HI differed from ours, and 4) they used different exclusion criteria to determine the final sample for analysis. Furthermore, they reported 27 prevalence comparisons, and in only one of them (bilateral low frequency PTA >15 but < 25 dB HL) did the 95% CIs fail to overlap. The

TABLE IV.
Prevalence of Speech-Frequency and High-Frequency HI Among US Youths Aged 12–19 Years, NHANES 2005–2010

	Sample No.	Population-Weighted, %‡	Speech-Frequency HI, % (95% CI)*			High-Frequency HI, % (95% CI)†		
			Overall§	Unilateral§	Bilateral§	Overall§	Unilateral§	Bilateral§
Total (2005–2010)	4,374	100.0	4.5 (3.7-5.4)	3.7 (3.0-4.5)	0.8 (0.5-1.2)	7.9 (6.8-9.2)	6.4 (5.4-7.5)	1.5 (1.1-2.1)
Sex								
Male	2,254	51.2	5.1 (4.0-6.4)	4.0 (3.2-5.0)	1.0 (0.6-1.9)	9.1 (7.3-11.2)	7.1 (5.6-8.9)	2.0 (1.4-3.0)
Female	2,120	48.8	3.9 (2.7-5.4)	3.4 (2.3-5.0)	0.5 (0.3-0.8)	6.7 (5.4-8.3)	5.7 (4.5-7.1)	1.0 (0.6-1.6)
Age, yr								
12–13	1,078	23.8	3.2 (2.0-5.2)	2.8 (1.6-4.8)	0.4 (0.2-0.7)	6.3 (4.6-8.6)	5.4 (3.9-7.4)	0.9 (0.5-1.8)
14–15	1,104	27.2	5.8 (3.8-8.8)	5.2 (3.5-7.8)	0.6 (0.2-1.6)	8.1 (6.0-10.7)	6.8 (5.2-9.0)	1.2 (0.5-3.1)
16–17	1,146	26.5	4.4 (3.1-6.2)	3.1 (2.2-4.4)	1.3 (0.6-2.8)	7.9 (6.2-10.1)	5.7 (4.1-7.7)	2.3 (1.4-3.8)
18-19	1,046	22.5	4.2 (3.0-6.0)	3.5 (2.4-5.1)	0.8 (0.4-1.4)	9.4 (7.3-12.2)	7.8 (5.7-10.4)	1.7 (1.0-2.8)
Race/ethnicity								
NH white	1,290	61.0	4.7 (3.6-6.2)	4.0 (3.1-5.3)	0.7 (0.4-1.4)	8.1 (6.5-10.1)	6.6 (5.3-8.2)	1.5 (0.9-2.3)
NH black	1,241	14.6	4.9 (3.6-6.7)	3.9 (2.8-5.4)	1.0 (0.6-1.7)	8.1 (6.6-9.8)	6.1 (5.0-7.5)	1.9 (1.3-3.0)
Hispanic	1,615	18.0	3.4 (2.6-4.4)	2.3 (1.7-3.2)	1.1 (0.6-1.9)	7.7 (6.2-9.5)	6.0 (4.9-7.4)	1.7 (1.0-2.9)
NH other	228	6.4	3.9 (2.0-7.6)	3.9 (2.0-7.6)	---	6.6 (3.7-11.6)	6.2 (3.4-11.2)	0.4 (0.1-3.2)
Poverty-to-income ratio								
<0.75	828	13.1	5.3 (3.6-7.8)	3.9 (2.4-6.3)	1.4 (0.8-2.4)	10.5 (8.0-13.7)	8.6 (6.3-11.5)	1.9 (1.0-3.7)
0.75–1.49	1,082	18.1	5.2 (3.7-7.1)	4.1 (2.0-4.5)	1.1 (0.6-2.0)	8.0 (6.2-10.3)	6.1 (4.5-8.2)	1.9 (1.2-3.2)
1.50–2.49	753	16.4	3.4 (1.9-6.0)	3.1 (2.8-6.3)	0.2 (0.04-1.3)	7.4 (4.9-11.1)	6.5 (4.1-10.2)	0.9 (0.4-2.2)
2.50–4.99	960	28.6	4.7 (3.1-7.1)	4.0 (1.9-4.9)	0.7 (0.3-1.8)	7.0 (4.8-10.0)	5.7 (4.1-7.8)	1.3 (0.6-3.1)
≥5.00	449	17.6	3.7 (2.1-6.5)	3.1 (1.7-5.7)	0.6 (0.1-4.0)	7.9 (5.2-11.7)	6.8 (4.4-10.1)	1.1 (0.4-3.6)
Unknown	302	6.2	4.7 (2.8-7.9)	4.0 (2.1-7.6)	0.8 (0.3-2.5)	7.9 (5.3-11.6)	4.7 (2.4-9.0)	3.2 (1.6-6.0)
Education (head of household)								
