# Quantitative and Qualitative Follow-Up Outcomes From a Preschool Audiologic Screening Program: Perspectives Over a Decade

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**Purpose:** This investigation reports on quantitative and qualitative follow-up information obtained from a preschool audiologic screening program covering a 10-year period (1995 to 2004).
**Method:** The audiologic screening consisted of a hearing (pure tone) and tympanometry screening. A total of 34,979 children, 3 to 5 years of age, were screened.
**Results:** Eighteen percent (6,337) of the children were referred for further hearing and/or medical ear evaluation. Of 1,421 follow-up responses received, 93% complied with the follow-up recommendations while 7% did not. Of 1,316 children in the follow-up group, outer and/or middle ear disorder in one or both ears was medically confirmed for 37%. Unilateral or bilateral hearing loss was diagnosed in 18% as conductive (12%), sensorineural (1%), mixed (0.4%), or unspecified (5%). Overall, hearing loss and/or otologic disorder was confirmed in 49% of the follow-up group, suggesting a prevalence of 1.8% in a preschool-age population. A small ($n = 32$) sample of unsolicited comments indicated that physicians most influenced noncompliance with hearing evaluation follow-up.
**Conclusions:** The quantitative hearing and otologic follow-up outcome data affirm the importance of audiologic screening in the preschool population. Qualitative data suggest that some physicians may not be advocating appropriate screening follow-up services.

**Key Words:** audiologic screening, preschool-age children, hearing and otologic follow-up

Early diagnosis and remediation of hearing loss are essential in reducing the potential impact on a child's speech-language skills, behavioral development, and academic performance (American Speech-Language-Hearing Association [ASHA], 2002; Joint Committee on Infant Hearing [JCIH], 2000; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998). Universal newborn hearing screening, as advocated by the JCIH (2000), serves a major role in the early identification of hearing loss at birth. Currently, mandates in 40 states and the District of Columbia, in addition to voluntary compliance programs in 5 states, have ensured access to newborn hearing screening services (ASHA, 2007).

Despite the wide availability of infant hearing screening services, congenital hearing loss, particularly mild or unilateral forms, may be missed in some infants (J. L. Johnson et al., 2005; White et al., 2005; Widen et al., 2005). White and colleagues (2005) estimated that approximately 23% of infants with permanent hearing loss would have passed the automated auditory brainstem response screening used in typical infant hearing screening paradigms. In addition, late-onset or acquired hearing loss may occur at any time throughout childhood as a result of various causes, including infectious diseases such as meningitis or otitis media (JCIH, 2002). Approximately 3 in 1,000 children will present with acquired deafness in early childhood (Northern & Downs, 2002). Otitis media with effusion (OME) is the main cause of acquired hearing loss in children (Cunningham & Cox, 2003). It is estimated that 90% of children will develop OME before school age, with episodes that may be chronic or recur (American Academy of Pediatrics, 2004). Given the high prevalence of OME in children, it is probable that nearly all children could present with some degree or period of hearing loss related to middle ear effusion at any time from birth to age 10 years (Northern & Downs, 2002).


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Moreover, children presenting with subtle forms of hearing loss such as unilateral or minimal losses (slight [16 to 25 dB HL] or mild [26 to 40 dB HL]) may not be identified early because these children can appear to hear normally and may develop appropriate speech and language skills (ASHA, 2002). Prevalence statistics of hearing loss in school-age children suggest that most hearing losses are unilateral and slight to mild in degree (Bess, Dodd-Murphy, & Parker, 1998; Niskar et al., 1998). It is widely recognized that hearing loss, including minimal or unilateral forms, affects communicative, social, and academic development in children (ASHA, 2002; Bess, 1985, 1986; Bess et al., 1998; Bess & Tharpe, 1986; JCIH, 2000; Yoshinaga-Itano et al., 1998).

Screening for hearing loss beyond newborn screening and throughout childhood is therefore necessary in order to assist in the identification of hearing loss that is late-onset or acquired, or not identified in early infancy. Federal legislation through the Individuals with Disabilities Education Act does require states to develop and implement identification and intervention services for infants, toddlers (birth to 2 years), and students (3 to 21 years) with disabilities, including hearing loss. Hearing screening for school-age children is widely available through legislation or coordinated statewide services in most states in the country (Penn, 1999). The American Academy of Audiology (1997) recommends that all children should receive screening for hearing loss at least once during their preschool years. Additionally, ASHA, in its Audiologic Assessment Panel's (1997) *Guidelines for Audiologic Screening,* recommends screening for outer and middle ear disorders for all children age 7 months through 6 years. Several studies support the value of using aural acoustic immittance measures for the identification of middle ear effusion in children (De Chicchis, Todd, & Nozza, 2000; Nozza, Bluestone, Kardatzke, & Bachman, 1992, 1994). Formal audiologic screening programs are therefore particularly important in assisting with the early identification and management of hearing and middle ear disorders during the formative preschool- and school-age years (Mundy, 2001).

