Prevalence of Childhood Hearing Loss

The Hispanic Health and Nutrition Examination Survey and the National Health and Nutrition Examination Survey II

David J. Lee,1,2 Orlando Gomez-Marin,1,3 and Heidi M. Lee4

Comparative analysis of the epidemiology of childhood hearing loss was undertaken among African-American, Hispanic-American, and non-Hispanic white children. Audiometric data on children aged 6–19 years were obtained from 688 African Americans, 330 Cuban Americans, 2,602 Mexican Americans, 1,025 Puerto Ricans, and 3,243 non-Hispanic whites who participated in either the National Health and Nutrition Examination Survey II, 1976–1980, or the Hispanic Health and Nutrition Examination Survey, 1982–1984. Hearing loss was defined as a pure-tone decibel hearing threshold level (averaged over 500, 1,000, and 2,000 Hz) greater than 15 in the ear with the best response. The prevalence (per 1,000) of bilateral hearing loss was 17.0 for African-American, 68.3 for Cuban-American, 27.6 for Mexican-American, 57.7 for Puerto Rican, and 15.5 for non-Hispanic white children. Differences in prevalence by ethnicity/race diminished when a more stringent definition of hearing loss (i.e., moderate or greater than 30 dB hearing threshold level) was used. There were no adolescent African-American males aged 16–19 years who had a hearing loss. After adjustment for age, the odds of hearing loss was significantly greater in males than in females only in non-Hispanic whites (odds ratio = 2.2; 95% confidence interval 1.6–3.3). On the basis of 1993 census population estimates in the United States, over 819,000 children aged 6–19 years have some degree of hearing impairment, and over 216,000 of these children have moderate or greater hearing impairment.

Received for publication July 21, 1995, and in final form June 6, 1996.

Abbreviations: CI, confidence interval; dBHL, decibel hearing threshold level; HHANES, Hispanic Health and Nutrition Examination Survey; NCHS, National Center for Health Statistics; NHANES II, National Health and Nutrition Examination Survey II.

1 Department of Epidemiology and Public Health, University of Miami School of Medicine, Miami, FL.
2 Department of Otolaryngology, University of Miami School of Medicine, Miami, FL.
3 Department of Pediatrics, University of Miami School of Medicine, Miami, FL.
4 Department of Speech Pathology and Audiology, Miami Children’s Hospital, Miami, FL.

Reprint requests to Dr. David J. Lee, Department of Epidemiology and Public Health, P. O. Box 016069 (R-669), Miami, FL 33101.

There are several published reports from national population-based audiometric surveys of non-Hispanic white and African-American children (1–4), but there are no comparable reports for the US Hispanic population. Comparative analyses of the epidemiology of childhood hearing loss among African-American, Hispanic-American, and non-Hispanic white American children have not been undertaken, nor have estimates been published of the number of hearing-impaired children residing in the United States. Furthermore, previously published prevalence estimates for US children have utilized definitions of hearing loss developed for adults (5). These definitions have been criticized for their inability to identify mild levels of hearing loss in children. In children, lower hearing threshold levels are clinically relevant, given the critical relation between hearing loss and language acquisition (6–8). Mild hearing loss levels, which fail to meet the threshold for traditional definitions of hearing loss in adults, may also be associated with poor scholastic performance in children (9).

This report examines the prevalence of hearing loss in children aged 6–19 years by using data from the Hispanic Health and Nutrition Examination Survey (HHANES) (10) and the National Health and Nutrition Examination Survey II (NHANES II) (11).