<High school	1,302	18.5	5.5 (4.1-7.4)	4.5 (3.3-6.2)	1.0 (0.6-1.9)	10.3 (8.2-13.0)	8.7 (6.5-11.4)	1.6 (1.0-2.7)
High school	992	22.9	5.0 (3.7-6.9)	4.1 (2.9-5.8)	0.9 (0.4-1.9)	6.9 (5.0-9.4)	4.8 (3.2-7.1)	2.1 (1.2-3.5)
Some college	1,219	30.4	4.0 (2.8-5.7)	3.5 (2.5-4.9)	0.5 (0.2-1.4)	7.5 (5.9-9.5)	6.2 (4.7-8.0)	1.4 (0.7-2.9)
≥College	673	23.6	3.3 (2.0-5.5)	2.4 (1.3-4.4)	0.9 (0.3-2.7)	6.7 (4.7-9.4)	5.7 (3.9-8.1)	1.0 (0.4-2.5)
Unknown	188	4.7	6.3 (2.0-18.0)	6.2 (1.9-18.0)	0.1 (0.01-0.7)	12.2 (6.4-22.1)	10.2 (5.7-17.7)	2.0 (0.5-8.3)
Birth weight, g								
<1,500	38	0.6	23.0 (8.2-49.9)	19.5 (6.1-47.5)	3.5 (0.8-14.7)	23.8 (8.8-50.4)	13.9 (3.4-42.3)	9.9 (2.8-29.5)
1,500–2,499	172	3.7	8.7 (4.6-15.9)	7.6 (3.6-15.1)	1.1 (0.3-3.7)	9.3 (5.0-16.5)	8.2 (4.3-15.0)	1.1 (0.4-3.2)
2,500–2,999	382	8.3	3.4 (1.5-7.3)	2.1 (0.8-5.4)	1.3 (0.3-5.1)	7.7 (5.0-11.6)	5.6 (3.6-8.6)	2.1 (0.8-5.7)
3,000–3,999	1,261	30.6	4.5 (2.9-6.7)	4.2 (2.7-6.6)	0.2 (0.1-0.6)	6.9 (5.3-9.0)	6.3 (4.8-8.3)	0.6 (0.2-1.6)
≥4,000	230	5.8	3.3 (1.7-6.6)	2.9 (1.1-7.7)	0.4 (0.1-1.6)	5.6 (2.3-13.3)	5.1 (1.9-13.1)	0.5 (0.2-1.9)
Missing: birth weight was not available for youths aged 16-19	2,291	50.9	4.3 (3.4-5.4)	3.3 (2.5-4.2)	1.0 (0.6-1.7)	8.5 (7.1-10.2)	6.5 (5.1-8.2)	2.0 (1.4-2.9)
Ever had asthma								
No	3,554	80.5	4.3 (3.4-5.4)	3.6 (2.8-4.6)	0.7 (0.4-1.2)	8.4 (7.2-9.9)	7.0 (5.8-8.4)	1.4 (1.0-1.9)
Yes	816	19.4	5.2 (3.8-7.2)	4.2 (2.9-6.0)	1.0 (0.5-2.2)	5.7 (4.0-7.9)	3.6 (2.5-5.2)	2.0 (1.1-3.7)
Ever had three or more ear infections								
No	3,109	61.6	3.2 (2.4-4.2)	2.6 (2.0-3.5)	0.5 (0.3-1.0)	6.7 (5.5-8.2)	5.5 (4.5-6.8)	1.2 (0.8-1.8)
Yes	1,226	37.4	6.6 (5.1-8.6)	5.5 (4.0-7.3)	1.2 (0.6-2.2)	9.9 (8.0-12.3)	7.8 (6.1-10.1)	2.1 (1.3-3.5)
Ever had ear tubes inserted								
No	3,996	88.1	3.9 (3.1-4.9)	3.4 (2.6-4.3)	0.5 (0.3-0.8)	7.1 (6.0-8.3)	6.0 (4.9-7.2)	1.1 (0.8-1.6)
Yes	352	11.2	9.4 (6.7-13.1)	6.6 (4.6-9.3)	2.8 (1.2-6.6)	15.0 (10.8-20.5)	10.2 (6.6-15.2)	4.9 (3.0-7.9)
Ever smoked cigarettes								
No	2,646	61.8	3.4 (2.5-4.5)	2.6 (1.9-3.6)	0.8 (0.4-1.3)	6.4 (5.1-8.1)	5.3 (4.2-6.8)	1.1 (0.7-1.6)
Yes	1,521	33.6	6.2 (4.9-7.7)	5.4 (4.3-6.7)	0.8 (0.4-1.7)	10.3 (8.5-12.4)	7.8 (6.1-10.0)	2.4 (1.6-3.7)
Unknown	207	4.6	6.9 (3.5-12.9)	6.0 (2.8-12.4)	0.8 (0.3-2.6)	11.0 (7.3-16.3)	10.0 (6.5-15.2)	1.0 (0.3-2.9)
Packs smoked past 30 days								
Nonsmoker	3,089	71.1	3.6 (2.8-4.7)	2.8 (2.2-3.7)	0.8 (0.5-1.3)	6.8 (5.5-8.4)	6.6 (4.5-7.0)	1.2 (0.8-1.7)
<1 pack/day	572	14.0	6.8 (4.5-10.2)	5.7 (3.7-8.8)	1.1 (0.4-2.7)	11.0 (8.4-14.3)	8.2 (5.6-11.8)	2.9 (1.5-5.5)