Currently, however, there are no universally mandated audiologic screening services for infants and toddlers 7 months through 2 years, or preschool-age children 3 to 5 years. Publicly funded preschool programs that provide audiologic screening services are becoming increasingly available but lack universally accepted methods on administration. Such programs may not follow protocols recommended by professional standards and may use inadequately trained personnel to perform the screenings (C. D. Johnson, 2002). Therefore, the applied screening procedures and referral and follow-up criteria differ among programs and may not be specific to the professional *Guidelines for Audiologic Screening* (ASHA Audiologic Assessment Panel, 1997). As such, varying screening outcomes have been reported in the literature (see Allen, Stuart, Everett, & Elangovan, 2004, for a more complete discussion of the differences among screening protocols).

The purpose of this investigation was to report on long-range quantitative and qualitative follow-up information obtained from a preschool hearing (pure tone) and tympanometry screening program. The Long Island Hearing Screening Program (LIHSP) is a nonprofit professional organization concerned with the detection of auditory disorders in preschool-age children. The program has been in operation for 30 years and has screened more than 180,000 children from 3 to 5 years of age since 1975. This investigation reviews screening and follow-up data maintained by the LIHSP over a 10-year period (1995 to 2004). In addition to a quantitative analysis of the screening and follow-up outcomes, a qualitative review of unsolicited comments by parents and physicians who did and did not follow up with the screening recommendations was conducted. It was anticipated that the findings of this large-scale, long-range study will provide additional evidence on the importance of screening for hearing and outer/middle ear disorders in the preschool population and an insight into screening follow-up practices.

## Method

The LIHSP audiologic screening services were performed for children age 3 to 5 years on site in private, nonprofit, or public preschools, day care centers, or Head Start programs. Services were conducted by graduate-level audiology or speech-language pathology students under the supervision of an ASHA-certified audiologist licensed by New York State. Several graduate programs in the Long Island, New York, area are associated with the LIHSP organization, including Adelphi University, Hofstra University, Long Island University-C.W. Post, St. John's University, Queens College, and the Long Island AuD Consortium. Individual consent forms documenting parental permission for the child to receive the screening services were obtained and housed by the screening site. A program release form signed by the director of the screening site documented that individual consent had been granted by the parent of each child who participated in the screening. This study was approved by the institutional review board of Adelphi University.

The screening test room environment varied by test site; however, settings were chosen to ensure minimal visual distractions and appropriate ambient noise levels as determined by psychoacoustic listening checks conducted by the supervisor and at least one examiner. Specifically, the test room was considered appropriate for performing the hearing screening when the listener detected each test stimulus at the hearing screening level criteria (see below) without report of hearing any other sound that could interfere with the hearing measurements (American National Standards Institute [ANSI], 1999). Depending on the room size, four to five test stations were typically set up in one test area spaced as far apart from the other as the room dimensions allowed. A single test station consisted of one piece of equipment (portable audiometer or tympanometer) set on a table and two surrounding chairs, one each for the examiner and the child to be tested. The tympanometer (Grason-Stadler 1737) was located at one test station, and the remaining three to four test stations contained the audiometers (Beltone 119, Beltone Scout: TDH 50 earphones, MX51 cushions; Grason-Stadler 1717: TDH 39 earphones, MX51 cushions). Several audiometers and tympanometers were used over the 10-year period of this project: Beltone 119 ($n$ = 2), Beltone Scout ($n$ = 5), Grason-Stadler 1717 ($n$ = 2), Grason-Stadler 1737 ($n$ = 3). Annual and daily biologic calibrations of the audiometric

equipment were conducted to ensure proper functioning of the equipment (ANSI, 1989, 1996).

Each child received a hearing (pure tone) screening followed by a tympanometry screening. Groups of up to 15 children at once were permitted into the test room. The initial instructions for the hearing screening were provided by the supervising audiologist to the children as a group. First, a brief demonstration of earphone placement was conducted. Next, the audiologist demonstrated a hand-raising listening task with the presentation of a high-intensity (e.g., 110 dB HL) pure tone (e.g., 3000 Hz) delivered through an earphone held up within a few feet from the children. The children were then asked to participate, and the task was repeated several times. The children were asked to maintain quiet during the testing process in an effort to minimize auditory distractions during the screenings. Following the group instruction, each child in turn was screened individually.