MATERIALS AND METHODS
Study population and design

The HHANES, conducted in 1982–1984 by the National Center for Health Statistics (NCHS), used a complex multistage sampling design, obtaining a rep-
representative sample of Mexican Americans from the southwestern states (Texas, New Mexico, Colorado, Arizona, and California), Cuban Americans from the Miami area, and Puerto Ricans from the New York City area (10, 12). The sampling design employed assured an 87 percent representation of the population of Mexican origin in these five southwestern states as well as 84 percent of all persons of Mexican origin in the United States (12). The HHANES was representative of 96 percent of the Cuban-American population in the Miami, Florida, area and was representative of 57 percent of the population of Cuban origin in the United States. The Puerto Rican portion of the survey was representative of 90 percent of this population in the New York City area and of 59 percent of the US Puerto Rican population. Overall, the three Hispanic groups included in the HHANES are representative of approximately 76 percent of the 1980 US population of Hispanic origin. A small percentage of participants originally misidentified as being of Hispanic origin were excluded from this analysis. Informed consent was obtained from all participants or their parents.

The NHANES II, conducted in 1976–1980 by the NCHS, also used a complex sample design, obtaining a nationally representative sample of African Americans and whites (11). In this survey, race was ascertained by the interviewer, who was instructed to record race as “white,” “black,” or “other.” Those identified as other were excluded from this analysis. Participants (or their parents) were asked to identify their country of origin. Children identified as being of “Chicano,” “Cuban,” “Mexican,” “Mexicano,” “Mexican American,” or “Puerto Rican” origin were excluded from this analysis (n = 278). Informed consent was obtained from all participants or their parents.

Data collection for the HHANES and the NHANES II took place in two phases. Participants were first administered a household interview. Next, they were given a comprehensive physical examination at centrally located examination trailers. Overall response rates for participating in the household interview and attending the physical examination, where audiometric data were collected, were 61, 76, and 75 percent, respectively, for Cuban Americans, Mexican Americans, and Puerto Ricans (10). Response rates for the NHANES II were 76 percent for African Americans and 73 percent for whites (13).

Our analyses are limited to children aged 6–19 years. Participants with incomplete audiometric data (n = 41) and those who were tested during possible audiometric equipment malfunction (n = 19) were excluded from these analyses. Complete pure-tone audiometric data were collected on 688 African Americans, 330 Cuban Americans, 2,602 Mexican Americans, 1,025 Puerto Ricans, and 3,243 non-Hispanic whites.

Hearing measures

Audiometric testing was conducted in the NHANES II and the HHANES using similar methodology (14, 15), including the same calibration specifications for audiometric equipment (16). Identical equipment was used in the studies, including audiometers (model 200-C, Beltone, Chicago, Illinois), sound level meters (model 2203, BrYel & Kjar, Decatur, Georgia), artificial ear couplers (BrYel & Kjar model 4151), condenser microphones (BrYel & Kjar model 4144), octave band filters (BrYel & Kjar model 1613), and acoustic calibrators (BrYel & Kjar model 4230). Air-conduction thresholds were obtained in sound-treated rooms at 500, 1,000, 2,000, and 4,000 Hz, with testing repeated at 1,000 Hz. Masked thresholds were obtained when there was an interaural difference in air-conduction thresholds of greater than 40 dB hearing threshold level (dBHL) (14, 15).

Pure-tone averages were calculated by averaging thresholds obtained at frequencies of 500, 1,000, and 2,000 Hz (6). The better (i.e., lower) of the two threshold responses at 1,000 Hz was used in calculation of pure-tone average. Masked threshold values were used when appropriate. Overall hearing loss was defined as a pure-tone average of greater than 15 dBHL in the ear with the better (i.e., lower) hearing sensitivity (6). Slight-to-mild hearing loss was defined as a pure-tone average 16–30 dBHL, and moderate or greater hearing loss was defined as a pure-tone average that exceeded 30 dBHL (6).

Prior to completing our primary analyses, we sought to determine the influence of nonparticipation in the physical examination during which the audiometric testing took place. During the HHANES household examination, the children or their parents were asked:

1) “Have you ever had trouble hearing with one or both ears? Do not include any problems which lasted just a short period of time such as during a cold,” or 2) “Has [the sample person] ever had trouble hearing with one or both ears? Do not include any problems which lasted just a short period of time such as during a cold.” The NHANES II interview includes similar questions except that the words “deafness or” preceded the words “trouble hearing.” We coded participants as having self-reported hearing difficulties if a positive response was given to either of these questions.