(Continues)

TABLE IV.
Continued

	Sample No.	Population-Weighted, %‡	Speech-Frequency HI, % (95% CI)*			High-Frequency HI, % (95% CI)†		
			Overall§	Unilateral§	Bilateral§	Overall§	Unilateral§	Bilateral§
≥1 pack/day	36	1.3	8.0 (1.8-29.3)	8.0 (1.8-29.3)	---	10.2 (4.1-23.4)	10.2 (4.1-23.4)	---
Unknown	677	13.6	6.1 (3.9-9.3)	5.7 (3.6-9.0)	0.4 (0.2-1.1)	10.2 (7.7-13.3)	8.3 (6.0-11.2)	1.9 (0.9-4.0)
Body mass index								
Underweight (<18.5)	569	14.5	3.2 (1.9-5.4)	3.0 (1.7-5.2)	0.2 (0.1-0.9)	5.6 (3.7-8.4)	5.1 (3.2-7.9)	0.5 (0.2-1.3)
Normal (18.5–24.9)	2,265	54.3	3.5 (2.5-4.8)	2.9 (2.0-4.1)	0.6 (0.3-1.3)	7.0 (5.5-8.8)	5.9 (4.6-7.6)	1.1 (0.7-1.7)
Overweight (25.0–29.9)	814	17.2	6.7 (4.8-9.1)	5.7 (4.0-8.0)	1.0 (0.5-2.1)	10.9 (8.7-13.7)	8.7 (6.7-11.3)	2.2 (1.3-3.7)
Obese (≥30)	687	13.0	6.2 (3.8-9.8)	4.6 (3.0-7.0)	1.5 (0.6-3.9)	10.6 (7.9-14.0)	7.0 (5.0-9.6)	3.6 (2.0-6.3)
Ever used firearms								
No	3,662	75.6	3.9 (3.2-4.9)	3.4 (2.7-4.3)	0.5 (0.3-0.8)	7.4 (6.2-8.8)	6.0 (4.9-7.2)	1.4 (1.0-2.0)
Yes	708	24.3	6.1 (4.3-8.5)	4.6 (3.1-6.7)	1.5 (0.7-3.3)	9.5 (7.4-12.2)	7.7 (6.0-9.9)	1.8 (1.0-3.3)
Ever had job where exposed to loud noise for 5 or more hours per week								
No	4,064	91.7	4.2 (3.4-5.1)	3.6 (2.9-4.4)	0.7 (0.4-1.0)	7.9 (6.8-9.2)	6.5 (5.5-7.7)	1.5 (1.1-2.0)
Yes	307	8.2	7.3 (4.6-11.4)	5.2 (3.1-8.5)	2.1 (0.7-5.8)	7.6 (4.5-12.6)	5.5 (3.5-8.5)	2.1 (0.7-5.8)
Outside of a job, ever exposed to steady loud noise or music for 5 or more hours per week								
No	3,399	75.6	4.0 (3.1-5.2)	3.5 (2.6-4.6)	0.6 (0.3-1.0)	7.5 (6.3-9.0)	6.5 (5.4-7.7)	1.1 (0.8-1.5)
Yes	970	24.4	5.8 (4.2-8.0)	4.4 (3.3-5.9)	1.4 (0.7-2.8)	9.1 (7.0-11.6)	6.2 (4.5-8.4)	2.9 (1.7-4.7)

*Speech-frequency HI is defined by PTA of thresholds at 0.5, 1, 2, and 4 kHz ≥ 20 dB HL.
†High-frequency HI is defined by PTA of thresholds at 3, 4, and 6 kHz ≥ 20 dB HL.
‡Population-weighted percent is the subgroup percentage for each characteristic based on the US youth population aged 12 to 19 years, 2005–2010.
§Overall HI is the sum of bilateral (better ear) and unilateral HI, also known as HI in either one or both ears. Unilateral HI is defined by the PTA of thresholds (either speech or high frequencies) ≥ 20 dB HL in one ear, but <20 dB HL in the other ear. Bilateral HI is defined by the PTA of thresholds (either speech or high frequencies) ≥ 20 dB HL in both ears.
CI = confidence interval; HI = hearing impairment; NH = non-Hispanic; NHANES = National Health and Nutrition Examination Survey; PTA = pure-tone average.

combined type I error rate across multiple comparisons was therefore considerably greater than .05. Hence, the one significant comparison may easily have been spurious. They found no increase in audiometric notching between surveys, and no association between reported noise exposure and HI. Two subsequent reports found—as we did—no increase in HI between the 1988 to 1994 survey and either the 2005 to 2006 or 2005 to 2010 surveys.[47,48]

The 2005 to 2010 survey, unlike the 1966 to 1970 survey, included 18 to 19 year olds, but excluding them would not have changed the finding of declining HI prevalence. Table IV shows that their speech-frequency prevalence was essentially identical to that of the total subject group. High-frequency HI was slightly (nonsignificantly) higher for 18 to 19 year olds (Table IV); if this age range had been excluded, the difference between the 1966 to 1970 and 2005 to 2010 surveys would have been even greater.

Although cross-sectional hearing surveys cannot demonstrate causation, changes in risk factor prevalence (e.g., survival of very low birth weight infants, noise exposure, OM, and immunization) may provide hints of the reasons for changes in HI prevalence. Males had more HI than females in both the 1966 to 1970 and the 2005 to 2010 surveys, with ORs that were similar in both surveys. Male sex is also an independent risk factor for HI in adults of all ages.[9,10] This could reflect either inherent susceptibility to HI, confounding (e.g., males tend to have more noise exposure than females[49]), or both. A decline in noise exposure could underlie the reduction in high-frequency HI we report. However, the lack of the same exact questions in these two surveys prevents a direct comparison.

Reductions in occupational noise exposure, including on the family farm, could have led to improved hearing in later surveys. The trend that began in the United States in the 1920s toward increased mechanization in agriculture (i.e., the manufacture and use of farm machinery) leveled off in the 1960s[50]; however, the result was increased noise exposure and hearing loss in farm families.[51] Farm youths are exposed to both machinery noise and potentially toxic chemicals that together can increase the risk of hearing loss.[52] Still, the family-farm population declined steadily throughout the 20th century, and the average age of farm workers increased.[53] In addition to reduced number of youths on family farms, the 1980s saw the beginning of massive manufacturing job losses as well as federal regulation of occupational noise exposure. Some of the youths in these surveys would have had noisy jobs, and those jobs were probably less abundant, with some degree of hearing protection, by the 2005 to 2010 survey.