The hearing screening was performed by a single examiner (graduate student) under the supervision of the audiologist. The hand-raising task was redemonstrated. Play audiometry techniques were conducted by one or two examiners when the child could not be tested reliably using the hand-raising task. Difficult-to-test children were screened by the audiology supervisor. The auditory signals were air-conducted pure tones delivered through earphones at 20 dB HL at 1000, 2000, 3000, and 4000 Hz, and presented to each ear separately. The ambient noise levels in the room were monitored by the audiology supervisor throughout the test session by one or more of the following ways: performing psychoacoustic listening checks at the screening level criteria, reminding the children in the test room to maintain quiet, and/or requesting that the teacher aides remove disruptive children from the test area. When one or more frequencies were not perceived at 20 dB HL in either ear, the child was retested in the same test session by a different examiner. This practice served to further ensure that background noise levels did not interfere with the hearing measurements. A referral for hearing evaluation was made when a pure tone was not perceived at 20 dB HL at any one frequency in either ear, or when a child could not be tested reliably following the screening retest.

The audiology supervisor performed the tympanometry screening, which consisted of a tympanogram recorded using a 226-Hz probe tone, 600/200 daPa/s sweep rate (except near the tympanometric peak, where the sweep rate slowed to 200 daPa/s). Otoscopy (using two Welch Allyn 25020 handheld otoscopes) was performed for children with known tympanostomy tubes or for those in which tympanometry revealed reduced peak compensated static acoustic admittance ($Y_{tm} < 0.3$ cm$^3$) in isolation or accompanied by an excessively large ear canal volume (>1.0 cm$^3$), or when testing could not be conducted due to an inability to maintain a hermetic seal. A referral for medical evaluation of the ear was made when (a) there was visual observation of ear drainage or other previously undetected structural defect(s) of the ear, or ear canal abnormalities (such as impacted cerumen or foreign bodies); (b) the tympanogram revealed reduced peak admittance ($Y_{tm} < 0.3$ cm$^3$) in isolation or accompanied by excessively large ear canal volume (>1.0 cm$^3$) readings in the absence of tympanostomy tubes; or (c) ear canal volume readings suggested tubes were not patent (<1.0 cm$^3$).

The screening procedures and pass/refer criteria used by the LIHSP differed from the ASHA 1997 guidelines for screening for hearing impairment in preschool children age 3 to 5 years and for outer and middle ear disorders from birth to 18 years in the following ways: (a) 3000 Hz was additionally screened, (b) pure-tone rescreening was conducted for children who did not initially pass in the same test session, (c) otoscopy was performed following positive tympanometry results instead of preceding tympanometry, and (d) medical referral was recommended following initial positive tympanometry outcomes; the LIHSP protocol did not include a tympanometry rescreen 6–8 weeks from the time of the initial test prior to a medical referral for children who did not pass, as is recommended by the ASHA 1997 guidelines.

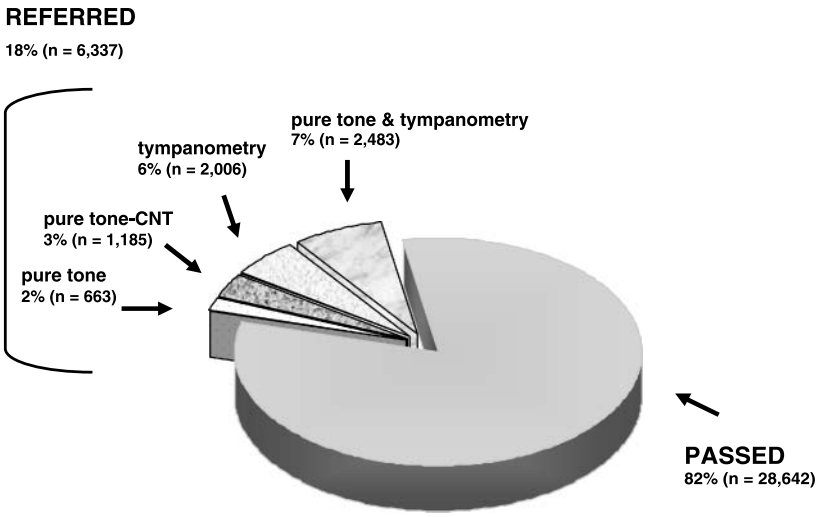
Following a "refer" outcome, an information letter, referral form, and self-addressed envelope were sent home to parents through the screening site. The information letter, intended for parents, explained the screening test methods and results, the importance of follow-up, and detailed procedures for obtaining further hearing and/or medical ear services (by a pediatrician, family physician, medical ear specialist, or licensed audiologist). Parents were informed that the follow-up information would be kept confidential and would be used only for statistical purposes. The significance of returning the referral form to the LIHSP was emphasized by indicating that the follow-up information was "vital" in order for the program to improve upon the screening services. The referral form, intended for the examiner, included the screening results and sections for the examiner to indicate the relevant otoscopic, pure-tone, and tympanogram follow-up outcomes and recommendations. Instructions were provided in the parent letter that indicated that the referral form, upon completion by the examiner, was to be returned to the LIHSP in the self-addressed envelope. Three months after the screening date, follow-up postcards were delivered through the screening site to parents of children who had not returned the original referral form. The postcards, which were postage-paid and self-addressed, included brief questions inquiring whether the child had been examined (and by whom), which examinations (medical, hearing, tympanogram) had been performed with the respective outcomes, and whether additional tests or treatments were advised.

