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(FORM UPDATED: 08/11/2010)

WISCONSIN STATE LEGISLATURE ...
PUBLIC HEARING - COMMITTEE RECORDS

2009-10
(session year)

Senate
(Assembly, Senate or Joint)

Committee on ... Health, Health Insurance, Privacy, Property Tax Relief, and Revenue (SC-HHIPPTRR)

COMMITTEE NOTICES ...

- Committee Reports ... **CR**
- Executive Sessions ... **ES**
- Public Hearings ... **PH**

INFORMATION COLLECTED BY COMMITTEE FOR AND AGAINST PROPOSAL

- Appointments ... **Appt** (w/Record of Comm. Proceedings)
- Clearinghouse Rules ... **CRule** (w/Record of Comm. Proceedings)
- Hearing Records ... bills and resolutions (w/Record of Comm. Proceedings)
  (**ab** = Assembly Bill) (**ar** = Assembly Resolution) (**ajr** = Assembly Joint Resolution)
  (**sb** = Senate Bill) (**sr** = Senate Resolution) (**sjr** = Senate Joint Resolution)
- Miscellaneous ... **Misc**

* Contents organized for archiving by: Stefanie Rose (LRB) (June 2012)

Statement to the Assembly/ Senate Public Hearing for Hearing Aid Bills #27/#16

I come before you as the grandmother of Dylan, who has a genetic Bilateral Hearing Loss. His story is like many others in this room. The insurance company paid for the testing of his hearing, but upon diagnosis of hearing loss his parents were told that the insurance would not pay for hearing aids.

Dylan's parents qualified for help from the HIKE Fund to get his hearing aids, but presently the HIKE Fund is no longer even taking applications, because they cannot raise enough money to fill the needs of the many applicants. This leaves audiologists spending too much of their time away from families to searching for resources for hearing aids for their children.

Dylan's communication skills and understanding have rapidly progressed since getting his hearing aids. He still needs extra speech intervention, but he is far ahead of where he would be without the hearing aids. Had he gotten them earlier than 3 ½ years old he would have been even further ahead.

When babysitting for him one night, he began talking about the heart and being a nurse I decided this was a "teaching moment". We looked at a children's website, which showed how the heart works, where it is located in the chest and how it pumps. Then he and I compared the veins on our hands and arms, so he could visualize what he was seeing on the website.

But Dylan's knowledge of the heart became very real on December 2nd of last year. His "Opa" died of a sudden heart attack. When his daddy told him that Opa had died of a heart attack, Dylan said, I know where the heart is and he pointed to his chest" and then in his sweet caring way he said, "Opa's spirit is in my heart always" as he pointed to his heart. If Dylan was not able to hear and to comprehend things like "the heart" he would never understand why "Opa" had left him. They were buddies and Dylan communicates his feelings of his loss very profoundly and quite often.

You will realize that the statements being made to this Committee may be different, but a similar theme echoes throughout this room--Early intervention influences language and vocabulary development. Scientific studies have proven it and families recognize it daily as their " now hearing child" interacts in a hearing world, if they are able to receive hearing aids. (See Benefits of Early Intervention For Children With Hearing Loss)

I ask that you listen carefully to the information and life stories being presented today and vote to move the Hearing Aid/Cochlear Implant Bills 27/16 requiring health insurance coverage of hearing and cochlear implants for persons under 18 years of age out of these committees to the floor for a vote.

Thank you,

Judy Wagner, R.N.
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WISCONSIN STATE LEGISLATURE

Facts about Children who are Deaf or Hard of Hearing in Wisconsin

- Hospitals in Wisconsin screen newborns before discharge for early detection of hearing loss. One major purpose of this program is to identify children so that they can receive early intervention.

- In 2007, there were 95 newborn babies in Wisconsin identified as having hearing loss through the newborn hearing screening test. There are approximately 200 children who are identified as deaf or hard of hearing annually.

- Insurance companies are not required to pay for hearing aids or cochlear implants for children who need them.
  - According to a survey conducted by the Wisconsin Families for Hands & Voices, 54% of the parents surveyed did not have insurance that covered any of the cost of hearing aids or cochlear implants.
  - The average out of pocket expense for hearing aids for families with no insurance coverage was $4,100.
  - Families who had partial coverage of hearing aids paid an average out of pocket expense of $3,727.

- Families in Wisconsin are struggling to pay for hearing aids and cochlear implants for their children. The result is that some families are going into debt, and some children are significantly delayed in receiving intervention or simply do not receive the appropriate intervention at all.

- Intervention through hearing aids or cochlear implants can allow a child to maximize their language and speech.

- It costs far more in the long-run to educate and support individuals who do not receive appropriate early intervention than to provide it as soon as possible.
  - Research shows that early intervention can provide a savings of between $5,000 - $10,000 per child per year in reduced or eliminated special education services[1]. And over a lifetime, early intervention can reach a savings of about 1 million dollars per person[2].

- Wisconsin State Employees already have coverage under the state healthcare plan.