For youths, nonoccupational exposures may be more important. Most hunters begin in childhood or adolescence,[54] and few use hearing protection regularly.[55] Although hunting license sales in the United States remained fairly stable between 1965 and 2015 (14 to 17 million/year),[56] the population grew by 67%. If the proportion of youths with unprotected exposure to gunfire fell between the 1966 to 1970 and 2005 to 2010 surveys, this could have reduced the prevalence of high-frequency HI.

TABLE V.

Bilateral Speech-Frequency HI—Associations With Sociodemographic, Health, Noise Exposure and Other Factors for US Youths Aged 12–17 Years, NHES, 1966–1970, Compared to Youths Aged 12–19 Years, NHANES, 2005–2010

	Bilateral Speech-Frequency HI* ▸ NHES, 1966–1970			Bilateral Speech-Frequency HI* ▸ NHANES, 2005–2010		
	OR (95% CI), Unadjusted	OR (95% CI), Adjusted for Sex, Age, Race, and Family Income	OR (95% CI), Adjusted for All Variables Shown	OR (95% CI), Unadjusted	OR (95% CI), Adjusted for Sex, Age, Race, and Family Income	OR (95% CI), Adjusted for All Variables Shown
Sociodemographic factors						
Sex						
Male	1.6 (1.2-2.1)	1.6 (1.2-2.1)	1.8 (1.3-2.5)	2.1 (0.9-4.9)	2.2 (0.9-5.2)	2.1 (0.9-4.6)
Female	1.0	1.0	1.0	1.0	1.0	1.0
Age, yr						
12–13	1.0	1.0	1.0	1.0	1.0	1.0
14–15	0.8 (0.5-1.1)	0.8 (0.5-1.1)	0.8 (0.5-1.2)	1.6 (0.5-4.9)	1.7 (0.5-5.1)	1.8 (0.6-5.4)
16–17	0.7 (0.5-1.0)	0.7 (0.5-1.0)	0.7 (0.4-1.1)	3.2 (1.1-9.4)	3.3 (1.2-9.6)	3.6 (0.2-66.1)
18–19				1.9 (0.8-4.7)	1.8 (0.7-4.5)	1.3 (0.1-20.4)
Race						
White†	1.0	1.0	1.0	1.0	1.0	1.0
Black†	1.4 (1.0-2.0)	1.0 (0.6-1.4)	1.1 (0.7-1.6)	1.4 (0.6-3.4)	1.2 (0.5-2.7)	2.1 (0.8-5.8)
Hispanic				1.5 (0.6-3.8)	1.3 (0.6-2.9)	2.5 (1.0-6.0)
Other†	1.2 (0.1-9.9)	1.1 (0.1-9.4)	1.6 (0.2-15.4)			
Family income						
<$5000	4.5 (2.1-4.8)	4.6 (2.3-9.2)	2.8 (1.3-6.3)			
$5,000–$9,999	2.5 (1.2-5.2)	2.5 (1.2-5.3)	1.7 (0.8-4.0)			
$10,000–$14,999	1.3 (0.6-2.7)	1.3 (0.6-2.8)	1.2 (0.6-2.7)			
≥$15,000	1.0	1.0	1.0			
Poverty-to-income ratio						
< 1.50				2.1 (0.3-17.2)	2.1 (0.3-14.8)	2.4 (0.4-16.0)
1.50–2.49				0.4 (0.0-6.0)	0.4 (0.0-5.8)	0.4 (0.0-5.4)
2.50–4.99				1.3 (0.1-11.9)	1.3 (0.1-11.4)	1.2 (0.1-13.4)
≥ 5.00				1.0	1.0	1.0
Health factors						
Birth weight, g						
<1,500	1.4 (0.2-12.8)	1.7 (0.2-12.9)	2.1 (0.5- 9.1)	19.8 (3.0-130.5)	20.1 (2.3-171.7)	17.8 (2.5-125.1)
1,500–2,499	1.1 (0.6-2.0)	1.0 (0.5-2.0)	1.0 (0.5-2.0)	5.3 (1.2-23.4)	6.0 (1.3-28.4)	8.4 (1.7-42.0)
2,500–2,999	1.2 (0.7-2.0)	1.2 (0.7-2.0)	1.2 (0.7-1.9)	5.6 (1.0-31.5)	5.8 (1.0-35.3)	5.4 (1.1-26.2)
3,000–3,999	1.0	1.0	1.0	1.0	1.0	1.0
≥4,000	1.3 (0.8-2.4)	1.2 (0.7-2.3)	1.6 (0.9-2.9)	1.8 (0.4-9.2)	1.5 (0.3-7.6)	1.1 (0.2-7.4)
Unknown	1.4 (1.0-2.0)	1.4 (1.0-1.9)	1.1 (0.6-1.8)	4.5 (1.5-13.5)	1.1 (0.1-10.7)	1.7 (0.1-20.6)
Ever had asthma						
No	1.0	1.0	1.0	1.0	1.0	1.0
Yes	0.5 (0.2-1.6)	0.5 (0.2-1.5)	0.5 (0.1-1.5)	1.4 (0.5-3.6)	1.4 (0.5-3.6)	0.9 (0.3-2.4)
Earache in past year						
No	1.0	1.0	1.0			
Yes	2.9 (2.2-3.9)	3.0 (2.2-4.1)	2.0 (1.3-3.1)			
How often had earache in past year						
Not at all	1.0	1.0	1.0			
Not very often	2.0 (1.5-2.6)	2.0 (1.5-2.6)	1.4 (0.9-2.2)			
Quite often	7.5 (3.7-15.2)	7.8 (3.7-16.7)	3.9 (2.7-9.4)			
Ear drums opened or lanced						
No	1.0	1.0	1.0			
Yes	5.3 (3.2-8.6)	5.6 (3.4-9.2)	3.2 (1.5-6.9)			