## Results

### *Quantitative Screening and Follow-Up Data*

A total of 34,979 children were screened during the period of this investigation (1995–2004). Eighty-two percent of the children ($n$ = 28,642) passed both the pure-tone and tympanometry screen; 6,337 children did not pass the pure-tone and/or tympanometry screening, yielding an overall refer rate of 18% (see Figure 1). Specifically, 5% ($n$ = 1,848) did not pass the pure-tone screening in isolation, which included 3% ($n$ = 1,185) of children who could not be tested; 6% ($n$ = 2,006) did not pass the tympanometry screening in

**Figure 1. Pass/refer pure-tone and tympanometry screening outcomes. Total number of children screened = 34,979. CNT = could not test.**




isolation; and 7% ($n$ = 2,483) did not pass both the pure-tone and tympanometry screening. Pass/refer data specific to age were not available for this type of analysis.

Of the 6,337 children referred for further testing, a total of 1,433 (23%) follow-up responses (referral forms or postcards) were received within 6 months of the referral date and were completed by audiologists, family physicians, parents, pediatricians, medical ear specialists (otologists, otolaryngologists), or school nurses. Twelve (1%) of the total responses were returned incomplete and considered not valid because they indicated the child had moved or no longer attended the school program. Of the 1,421 valid responses, 93% ($n$ = 1,316) indicated that the parent had followed up with the recommendations of the screening program, representing a 21% follow-up rate. Six (0.4%) respondents indicated that follow-up was in process, and 99 (7%) of the respondents indicated that follow-up was not pursued.

The age and gender distribution of the follow-up group was as follows: 3 years ($n$ = 256), 4 years ($n$ = 285), 5 years ($n$ = 129), age unspecified 3–5 years ($n$ = 646); male ($n$ = 645), female ($n$ = 607), gender unspecified ($n$ = 64). Figure 2 shows a flowchart of the follow-up outcomes. Medical ear evaluation was performed on 52% ($n$ = 682) of the follow-up group and was either not conducted or unreported for 48% ($n$ = 634; see Figure 3). Normal outer and middle ear function was reported bilaterally for 15% ($n$ = 202) of the children. Outer and/or middle ear disorder in one or both ears was medically confirmed for 37% ($n$ = 480) of children. Bilateral otologic disorder ($n$ = 358) was three times as prevalent as unilateral ($n$ = 122) disorder.

Middle ear disorders accounted for the largest percentage (26%; $n$ = 338) of the otologic disorders identified in the follow-up group. Otitis media in some form—acute, with infected (e.g., purulent) or noninfected (e.g., serous) effusion or without effusion—was the most common middle ear disorder, occurring in 25.5% ($n$ = 335) of children. Bilateral cases of otitis media ($n$ = 247) were almost three times as prevalent as unilateral cases ($n$ = 88). A small number of children presented with other middle ear disorders, such as tympanic membrane perforation ($n$ = 1) or cholesteatoma ($n$ = 2). Impacted cerumen was the most common outer ear condition, identified in approximately 8% ($n$ = 102) of children. The presence of a foreign body in the ear canal was noted in 2 children. The combination of outer ear (impacted cerumen) and middle ear (OME) disorders in the same ear was reported in 3% ($n$ = 38) of children.

**Figure 2. Follow-up outcomes. Total number of children screened = 34,979; number of children referred = 6,337. Total follow-up responses include 6 reportedly in process of follow-up; some children received both medical and hearing follow-up services. Percentages are outcomes of the follow-up group ($n$ = 1,316). Medical = medical ear evaluation; Disorder = outer and/or middle ear disorder.**