- Connecticut, Kentucky, Louisiana, Maryland, Minnesota, Missouri, Oklahoma, Rhode Island, Maine, and New Mexico all have laws that require insurance coverage for children who are deaf or hard of hearing.

* This fact sheet was created by Disability Rights Wisconsin in conjunction with Wisconsin Families for Hands & Voices.

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[1] Yoshinaga-Itano, Christie, and Gravel, Judith. The Evidence for Universal Newborn Hearing Screening. American Journal of Audiology, December 2001: 10: 62-64.

[2] These figures are based on 1993 numbers as reported by Johnson, J.L., Mauk, G.W., Takekawa, K.M., Simon, P.R., Sia, C.C.J. and Blackwell, P.M. Implementing a statewide system of services for infants and toddlers with hearing disabilities. *Seminars in Hearing*. 1993; 14:105-119.

WISCONSIN STATE LEGISLATURE

Language of Early- and Later-identified Children With Hearing Loss

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ABSTRACT. *Objective.* To compare the language abilities of earlier- and later-identified deaf and hard-of-hearing children.

Method. We compared the receptive and expressive language abilities of 72 deaf or hard-of-hearing children whose hearing losses were identified by 6 months of age with 78 children whose hearing losses were identified after the age of 6 months. All of the children received early intervention services within an average of 2 months after identification. The participants' receptive and expressive language abilities were measured using the *Minnesota Child Development Inventory.*

Results. Children whose hearing losses were identified by 6 months of age demonstrated significantly better language scores than children identified after 6 months of age. For children with normal cognitive abilities, this language advantage was found across all test ages, communication modes, degrees of hearing loss, and socioeconomic strata. It also was independent of gender, minority status, and the presence or absence of additional disabilities.

Conclusions. Significantly better language development was associated with early identification of hearing loss and early intervention. There was no significant difference between the earlier- and later-identified groups on several variables frequently associated with language ability in deaf and hard-of-hearing children. Thus, the variable on which the two groups differed (age of identification and intervention) must be considered a potential explanation for the language advantage documented in the earlier-identified group. *Pediatrics* 1998; 102:1161–1171; *hearing loss, early identification, early intervention, language, newborn hearing screening.*

ABBREVIATIONS. SD, standard deviation; *df*, degrees of freedom; dB, decibels; dB HL, decibels hearing level; CQ, cognitive quotient; MCDI, *Minnesota Child Development Inventory*; MLU, mean length of utterance; LQ, language quotient; ANCOVA, analysis of covariance.

Hearing loss that is bilateral and permanent is estimated to be present in 1.2 to 5.7 per 1000 live births.[1–4] The typical consequences of this condition include significant delays in language development and academic achievement. These delays are apparent for both children with mild and moderate hearing loss[5–7] as well as for those whose losses fall in the severe and profound ranges.[8–11] Despite advances in hearing aid technology, improved educational techniques, and intensive intervention services, there has been virtually no change in the academic statistics of this population since the systematic collection of national data >30 years ago.[12,13] These data indicate that the average deaf student graduates from high school with language and academic achievement levels below that of the average fourth-grade hearing student.[14,15] Similarly, for hard-of-hearing children, achievement is also below that of their hearing peers with average reading scores for high school graduates at the fifth-grade level.[15] These limitations in reading have a pervasive negative impact on overall academic achievement.[16]

Many professionals in both health care and special education have supported early identification of hearing loss and subsequent intervention as a means to improving the language and academic outcomes of deaf and hard-of-hearing individuals.[4,17–20] In 1994, the Joint Committee on Infant Hearing[21] released a position statement endorsing the goal of universal detection of infants with hearing loss as early as possible, preferably by 3 months of age. This position statement was endorsed by the American Academy of Pediatrics. This priority is in concert with the national initiative Healthy People 2000,[22] the National Institutes of Health Consensus Statement,[23] and the position statement of the American Academy of Audiology.[24] All of these position statements support the need to identify all infants with hearing loss. Both the Joint Committee on Infant Hearing and the American Academy of Audiology recommend accomplishing this goal by evaluating all infants before discharge from the newborn nursery.

Despite widespread support for universal newborn hearing screening, this mandate has been challenged by Bess and Paradise[25] partly on the grounds that "no empirical evidence . . . supports the proposition that outcomes in children with congenital hearing loss are more favorable if treatment is begun early in infancy rather than later in childhood (eg, 6 months vs 18 months)". At the time, this statement was reasonable in that before Bess and Paradise's commentary, studies examining the effects of early identification and subsequent intervention either defined early identification as before 18 months (rather than 6 months) of age[26] or did not specify the number of children identified by the age of 6 months.[27] Nevertheless, in one of these older studies, White and White[26] reported significantly better language scores for a group of severely and profoundly deaf children

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Received for publication Aug 5, 1997; accepted Jun 22, 1998.

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whose average age of identification was 11.9 months (with an average age at intervention of 14 months) as compared with children with the same degree of hearing loss whose average age of identification was 19.5 months (with an average age at intervention of 26 months).