(Continues)

TABLE V.
Continued

	Bilateral Speech-Frequency HI* ▸ NHES, 1966–1970			Bilateral Speech-Frequency HI* ▸ NHANES, 2005–2010		
	OR (95% CI), Unadjusted	OR (95% CI), Adjusted for Sex, Age, Race, and Family Income	OR (95% CI), Adjusted for All Variables Shown	OR (95% CI), Unadjusted	OR (95% CI), Adjusted for Sex, Age, Race, and Family Income	OR (95% CI), Adjusted for All Variables Shown
Running ear or discharge						
No	1.0	1.0	1.0			
Yes, once	1.3 (0.5-3.3)	1.3 (0.5-3.3)	1.1 (0.4-3.2)			
Yes, more than once	4.1 (3.0-5.7)	4.2 (3.0-5.7)	2.2 (1.5-3.3)			
Ever had three or more ear infections						
No				1.0	1.0	1.0
Yes				2.3 (0.9-5.6)	2.9 (1.0-7.9)	1.4 (0.5-3.7)
Ever had ear tubes inserted						
No				1.0	1.0	1.0
Yes				5.7 (1.9-16.7)	6.9 (2.4-19.7)	6.7 (3.1-14.7)
Ever smoked cigarettes						
No	1.0	1.0	1.0	1.0	1.0	1.0
Yes	0.9 (0.7-1.2)	1.0 (0.7-1.4)	0.9 (0.5-1.4)	1.1 (0.4-2.8)	0.8 (0.3-1.9)	0.7 (0.2-2.8)
Packs smoked currently						
Nonsmoker	1.0	1.0	1.0	1.0	1.0	1.0
<1 pack per day	1.4 (1.0-2.0)	1.4 (0.9-2.1)	1.7 (1.1-2.8)	1.4 (0.5-4.3)	1.0 (0.4-2.9)	1.0 (0.2-4.0)
≥1 pack per day	1.5 (0.9-2.4)	1.5 (0.9-2.7)	2.4 (1.1-5.2)	—	—	—
Body mass index (BMI)						
Underweight (<18.5)	1.2 (0.8-1.7)	1.0 (0.7-1.4)	1.0 (0.7-1.4)	0.4 (0.1-2.7)	0.5 (0.1-3.1)	0.6 (0.1-3.6)
Normal (18.5–24.9)	1.0	1.0	1.0	1.0	1.0	1.0
Overweight (25.0–29.9)	1.0 (0.6-1.5)	0.9 (0.6-1.4)	1.0 (0.5-1.8)	1.8 (0.6-5.2)	1.7 (0.6-4.7)	1.7 (0.6-5.0)
Obese (≥30.0)	1.4 (0.6-3.0)	1.4 (0.6-3.1)	0.9 (0.3-2.5)	2.6 (0.8-9.1)	2.3 (0.7-8.0)	1.6 (0.6-4.4)
General health status						
Excellent	1.0	1.0	1.0	1.0	1.0	1.0
Very good	1.0 (0.6-1.7)	1.0 (0.6-1.6)	1.7 (1.1-2.5)	0.6 (0.1-3.5)	0.7 (0.1-3.6)	0.5 (0.1-3.0)
Good	2.2 (1.5-3.2)	2.3 (1.5-3.6)	2.0 (1.1-3.5)	1.8 (0.7-4.3)	1.9 (0.7-4.8)	1.5 (0.6-4.0)
Fair or poor	2.9 (1.3-6.3)	3.2 (1.6-6.6)	1.7 (0.7-4.1)	3.6 (1.2-10.7)	3.6 (1.1-12.0)	2.3 (0.7-7.4)
Ever unconscious						
No	1.0	1.0	1.0			
Yes, ≤ 1 hour	0.6 (0.4-1.0)	0.7 (0.4-1.1)	0.5 (0.3-1.1)			
Yes, 2 hours to < 1 day	1.5 (0.5-4.2)	1.4 (0.5-4.5)	1.1 (0.3-4.3)			
Yes, ≥ 1 day	2.9 (0.6-13.0)	2.2 (0.5-10.3)	1.7 (0.4-6.9)			
Noise exposure and other factors						
Ever used firearms						
No				1.0	1.0	1.0
Yes				2.9 (1.1-7.6)	3.3 (1.2-9.2)	3.1 (1.0-9.2)
Hours worked per week during school year						
Does not work	1.0	1.0	1.0			
1–4 hours	0.7 (0.4-1.4)	0.7 (0.4-1.4)	0.8 (0.4-1.5)			
5–9 hours	0.6 (0.4-1.0)	0.7 (0.4-1.1)	0.6 (0.4-0.9)			
≥10 hours	0.5 (0.4-0.8)	0.6 (0.4-0.9)	0.6 (0.4-0.9)			
Ever had job where exposed to loud noise for 5 or more hours per week						
No				1.0	1.0	1.0
Yes				3.3 (1.0-10.3)	2.9 (0.8-11.4)	3.3 (0.9-11.4)

(Continues)