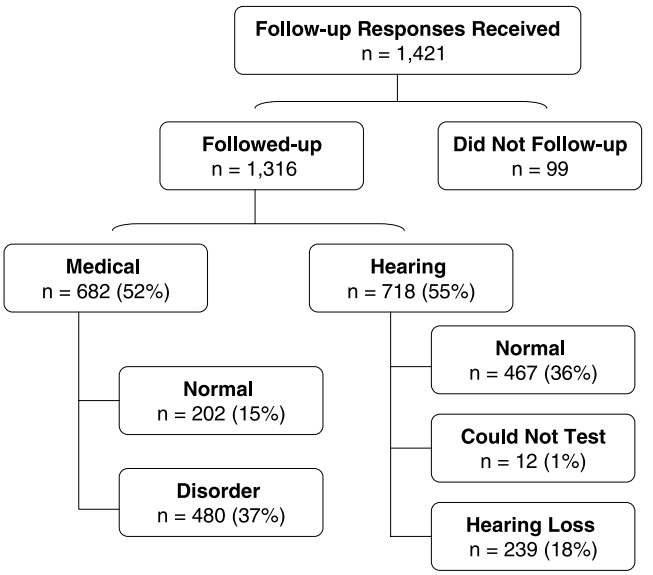
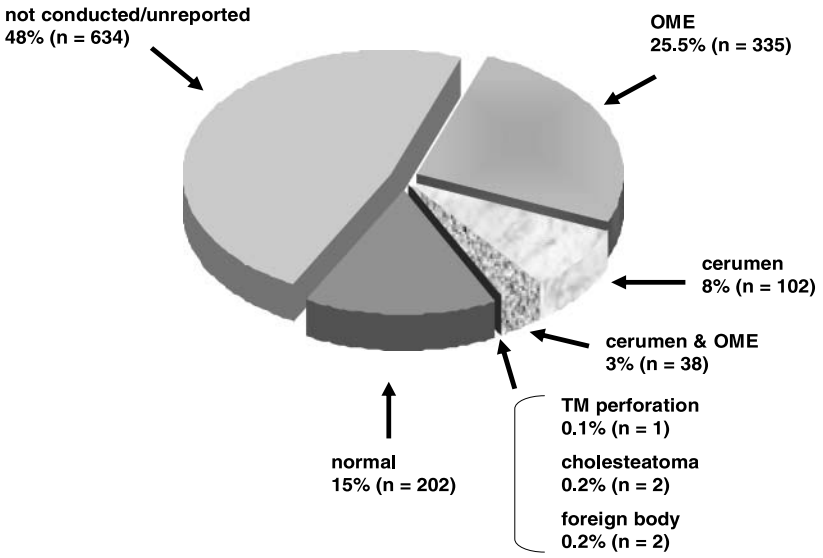


**Figure 3. Medical ear evaluation outcomes. Data represent follow-up outcomes of 1,316 children; OME = otitis media with effusion; TM = tympanic membrane.**




Hearing evaluation or screening services were pursued by 55% ($n$ = 718) of the follow-up group and were either not conducted or unreported for 45% ($n$ = 598). Twelve children (1%) reportedly could not be tested. Normal hearing was confirmed in 36% ($n$ = 467) of children. Unilateral or bilateral hearing loss, ranging in degree from slight to profound (>90 dB HL), was diagnosed in 18% ($n$ = 239) of children and was conductive (CHL) for 12% ($n$ = 156), sensorineural (SNHL) for 1% ($n$ = 15), mixed for 0.4% ($n$ = 5), and unspecified (UHL) for 5% ($n$ = 63). Bilateral hearing loss ($n$ = 153) was diagnosed in approximately twice as many children as unilateral loss ($n$ = 86). A subset of 5 (0.4%) children with bilateral hearing loss presented with a different type of hearing loss in each ear: SNHL and mixed ($n$ = 2), CHL and mixed, CHL and UHL, mixed and UHL. The gender distribution of children identified with hearing loss was fairly similar: male = 128, female = 100, unspecified = 11.

Mean air conduction thresholds (in dB HL) by age according to type of unilateral or bilateral hearing loss diagnosed in the follow-up group ($n$ = 239) are displayed in Tables 1

**Table 1. Mean audiometric data by age for confirmed unilateral hearing loss in follow-up group.**

| | | | Air conduction thresholds (in dB HL) by frequency (Hz) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Right or left ear | | | | | | |
| Hearing loss type | Age | $n$ | PTA | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| CHL | 3 | 10 | 23 | 27 | 30 | 23 | 13 | 23 | 25 |
| (total $n$ = 48) | 4 | 20 | 23 | 26 | 26 | 24 | 18 | 23 | 33 |
| | 5 | 11 | 25 | 32 | 30 | 25 | 20 | 24 | 31 |
| | — | 7 | 23 | 29 | 28 | 25 | 18 | 19 | 32 |
| Mixed | 4 | 2 | 27 | 20 | 18 | 25 | 38 | 50 | 45 |
| (total $n$ = 4) | 5 | 2 | 28 | 22 | 23 | 27 | 34 | 43 | 45 |
| SNHL | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 25 | |
| (total $n$ = 10) | 4 | 4 | 69 | 59 | 66 | 69 | 73 | 78 | 67 |
| | 5 | 3 | 81 | 77 | 85 | 80 | 77 | 83 | 115 |
| | — | 2 | 52 | 50 | 55 | 50 | 50 | 78 | 88 |
| UHL | 3 | 5 | 22 | 23 | 26 | 24 | 16 | 23 | |
| (total $n$ = 24) | 4 | 8 | 16 | 24 | 18 | 16 | 16 | 18 | 31 |
| | 5 | 4 | 18 | 23 | 20 | 17 | 14 | 20 | 43 |
| | — | 7 | 18 | 20 | 20 | 20 | 13 | 18 | 15 |

*Note.* $n$ = number of children; PTA = 3-frequency pure-tone average of 500, 1000, and 2000 Hz (2 frequencies used when 3 not available); CHL = conductive hearing loss; SNHL = sensorineural hearing loss; UHL = unspecified hearing loss; dash indicates information not available.

and 2, respectively. Observations regarding hearing loss by age are limited, as age was unspecified for 19% ($n$ = 45) of children diagnosed with hearing loss; however, 4 years represented the largest ($n$ = 85) age group presenting with hearing loss, with fairly equal distribution among 3-year-olds ($n$ = 53) and 5-year-olds ($n$ = 56).