Prevalence rates of self-reported hearing loss were then compared to determine whether those who reported hearing difficulties were more or less likely to
attend the physical examination where audiometric testing was completed.

### Statistical analysis

Because of the multistage sampling design, all analyses were performed with adjustments for sample weights and design effects by using the SUDAAN statistical package for analysis of complex sample surveys (10, 17).

Prevalence rates of hearing loss (per 1,000) and 95 percent confidence intervals were reported for all comparisons. Ninety-five percent confidence intervals were calculated using standard error estimates with a level of precision of 100. Prevalence rates and confidence intervals were then rounded to the nearest one tenth prior to being reported. Any two prevalence rates whose 95 percent confidence intervals did not overlap were considered significantly different at the 5 percent level. To allow for comparisons across ethnic groups, we adjusted prevalence rates for age and gender by using the direct adjustment method via the 1993 US population distribution for children aged 6–19 years as the standard (18).

Logistic regression was used to estimate the odds of hearing loss in males versus females after controlling for age. Prior to completing these analyses, interactions between age and gender were examined.

Estimates of the number of hearing-impaired African-American, Cuban-American, Mexican-American, Puerto Rican, and non-Hispanic white children residing in the United States were derived by applying prevalence rates to the race-ethnic-specific estimates of the number of children residing in the United States. We selected 1993 projected population data that provide the most recent estimates of the number Hispanics and non-Hispanics residing in the United States (18, 19). Because published census estimates for Hispanic children were reported only in 5-year age intervals (i.e., 5–9, 10–14, and 15–19 years), we reduced the published number of Hispanic children aged 5–9 years by 20 percent to obtain an estimate of the number of children aged 6–9 years. This assumes that the age distribution in 5- to 9-year category is uniform.

### RESULTS

Table 1 presents the rate (per 1,000) of self-reported hearing loss in participants who did and those who did not complete audiometric testing. For each ethnic group, self-reported hearing loss rates were higher in those who completed audiometric testing. However, these differences were significant only for Cuban Americans. Reported hearing loss rates in Cuban Americans who completed testing were over six times higher than in those who did not complete testing.

Table 2 presents the prevalence of hearing loss by ethnicity and severity of hearing loss. Also presented are ethnicity-specific rates adjusted for age and gender. The prevalence of slight/mild hearing loss (16–30 dBHL) ranged from 9.4 per 1,000 in African-American children to 56.6 per 1,000 in Cuban-American children. Cuban-American and Puerto Rican children had significantly higher age- and gender-adjusted rates of slight/mild hearing loss than did African-American, Mexican-American, and non-Hispanic white children. Cuban-American children also had a significantly higher prevalence of hearing loss than did Mexican-American children. Prevalence rates for moderate and greater hearing loss (>30 dBHL) ranged from 3.7 per 1,000 in non-Hispanic whites to 11.7 per 1,000 in Cuban Americans. There were no statistically significant differences in the age- and gender-adjusted prevalence of moderate and greater hearing loss. Prevalence rates of overall hearing loss (>15 dBHL) ranged from 15.5 per 1,000 in non-Hispanic whites to 68.3 per 1,000 in Cuban Americans. There were no statistically significant differences in the age- and gender-adjusted prevalence of moderate and greater hearing loss. Prevalence rates of overall hearing loss (>15 dBHL) ranged from 15.5 per 1,000 in non-Hispanic whites to 68.3 per 1,000 in Cuban Americans. The latter ethnic group had an age- and gender-adjusted prevalence rate that was significantly higher than the rates for all other groups with the exception of the rate for Puerto Ricans. The rate for Puerto Rican children was also

---

**Table 1.** Ethnic-specific prevalence rates (per 1,000) of self-reported hearing loss by examination status: results from the Hispanic Health and Nutrition Examination Survey, 1982–1984, and the National Health and Nutrition Examination Survey II, 1976–1980