TABLE V.
Continued

	Bilateral Speech-Frequency HI* ▸ NHES, 1966–1970			Bilateral Speech-Frequency HI* ▸ NHANES, 2005–2010		
	OR (95% CI), Unadjusted	OR (95% CI), Adjusted for Sex, Age, Race, and Family Income	OR (95% CI), Adjusted for All Variables Shown	OR (95% CI), Unadjusted	OR (95% CI), Adjusted for Sex, Age, Race, and Family Income	OR (95% CI), Adjusted for All Variables Shown
Hours listened to radio						
None	1.0	1.0	1.0			
<4 hours/day	0.6 (0.4-0.9)	0.7 (0.4-1.1)	0.6 (0.4-1.1)			
≥4 hours/day	0.7 (0.4-1.2)	1.0 (0.6-1.6)	0.7 (0.4-1.3)			
Outside of a job, ever exposed to steady loud noise or music for 5 or more hours per week						
No				1.0	1.0	1.0
Yes				2.4 (0.9-6.4)	2.1 (0.8-6.1)	1.7 (0.6-5.1)

*Bilateral speech-frequency HI is defined by the PTA of thresholds across 0.5, 1, 2, and 4 kHz ≥ 20 dB HL in both ears.

†In NHANES 2005–2010, race/ethnicity was defined as Hispanic (Latino) versus NH white, NH black, and NH other, whereas in the earlier NHES 1966–1970, Hispanic ethnicity was not ascertained.

CI = confidence interval; HI = hearing impairment; NH = non-Hispanic; NHANES = National Health and Nutrition Examination Survey; NHES = National Health Examination Survey; OR = odds ratio; PTA = pure-tone average.

TABLE VI.
Bilateral High-Frequency HI – Associations With Sociodemographic, Health, Noise Exposure and Other Factors for US Youths Aged 12–17 Years, NHES Cycle 3 1966 – 1970, Compared to Youths Aged 12–19 Years, NHANES 2005–2010

	Bilateral High-Frequency HI* ▸ NHES Cycle 3, 1966–1970			Bilateral High-Frequency HI* ▸ NHANES, 2005–2010		
	OR (95% CI), Unadjusted	OR (95% CI), Adjusted for Sex, Age, Race, and Family Income	OR (95% CI) Adjusted for All Variables Shown	OR (95% CI) Unadjusted	OR (95% CI) Adjusted for Sex, Age, Race, and Family Income	OR (95% CI) Adjusted for All Variables Shown
Sociodemographic factors						
Sex						
Male	2.0 (1.7-2.3)	2.3 (1.9-2.7)	2.4 (2.0-2.9)	2.1 (1.1-3.9)	2.1 (1.1-3.9)	2.5 (1.2-5.0)
Female	1.0	1.0	1.0	1.0	1.0	1.0
Age, yr						
12–13	1.0	1.0	1.0	1.0	1.0	1.0
14–15	1.0 (0.9-1.2)	1.1 (0.9-1.3)	1.0 (0.8-1.2)	1.4 (0.4-4.9)	1.4 (0.4-5.0)	1.1 (0.3-3.9)
16–17	1.1 (0.9-1.3)	1.2 (1.0-1.5)	1.0 (0.7-1.3)	2.5 (1.1-5.7)	2.6 (1.1-6.0)	0.4 (0.1-2.4)
18–19				1.9 (0.9-4.2)	1.7 (0.8-3.9)	0.3 (0.0-1.4)
Race/ethnicity						
White†	1.0	1.0	1.0	1.0	1.0	1.0
Black†	1.2 (1.0-1.5)	0.9 (0.7-1.2)	0.9 (0.6-1.3)	1.3 (0.7-2.4)	1.1 (0.6-2.1)	1.0 (0.5-2.1)
Hispanic				1.1 (0.6-2.3)	1.0 (0.5-2.0)	1.0 (0.4-2.3)
Other†	0.6 (0.2-1.9)	0.5 (0.1-1.8)	0.6 (0.1-2.9)	0.3 (0.0-2.3)	0.3 (0.0-2.2)	0.3 (0.0-2.2)
Family income						
<$5000	2.5 (1.8-3.4)	2.7 (2.0-3.7)	1.8 (1.2-2.7)			
$5,000–9,999	1.6 (1.1-2.3)	1.6 (1.1-2.3)	1.3 (0.9-2.0)			
$10,000–14,999	1.1 (0.7-1.8)	1.2 (0.8-1.8)	1.1 (0.7-1.7)			
≥$15,000	1.0	1.0	1.0			
Poverty-to-income						
< 1.50				1.7 (0.5-6.0)	1.8 (0.5-6.9)	1.6 (0.4-7.4)
1.50–2.49				0.8 (0.2-3.5)	0.8 (0.2-3.6)	0.7 (0.1-3.6)
2.50–4.99				1.2 (0.3-5.4)	1.2 (0.2-5.5)	1.1 (0.2-5.3)
≥ 5.00				1.0	1.0	1.0

(Continues)