Bilateral CHL ($n$ = 108) was more than twice as prevalent as unilateral CHL ($n$ = 48), with mean impaired thresholds ranging from 16 to 36 dB HL. Based on the two- or three-frequency pure-tone averages (PTAs), the majority of 264 ears confirmed with CHL were slight ($n$ = 110) to mild ($n$ = 87) in degree. A moderate (41 to 55 dB HL) degree of CHL was noted for 15 ears, and 1 was moderately severe (56 to 70 dB HL). Twenty-nine ears with PTAs within the normal range presented primarily with a low-frequency configuration of CHL. The degree of CHL was unspecified for 22 ears.

The mean thresholds of 10 children identified with unilateral SNHL ranged from 25 to 115 dB HL. The hearing loss for 5 children diagnosed with unilateral SNHL was profound in degree. Three children presented with high-frequency unilateral SNHL ranging from slight to severe (71 to 90 dB HL), and the PTAs for 2 children were slight and mild, respectively. Bilateral, primarily high-frequency SNHL was confirmed in 4 children, with mean impaired thresholds ranging from 18 to 53 dB HL at or above 1000 Hz. One child presented with a mild bilateral low-frequency SNHL.

The mean thresholds for 4 children with unilateral mixed hearing loss ranged from 18 to 50 dB HL, and thresholds were mild to profound for 1 child with bilateral mixed loss. Unilateral UHL was identified in 24 children and was bilateral for 39 children, with mean impaired thresholds across age ranging from 16 to 39 dB HL. Of 102 ears diagnosed with UHL, most PTAs were slight ($n$ = 34) or mild ($n$ = 24) in degree, and 10 were moderate. Thirteen ears with PTAs in the normal range presented with UHL in the low or high frequencies, particularly at 8000 Hz. The degree of UHL was unspecified for 21 ears.

Of the total 392 ears diagnosed with hearing loss, most PTAs of individual ears were within a slight ($n$ = 150; 38%) or mild ($n$ = 116; 30%) degree. Six percent ($n$ = 25) of ears demonstrated moderate loss; for 0.3% ($n$ = 1), loss was moderately severe, and profound for 2% ($n$ = 6). Six percent ($n$ = 75) of children in the follow-up group ($n$ = 1,316) presented with both confirmed hearing loss and otologic disorder. In all, 49% ($n$ = 643) of children in the follow-up group were ultimately diagnosed with some form of hearing loss and/or otologic disorder.

### *Qualitative Follow-Up Data*

A number ($n$ = 50) of respondents (parents or examiners) provided unsolicited written comments on the referral forms or follow-up postcards. Some ($n$ = 13) of the respondents who indicated compliance with the follow-up recommendations (and whose children were ultimately identified with outer and/or middle ear disorder or hearing loss) expressed their gratitude and praise of the screening program, and specifically mentioned their appreciation of the program's follow-up inquiry. A few respondents ($n$ = 5) who sought follow-up services expressed annoyance at finding what was ultimately considered a false-positive outcome.

The unsolicited written comments expressed by the respondents who did not comply with the follow-up recommendations were particularly insightful. Of the 99 who indicated that follow-up services were not conducted, one third ($n$ = 32; parents = 16; physicians = 16) provided written comments (see Table 3). Several ($n$ = 8) indicated that further hearing and/or otologic evaluation was not pursued because the child was being treated for middle ear infection at the time of the screening. Additionally, there were comments from parents who independently concluded that further hearing evaluation was not necessary because of perceived age ($n$ = 3) or language-limiting factors ($n$ = 1), or because hearing loss was not suspected ($n$ = 5). Almost half ($n$ = 15) of the 32 respondents indicated noncompliance with hearing evaluation referral following a physician's advice as follows: 3 were told there was no problem with their child's hearing, and 12 were informed that their child