<table>
<thead>
<tr>
<th>Ethnic group</th>
<th>Did not complete audiometric testing</th>
<th>Completed audiometric testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prevalence*</td>
<td>95% CI</td>
</tr>
<tr>
<td>African American</td>
<td>27.0</td>
<td>0.0–54.3</td>
</tr>
<tr>
<td>Cuban American</td>
<td>10.4</td>
<td>0.0–29.5</td>
</tr>
<tr>
<td>Mexican American</td>
<td>54.3</td>
<td>27.2–81.3</td>
</tr>
<tr>
<td>Puerto Rican</td>
<td>47.2</td>
<td>8.6–85.9</td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>60.4</td>
<td>41.9–79.0</td>
</tr>
</tbody>
</table>

* Rates adjusted for sample weights and design effects. Because of differences in question wording in the two surveys, comparison of prevalence rates in Hispanics and non-Hispanics should not be undertaken.
† CI, confidence interval.
significant higher than those for all other ethnic groups with the exception of Cuban Americans.

Table 3 presents the ethnic/gender-specific prevalence rates of hearing loss (>15 dBHL) by age group (6–10, 11–15, and 16–19 years). Because of the small sample sizes, confidence intervals for most prevalence estimates are wide. There was a trend toward lower prevalence rates with increasing age groups among males, but not generally among females. However, in part due to large standard errors, none of the differences in prevalence of hearing loss in males were statistically significant across age group categories.

There were no consistent associations between gender and hearing loss when the age-adjusted odds ratios for gender among the five ethnic groups were compared. However, non-Hispanic white males had a significantly higher prevalence of hearing loss than did their female counterparts (odds ratio = 2.3, 95 percent confidence interval (CI) 1.6–3.3). There was a significant interaction between age and gender when prevalence rates among Puerto Ricans were compared. This analysis was repeated in two subgroups of Puerto Ricans who were below the median age (6–12 years) and those who were at or above the median age (13–19 years). It was first confirmed that there were no age-by-gender interactions in each of these two age groups. Males in the age group 6–12 years had higher rates of hearing loss than did females. This difference in rates by gender approached statistical significance (odds ratio = 2.5, 95 percent CI 1.0–6.6). In the older age group, females had higher rates of hearing loss than did males. These differences, however, were not statistically significant (odds ratio = 0.4, 95 percent CI 0.1–1.2).

Table 4 presents the estimates of the number (in thousands) of African-American, Cuban-American, Mexican-American, Puerto Rican, and non-Hispanic white children aged 6–19 years in the United States by hearing loss severity and ethnicity. Approximately 819,000 children have a bilateral hearing loss of greater than 15 dBHL. The majority of these children (approximately 603,000) have a slight/mild hearing loss.
hearing loss (>15 dBHL) that were three to four times greater than those among African Americans and non-Hispanic whites. These differences, were, however, largely due to the higher prevalence of slight/mild hearing loss (16–30 dBHL). Nevertheless, the highest prevalence of moderate or greater hearing loss was found among Cuban Americans and Puerto Ricans. When prevalence of hearing loss among Hispanics was compared, Mexican Americans had significantly lower rates of slight/mild and overall hearing loss relative to the other Hispanic subgroups. The age- and gender-adjusted rate for moderate or greater hearing loss was also lowest among Mexican Americans (6.0 per 1,000), although this rate was not significantly different from the rates for Cuban Americans (12.1 per 1,000) and Puerto Ricans (9.5 per 1,000).

We found only limited evidence that males have higher rates of hearing loss than do females. Among non-Hispanic whites, higher rates of hearing loss were found in males versus females (odds ratio = 2.2, 95 percent CI 1.6–3.3). Higher rates of hearing loss that approached statistical significance were found for Puerto Rican males aged 6–12 years (odds ratio = 2.5, 95 percent CI 1.0–6.6). Gender comparisons in other ethnic/age groups were inconsistent and nonsignificant. Results of other studies have also noted inconsistent differences in frequency responses by gender. Some studies have reported no differences across a broad frequency spectrum (i.e., 250–8,000 Hz) (1) or when using pure-tone thresholds averaged over 500–4,000 Hz (20). Other studies have suggested a pattern of greater hearing loss in males than in females in the higher frequencies (i.e., >2,000 Hz) (3, 21). However, the magnitude of these gender differences in the higher frequencies is not large.