TABLE VI.
Continued

	Bilateral High-Frequency HI* ▸ NHES Cycle 3, 1966–1970			Bilateral High-Frequency HI* ▸ NHANES, 2005–2010		
	OR (95% CI), Unadjusted	OR (95% CI), Adjusted for Sex, Age, Race, and Family Income	OR (95% CI) Adjusted for All Variables Shown	OR (95% CI) Unadjusted	OR (95% CI) Adjusted for Sex, Age, Race, and Family Income	OR (95% CI) Adjusted for All Variables Shown
Health Factors						
Birth weight, g						
<1500	2.1 (0.8-5.7)	2.5 (0.9-7.4)	3.2 (1.2-8.8)	20.0 (3.8-106)	24.0 (4.6-124.2)	19.3 (5.2-71.9)
1500–2499	1.1 (0.9-1.5)	1.2 (0.9-1.6)	1.1 (0.8-1.5)	1.8 (0.4-8.1)	2.1 (0.5-9.3)	2.5 (0.5-11.9)
2500–2999	1.1 (0.9-1.3)	1.1 (0.9-1.4)	1.1 (0.9-1.5)	3.5 (1.2-10.3)	3.8 (1.3-11.2)	4.0 (1.2-12.8)
3000–3999	1.0	1.0	1.0	1.0	1.0	1.0
≥4000	1.4 (0.9-2.0)	1.2 (0.8-1.8)	1.3 (0.9-2.0)	0.9 (0.2-4.0)	0.7 (0.1-3.8)	0.6 (0.1-3.9)
Unknown	1.3 (1.0-1.7)	1.3 (0.9-1.7)	1.3 (0.9-1.9)	3.4 (1.2-9.4)	4.4 (0.7-28.7)	6.8 (1.0-45.8)
Ever had asthma						
No	1.0	1.0	1.0	1.0	1.0	1.0
Yes	1.4 (1.1-2.0)	1.5 (1.1-2.1)	1.5 (1.1-2.2)	1.4 (0.8-2.6)	1.4 (0.8-2.6)	0.9 (0.5-1.6)
Earache in past year						
No	1.0	1.0	1.0			
Yes	1.5 (1.2-1.8)	1.6 (1.3-2.0)	1.1 (0.8-1.5)			
How often had earache in past year						
Not at all	1.0	1.0	1.0			
Not very often	1.3 (1.1-1.6)	1.4 (1.2-1.6)	1.1 (0.9-1.4)			
Quite often	2.6 (1.5-4.4)	3.0 (1.5-5.9)	1.9 (0.8-4.2)			
Ear drums opened or lanced						
No	1.0	1.0	1.0			
Yes	2.1 (1.4-3.1)	2.1 (1.3-3.2)	1.5 (0.9-2.5)			
Running ear or discharge						
No	1.0	1.0	1.0			
Yes, once	1.0 (0.6-1.7)	1.0 (0.6-1.7)	1.0 (0.6-1.7)			
Yes, more than once	2.9 (2.2-3.7)	2.8 (2.2-3.7)	2.4 (1.6-3.4)			
Ever had three or more ear infections						
No				1.0	1.0	1.0
Yes				1.9 (1.0-3.8)	2.2 (1.0-4.9)	1.2 (0.4-3.3)
Ever had ear tubes inserted						
No				1.0	1.0	1.0
yes				4.8 (2.7-8.6)	4.5 (2.1-9.5)	4.6 (2.3-9.4)
Ever smoked cigarettes						
No	1.0	1.0	1.0	1.0	1.0	1.0
Yes	1.3 (1.2-1.5)	1.2 (1.0-1.5)	1.1 (0.8-1.5)	2.4 (1.5-3.9)	2.1 (1.3-3.3)	1.6 (0.9-2.7)
Packs smoked currently						
Nonsmoker	1.0	1.0	1.0	1.0	1.0	1.0
<1 pack per day	3.0 (2.0-4.4)	1.4 (1.1-1.7)	1.3 (1.0-1.8)	2.5 (1.2-5.3)	2.0 (0.9-4.6)	1.4 (0.6-3.2)
≥1 pack per day	1.6 (1.4-1.9)	2.5 (1.6-3.9)	2.4 (1.5-3.9)	—	—	—
Body mass index						
Underweight (<18.5)	1.1 (0.9-1.3)	1.1 (0.9-1.3)	1.0 (0.8-1.2)	0.5 (0.2-1.4)	0.5 (0.2-1.6)	0.7 (0.2-2.2)
Normal (18.5–24.9)	1.0	1.0	1.0	1.0	1.0	1.0
Overweight (25.0–29.9)	1.2 (0.9-1.5)	1.2 (0.9-1.5)	1.3 (1.0-1.6)	2.2 (1.1-4.1)	2.0 (1.1-3.9)	1.9 (0.9-3.6)
Obese (≥30.0)	1.6 (1.0-2.5)	1.6 (1.0-2.6)	1.3 (0.8-2.3)	3.5 (1.7-7.5)	3.3 (1.5-7.4)	2.9 (1.3-6.8)

(Continues)