**Table 2. Mean audiometric data by age for confirmed bilateral hearing loss in follow-up group.**

| | | | Air conduction thresholds (in dB HL) by frequency (Hz) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Right ear | | | | | | | Left ear | | | | | | |
| Hearing loss type | Age | $n$ | PTA | 250 | 500 | 1000 | 2000 | 4000 | 8000 | PTA | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| CHL | 3 | 30 | 30 | 34 | 33 | 31 | 24 | 29 | 36 | 29 | 34 | 32 | 31 | 23 | 28 | 34 |
| (total $n$ = 108) | 4 | 37 | 23 | 26 | 27 | 24 | 17 | 21 | 29 | 25 | 30 | 29 | 27 | 21 | 25 | 26 |
| | 5 | 26 | 25 | 27 | 27 | 27 | 20 | 25 | 28 | 23 | 27 | 25 | 24 | 18 | 22 | 25 |
| | — | 15 | 31 | 25 | 33 | 32 | 27 | 31 | 26 | 23 | 16 | 26 | 22 | 20 | 26 | 22 |
| Mixed | — | 1 | 90 | 90 | 85 | 95 | 90 | 100 | 105 | 40 | 35 | 35 | 45 | 40 | 65 | 85 |
| (total $n$ = 1) | | | | | | | | | | | | | | | | |
| SNHL | 4 | 2 | 13 | 20 | 15 | 10 | 15 | 40 | 50 | 10 | 10 | 10 | 10 | 10 | 40 | 20 |
| (total $n$ = 5) | 5 | 1 | 20 | | 30 | 15 | 15 | | | | 23 | | 30 | 15 | 15 | |
| | — | 2 | 20 | 10 | 8 | 20 | 33 | 43 | 53 | 17 | 13 | 13 | 18 | 20 | 43 | 50 |
| UHL | 3 | 7 | 30 | 20 | 33 | 34 | 25 | 29 | 20 | 34 | 30 | 38 | 31 | 34 | 39 | 15 |
| (total $n$ = 39) | 4 | 12 | 26 | 26 | 29 | 27 | 21 | 22 | 28 | 24 | 20 | 27 | 22 | 22 | 27 | 27 |
| | 5 | 9 | 19 | 19 | 21 | 21 | 17 | 23 | 28 | 19 | 20 | 21 | 21 | 19 | 26 | 33 |
| | — | 11 | 27 | 25 | 33 | 28 | 21 | 16 | 23 | 25 | 23 | 33 | 24 | 18 | 20 | 33 |

**Table 3. Reasons why follow-up was not pursued.**

| Responses | *n* |
|---|---|
| By physicians | |
| Child was too young to be tested | 11 |
| (Test when child is older | 3) |
| (Test when child is 4 years old | 2) |
| Child being treated for middle ear disorder at time of screening | 3 |
| No problem with hearing | 2 |
| By parents | |
| Child being treated for middle ear disorder at time of screening | 5 |
| Parent did not suspect a hearing problem | 5 |
| Parent felt child too young to be tested | 3 |
| Physician said child was too young to be tested (test when child is 4 years old) | 1 |
| Physician said there was no problem with hearing (test when child is older) | 1 |
| Child did not understand directions due to language barrier | 1 |

*Note.* Reasons were derived from 32 unsolicited comments written by parents ($n$ = 16) or physicians ($n$ = 16) who did not follow up ($n$ = 99) with audiologic screening recommendations.

was too young to be tested, and further told to pursue hearing testing when the child was older ($n$ = 4) or to specifically wait until the child was 4 years of age ($n$ = 3).

## Discussion

The screening outcomes revealed pass rates of 88% and 87% for pure tones and tympanometry, respectively, with an overall pass rate of 82% for both, which is fairly consistent with recent findings on preschool audiologic screening reported in the literature (Allen et al., 2004; Taylor & Brooks, 2000). With methodological differences among preschool audiologic screening protocols, however, a direct comparison of pass/refer screening outcome data between this and other studies is difficult. For instance, the LIHSP preschool hearing screening protocol used in this study, while similar to that of the current ASHA guidelines, included 3000 Hz in addition to the ASHA-recommended frequencies of 1000, 2000, and 4000 Hz, and a pure-tone rescreen in the same test session for children who did not initially pass. Otoscopy was performed following positive tympanometry results instead of preceding tympanometry. Also, the tympanometry screening outcomes reported in this study reflect initial screening data.

The outcome data revealed that 49% ($n$ = 643) of children in the follow-up group ($n$ = 1,316) were ultimately diagnosed with some form of hearing loss and/or otologic disorder; 37% ($n$ = 480) presented with confirmed outer/middle ear disorder, and 18% ($n$ = 239) presented with confirmed hearing loss. Compared with unilateral disorder, bilateral otologic disorder was identified in three times as many children, with otitis media as the most common diagnosis. Bilateral hearing loss was found to be nearly twice as prevalent as unilateral loss, with CHL identified in more than half ($n$ = 156) of children diagnosed with hearing loss. The majority (68%; $n$ = 266) of the hearing losses of individual ears ($n$ = 392) were slight or mild in degree. Reports on prevalence rates of hearing loss among school-age children also suggest that most present with slight to mild degrees of loss, though with a unilateral configuration (Bess et al., 1998; Niskar et al., 1998).