There are several advantages of these analyses over previously published results. Both surveys used in this analysis are representative of the US population. The NHANES II was designed to be a nationally representative study of African Americans and whites, while the HHANES was designed to be representative of the Mexican-American population in the southwestern United States, Cuban Americans in southern Florida, and Puerto Ricans in the New York City area. Although not designed to be representative of Hispanics nationwide, the HHANES is representative of 76 percent of the US Hispanic population (12).

The second advantage of these analyses is the similarity of methods used in the two surveys that allowed comparative analysis of the prevalence of hearing loss in Hispanics and non-Hispanics. These similarities included use of the same type of audiometric equipment and audiometric testing procedures. Similarities in sampling methods and overall testing procedures in
the two surveys also suggest that bias introduced by comparing studies conducted in different populations is minimized.

There are several limitations of this study that should be noted. First, we had relatively low statistical power to detect significant differences in hearing loss in various subgroups (e.g., gender and age categories). This was due, in part, to the relatively low prevalence of hearing loss in children. The NHANES II and HHANES surveys were not designed to provide stable estimates of conditions that occur infrequently in the US population. In addition, overall sample sizes of African Americans, Cuban Americans, and Puerto Ricans were relatively small.

Time and cost constraints prevented the inclusion of bone conduction audiometry in the HHANES and the NHANES II. Furthermore, immittance measures were not undertaken in the NHANES II. Immittance measures were assessed in the HHANES, although test results were never released by the NCHS, in part due to technical difficulties in reliably completing the procedure. Information obtained by bone conduction audiometry and immittance measures would have allowed the determination of type of hearing loss (i.e., sensorineural vs. conductive) and the percentage of hearing loss that was likely to be temporary (i.e., otitis media-related hearing loss) versus permanent. For example, the higher rates of mild hearing loss found in Hispanic children in this study may have been due to higher rates of otitis media in Hispanics versus non-Hispanics. Several researchers have noted a higher prevalence of otitis media among Hispanics versus non-Hispanic whites (22), but research on the prevalence of otitis media in the first 3 years of life has indicated that the highest prevalence of any ethnic/racial group was found among a small sample of Hispanics and others not classified as non-Hispanic white or African American (23). In a follow-up study of 46 low-birth-weight infants at risk for neurodevelopmental disorders, Hispanic children were more likely to experience their first episode of otitis media at a younger age than were African-American children (24). However, a random sample of pediatric medical charts in Galveston, Texas, revealed no significant differences in the incidence of otitis media between non-Hispanic children aged 0–8 years versus children with Hispanic surnames (25). Finally, in the 1988 National Health Interview Survey, parents of Hispanic children were more likely than African-American parents to report multiple “ear infections” in the previous year (26). However, in this study the highest rates of multiple ear infection were reported by the parents of non-Hispanic white children.

These inconsistent findings prevent us from speculating with a high degree of confidence that the higher rates of slight/mild hearing loss found among Hispanics in this study could be due in part to higher rates of otitis media in Hispanics versus non-Hispanic whites and African Americans. As indicated earlier, lack of bone conduction audiometry and immittance measures prevented us from testing this hypothesis. Future research on the epidemiology of hearing loss in children should include these measures as well as pure-tone audiometry to determine type of hearing loss. Such information is critical to assess the public health impact of hearing loss as well as to devise effective prevention strategies.