TABLE VI.
Continued

	Bilateral High-Frequency HI* ▸ NHES Cycle 3, 1966–1970			Bilateral High-Frequency HI* ▸ NHANES, 2005–2010		
	OR (95% CI), Unadjusted	OR (95% CI), Adjusted for Sex, Age, Race, and Family Income	OR (95% CI) Adjusted for All Variables Shown	OR (95% CI) Unadjusted	OR (95% CI) Adjusted for Sex, Age, Race, and Family Income	OR (95% CI) Adjusted for All Variables Shown
General health status						
Excellent	1.0	1.0	1.0	1.0	1.0	1.0
Very good	1.5 (1.3-1.8)	1.5 (1.2-1.8)	1.4 (1.1-1.7)	0.4 (0.2-1.0)	0.5 (0.2-1.1)	0.3 (0.1-0.8)
Good	2.0 (1.6-2.4)	1.8 (1.4-2.3)	1.6 (1.2-2.1)	1.4 (0.6-3.6)	1.5 (0.6-4.2)	1.0 (0.4-2.6)
Fair or poor	2.9 (2.0-4.3)	2.7 (1.8-4.2)	2.1 (1.1-3.9)	2.8 (1.2-6.5)	1.4 (0.5-3.7)	1.4 (0.5-3.6)
Ever unconscious						
No	1.0	1.0	1.0			
Yes, ≤ 1 hour	1.1 (0.8-1.5)	1.1 (0.8-1.4)	0.9 (0.6-1.2)			
Yes, 2 hours to < 1 day	2.0 (1.1-3.6)	1.8 (0.9-3.5)	1.7 (0.8-3.6)			
Yes, ≥ 1 day	3.3 (1.0-10.7)	2.4 (0.8-6.7)	2.1 (0.7-6.2)			
Noise exposure and other factors						
Ever used firearms						
No				1.0	1.0	1.0
Yes				1.3 (0.7-2.5)	1.2 (0.7-2.0)	0.8 (0.4-1.4)
Hours worked per week during school year						
Does not work	1.0	1.0	1.0			
1–4 hours	0.7 (0.5-1.0)	0.6 (0.5-0.9)	0.7 (0.5-1.0)			
5–9 hours	1.1 (0.8-1.6)	1.1 (0.8-1.5)	1.1 (0.7-1.5)			
≥10 hours	0.9 (0.7-1.1)	0.8 (0.6-1.1)	0.8 (0.6-1.1)			
Ever had job where exposed to loud noise for 5 or more hours per week						
No				1.0	1.0	1.0
Yes				1.4 (0.5-4.1)	1.1 (0.3-3.3)	0.8 (0.2-2.9)
Hours listened to radio						
None	1.0	1.0	1.0			
<4 hours/day	0.6 (0.5-0.8)	0.7 (0.5-0.9)	0.6 (0.5-0.9)			
≥4 hours/day	0.8 (0.6-1.1)	1.0 (0.7-1.4)	0.8 (0.6-1.3)			
Outside of a job, ever exposed to steady loud noise or music for 5 or more hours per week						
No				1.0	1.0	1.0
Yes				2.7 (1.6-4.6)	2.5 (1.4-4.3)	2.4 (1.3-4.2)

*Bilateral HF HI is defined by the PTA of thresholds across 3, 4, 6 kHz ≥ 20 dB HL in both ears.

†In NHANES 2005–2010, race/ethnicity was defined as Hispanic (Latino) versus NH white, NH black, and NH other, whereas in the earlier NHES 1966–1970, Hispanic ethnicity was not ascertained.

CI = confidence interval; HI = hearing impairment; NH = non-Hispanic; NHANES = National Health and Nutrition Examination Survey; NHES = National Health Examination Survey; OR = odds ratio; PTA = pure-tone average.

Prolonged recreational exposure to amplified music can cause NIHL and may be more common now than in previous decades. If so, effects on hearing in youths are not apparent in these surveys, either because they are too small or because stronger beneficial effects such as those mentioned above obscure them. Recent reviews of this literature have found no proven causal relationship between hearing loss and exposure to leisure noise in the young.[57,58]

Other changes after the 1966 to 1970 survey could also have contributed to better hearing. For example, comparisons of HI from the 1966 to 1970 and 2005 to 2010 surveys indicate relative improvements for black compared to white youth. This may have been due to reductions in racial health disparities for black children who began to have much better access to early childhood immunizations. After 1965, Medicaid gave children from low-income families better access to healthcare,[59] and healthcare improvements for low-income children were strengthened with the adoption of the State Children's Health Insurance Program in 1997 that simplified and revitalized Medicaid coverage for children.[60] Youth and adult smoking rates fell.[61–63] Vaccines for measles, mumps, rubella, and some of the bacteria that cause meningitis became widely available.[64,65]

Risk factors related to OM (earaches, otorrhea, myringotomy, ear tubes) were important predictors of HI. Medical management of OM evolved considerably between 1950 and 1980, with the availability of broad-spectrum antibiotics and middle ear ventilation tubes.[66,67] Although OM has often been shown to result in low-frequency or flat hearing loss,[68,69] other reports have emphasized associations with higher-frequency HI

as well.[70] Figure 2 shows that the hearing improvement in the 2005 to 2010 survey was mostly in high frequencies. Because hearing loss from OM is not primarily associated with high-frequency HI in this range,[71] this makes it less likely that reductions in hearing loss from OM has been a major contributor to the hearing improvement since 1970 in American youth.

The limitations of this study include lack of availability of identically worded interview questions across the 40-year time span of these three nationally representative health surveys. For example, if similar questions had been asked regarding major sources of noise exposure (occupational noise, including family farm exposures, and nonoccupational or recreational noise exposures), then we could have made more deliberate attempts to assess the relative importance of these preventable causes of hearing loss at each time period. Another limitation is the cross-sectional nature of these national health surveys, which prevent our drawing conclusions about cause and effect. However, we were able to identify cross-sectional changes for several important characteristics of the US population that occurred between the earliest (1966–1970) and most recent (2005–2010) time periods, which clearly had implications for increased or decreased HI. The earliest health survey, the NHES (1966–1970), had a higher participation rate, with 90.1% of the randomly selected and targeted youth sample examined, compared to the NHANES III 1988 to 1994 survey, with 78.6%, and the NHANES 2005 to 2010 survey with 77.3%. The latter two surveys included statistical oversamples for minority populations and post-sampling statistical adjustments to align the audiometric exam sample participants to the US population.[72] All three surveys were statistically sound and included sufficiently large samples of respondents to accurately represent the prevalence of hearing impairment and potentially associated risk factors for the US youth population in each era.

CONCLUSION

Epidemiological research on hearing loss in children has been limited because only a few large-scale nationally representative examination studies have ever been conducted using standard audiometric threshold measures. This report shows that HI prevalence in US youths declined after 1970; improvements were greatest for high frequencies and for the 10% of youths with the worst hearing. Although we cannot provide definitive answers based on cross-sectional health exam surveys, there are several possible reasons, including less noise exposure and more vaccinations, for this welcome change.

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