From the 34,979 children screened in this study, the outcome data suggest prevalence rates of 1.4% for otologic disorder and 0.7% for hearing loss, and a 1.8% prevalence of hearing loss and/or otologic disorder in a preschool-age population. These estimates should be viewed cautiously, however, because follow-up services were obtained at various facilities and the classification of hearing and otologic diagnoses was provided by respondents of various backgrounds (audiologists, parents, pediatricians, medical ear specialists, school nurses). Similar to the findings of this investigation however, a 0.5%–0.6% prevalence of confirmed CHL or SNHL has been reported by other preschool hearing screening studies in which follow-up audiometry was conducted and interpreted by trained examiners (Allen et al., 2004; Flanary, Flanary, Colombo, & Kloss, 1999). Higher prevalence rates (11%–15%) of hearing loss have been documented among a school-age population (Bess et al., 1998; Niskar et al., 1998).

An examination of the follow-up practices of the 6,337 referred children revealed a 21% rate of compliance over this period of review of the LIHSP (1995–2004). Since the aim of any audiologic screening program should be to have a 100% rate of compliance, the achieved compliance rate is considered less than optimal. Despite efforts to improve the rate of compliance, a 21% follow-up rate has been consistent throughout the program's 30-year history. For example, the current procedure of sending follow-up postcards 3 months after initial screening was added to the LIHSP follow-up protocol more than 10 years ago, without notable change in the compliance rate. Noncompliance was reported by 99 respondents, suggesting a rate close to 2%. However, it should be noted that since 78% ($n$ = 4,916) of those referred did not provide feedback on follow-up, it is most likely that the actual rates of compliance or noncompliance are higher than reported. While a well-designed follow-up tracking procedure to ensure compliance to the screening recommendations is as important as the screening itself, this remains one of the major challenges to audiologic screening paradigms (Allen et al., 2004; C. D. Johnson, 2002).

Of particular interest were the unsolicited written comments provided by 32 parents or physicians on the referral

forms or follow-up postcards, which provided some insight with regard to negative hearing follow-up practices. Because the comments were unsolicited and of a small sample size, it would be erroneous to draw concrete conclusions regarding the reasons why follow-up services were not pursued; however, some common themes were evident. Some ($n$ = 8) parents reported noncompliance with hearing follow-up services as they independently did not suspect hearing loss or concluded that their child was too young to be tested, while almost twice as many more ($n$ = 15) did not comply with the screening recommendations as advised by a physician for the same reasons. These findings appear to indicate that some physicians contribute to negative hearing screening follow-up actions. An analogous finding was reported by Halloran, Wall, Evans, Hardin, and Woolley (2005) in a recent study of hearing screening referral practices, where pediatricians failed to recheck or refer more than half of children who had failed the screening at well child visits.

It appears specifically that there may be a misconception among some physicians about the age at which reliable hearing evaluation can be conducted. More than half ($n$ = 7) of parents reportedly advised by physicians that their child was too young to be tested ($n$ = 12) were also told to postpone hearing follow-up services until the child was older, or specifically until age 4 years. In their study, Halloran et al. (2005) surmised that recent changes by the American Academy of Pediatrics (2000) in the recommendations for the age of hearing screening to begin at age 4 years (from 3 years) may have influenced the lack of (at least immediate) action taken by pediatricians regarding hearing screening failures.

The qualitative comments by parents and physicians revealed that physicians most influenced noncompliance with hearing evaluation follow-up. Specifically, it appears that instances of noncompliance result from misconceptions by parents and physicians regarding appropriate audiologic services. These qualitative data suggest that parents and physicians may require further information regarding appropriate hearing follow-up services, which may serve to improve compliance with referral recommendations. One solution may be to incorporate information regarding types of age-appropriate audiologic tests in the screening referral letters to parents and physicians. Additionally it would be important to include information about subtle hearing losses (such as minimal or unilateral types) in order to educate those parents or physicians who dismiss hearing screening referral due to their assumption that the child does not have a hearing problem.

## Conclusion

The quantitative outcomes from this investigation on a preschool audiologic screening program revealed prevalence rates of 1.4% for otologic disorder, 0.7% for previously unidentified hearing loss, and 1.8% for hearing loss and/or otologic disorder in children 3 to 5 years of age. With the documented evidence on the impact of hearing loss (including minimal or unilateral forms) on a child's speech-language skills, behavioral development and academic performance, these follow-up data affirm the importance of audiologic screening in the preschool population.

Qualitative data from a small sample of unsolicited comments suggest that some physicians may not be advocating appropriate screening follow-up services and may influence parental noncompliance. The physician's role is of utmost importance in ensuring that preschool-age children receive appropriate and timely audiologic screening and follow-up services, particularly in the absence of formal preschool audiologic screening programs.

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