Potential nonresponse bias to the physical examination during which audiometric data were collected...
may be another study limitation. Self-reported lifetime prevalence of hearing loss was significantly higher in Cuban-American children who attended their physical examination versus those who did not. It is therefore possible that prevalence estimates for Cuban-American children are overestimates of the "true" prevalence of hearing loss in this ethnic group. However, we calculated the sensitivity of this self-report measure in Cuban Americans by using our audiometrically defined measure of overall hearing loss (i.e., >15 dBHL) as our "gold standard." We found a sensitivity of only 25 percent, suggesting that lifetime prevalence of self-reported hearing difficulties is a poor predictor of current hearing loss. Nevertheless, the finding that Cuban-American children who reported a lifetime history were more likely to have attended their physical examination raises the strong possibility that at least a portion of the elevated rates of audiometrically confirmed hearing loss found in Cuban-American children is due to nonresponse bias. This possibility, in conjunction with the small sample size used to estimate prevalence in this ethnic group, suggests that additional research is needed to provide more accurate estimates of hearing loss in Cuban-American children.

It is unknown whether nonresponse to the household interview was also influenced by self-reported hearing difficulties identified by the children or their parents. However, one study of the influence of nonresponse to the NHANES II household interview on prevalence of selected health conditions in adults has been undertaken (27). This study compared questionnaire responses from the 1976 National Health Interview Survey, which had a very low percentage of nonrespondents (i.e., less than 4 percent), with similar questionnaire items asked during the NHANES II household interview. Two items included in this analysis were "deafness" and "ear infections." There were no differences in the percentages of respondents who replied positively to two these questions in the two surveys, suggesting that the NHANES II nonresponse was not influenced by concerns over ear infections or severe hearing problems. Unfortunately, this analysis was limited to adults aged 20–74 years. It is not known whether similar results hold also for children.

It should also be reiterated that all prevalence estimates in this analysis were adjusted using weights provided by NCHS. These weights adjust for nonresponse and noncoverage within primary sampling units (12). More specifically, these weights adjust for nonresponse to the household interview and to the examination during which audiometric testing was completed. Furthermore, a recently completed comprehensive analysis of nonresponse bias in the HHANES suggested that while response rates were higher in those with a health care need or condition, this response pattern was unlikely to cause significant bias in prevalence estimates (28).

Finally, differences in prevalence rates in Hispanics versus non-Hispanics may be due to trends in hearing loss rates in children. Since the NHANES II was conducted in 1976–1980 and the HHANES in 1982–1984, it is possible that higher rates of hearing loss reported for Hispanics could be due to increasing prevalence of hearing loss in the US population over time. However, there has been little increase in the prevalence of self-reported hearing loss in children noted in the National Health Interview Surveys. For example, the prevalence (per 1,000) of any degree of hearing impairment increased from 16.2 in 1971 to 18.2 in 1990–1991 (29). Extrapolating from these self-report data, it is therefore unlikely that the significant differences in prevalence rates in non-Hispanics versus Hispanics reported in this paper can be explained in large part by any trends from 1976–1980 to 1982–1984.

Hearing loss was defined in this analysis as bilateral threshold responses that exceeded 15 dBHL averaged over three frequencies: 500, 1,000, and 2,000 Hz. This threshold is lower than that which is typically used for adults and was selected because of concerns that lower levels of hearing loss may adversely affect language acquisition and perhaps educational achievement (6, 7). Evidence to support an association between mild hearing loss and these outcomes is limited and has been criticized on methodological grounds (9). Additional research is needed to determine age-specific optimal audiometric thresholds that correlate with outcomes of public health importance such as language acquisition, educational achievement, and psychologic well-being.

To summarize, this paper found significantly higher rates of hearing loss in Cuban-American and Puerto Rican than in African-American, Mexican-American, and non-Hispanic white children. These differences were largely due to a higher prevalence of slight/mild (16–30 dBHL) hearing loss in these two Hispanic groups. There were no consistent differences in prevalence of hearing loss by age or gender across the five ethnic/racial groups. Additional research is needed to determine the type of hearing loss (i.e., conductive vs. sensorineural). Finally, additional research is needed to confirm the high prevalence estimates reported for Cuban-American and Puerto Rican children and to identify factors that account for higher rates of hearing loss in these Hispanic populations.
REFERENCES