Since the publication of Bess and Paradise's commentary, Robinshaw[28] described 5 young children with severe and profound hearing loss whose deafness was confirmed between 3 and 5 months of age. All of the children wore hearing aids by the age of 6 months. Robinshaw compared her deaf children with 5 normally-hearing control children and to data from a previous study involving 12 children with severe and profound hearing loss whose average age of identification was 2 years, 3 months. She found that the earlier-identified children acquired vocal communicative and linguistic skills at an age similar to the 5 normally-hearing control children and well before the deaf children who were identified later. Her investigation supports the value of early identification followed by immediate amplification; however, the group of children studied was small, only children with severe and profound hearing loss were included, and no data from standardized assessments were presented. In addition, the only treatment consistent across all 5 children was the early fitting of amplification. The frequency of additional early intervention varied among children.

Apuzzo and Yoshinaga-Itano[29] responded to Bess and Paradise's[25] concerns more directly. They compared language ability at 40 months of age across four age-of-identification groups: 1) 0 to 2 months, 2) 3 to 12 months, 3) 13 to 18 months, and 4) 19 to 25 months. The hearing loss of the children in each of the groups ranged from mild to profound and all of the children received ongoing intervention services from the same program shortly after their hearing loss was identified. Apuzzo and Yoshinaga-Itano reported that the first age-of-identification group (ie, those children identified before 3 months of age) had significantly higher language scores than those identified after the age of 2 months despite all children receiving similar intervention programming.

In the Apuzzo and Yoshinaga-Itano[29] study, all of the children in the earlier-identified group were diagnosed within the first 2 months of life because they presented with characteristics on the high risk registry for hearing loss. Within that study, there were only a few children without significant cognitive delay identified before 12 months of age despite including the entire sample of young children with hearing loss from a 10-year database of >350 children. Because of the small number of children in the earlier-identified group, the question of whether early identification and intervention was associated with better language scores for all deaf and hard-of-hearing children or only for children who exhibited specific demographic characteristics could not be addressed. Because of the institution of universal newborn hearing screening, within the last few years the number of children identified early with hearing loss who have normal cognitive ability has increased dramatically.

Moeller[30] reported a retrospective longitudinal study of 100 deaf and hard-of-hearing children, 25 of whom had been identified before 6 months of age. These children were tested every 6 months until the age of 5 years. Children identified with hearing loss before 6 months of age maintained age-appropriate language skills and had significantly better language skills than those children who were identified after 6 months of age. Similar to the study conducted by Apuzzo and Yoshinaga-Itano,[29] Moeller's early identification group consisted primarily of children identified through the high-risk register for hearing loss. Additionally, the earlier- and later-identified groups were not comparable on the full range of demographic variables frequently associated with language ability in deaf and hard-of-hearing children.

The purpose of the present investigation was to compare the language skills of a large group of children whose hearing losses were identified by 6 months of age with children who were identified after the age of 6 months. Because it was hypothesized that the advantage of early identification might vary, the effect was examined within a variety of subgroups formed on the basis of demographic variables frequently associated with language development. Specifically, comparisons of children who were earlier-identified versus later-identified were made within subgroups based on cognitive ability, age at testing, communication mode, minority status, gender, degree of hearing loss, socioeconomic status, and presence or absence of additional disabilities.

METHODS

Participants

The participants in this study were 150 deaf and hard-of-hearing children living in Colorado. At the time of data collection, the participants ranged in chronologic age from 1 year, 1 month to 3 years, 0 months (mean = 2 years, 2 months; standard deviation [SD] = 7.0 months). See Table 1 for a description of the demographic characteristics of this sample.

Age of Identification

The participants were divided into two groups based on the age of identification of their hearing loss. Group one (the earlier-identified group) consisted of 72 children (34 males; 38 females) whose hearing losses were identified between birth and 6 months of age. Group two (the later-identified group) included 78 children (41 males; 37 females) whose hearing losses were identified after the age of 6 months.

Intervention Program

Data regarding the age of amplification fitting were available for 80% of the sample. The median time that elapsed between identification and receiving amplification was 2 months for the earlier-identified group and 1 month for the children who were identified later. All of the participants in each group received ongoing early intervention services that focused on improving the child's communication and language skills. The onset date of these services was available for 82% of the sample. The median time between identification and ongoing intervention was 3 months for the earlier-identified group and 1 month for the group that was identified later. Three children in the earlier-identified group and 3 children in the later-identified group received their intervention services from a private center-based program that specialized in working with deaf and hard-of-hearing children. All of the remaining children in each group (96% of the total sample) were enrolled in the Colorado Home Intervention Program.

The Colorado Home Intervention Program provides early intervention services specifically to families who have deaf or hard-

TABLE 1. Demographic Characteristics of Study Sample by Age of Identification of Hearing Loss

Demographic Variable/ Category of Variable	Age of Identification of Hearing Loss			
	By 6 Months		After 6 Months	
	n	%	n	%
Gender				
Female	38	53	37	47
Male	34	47	41	53
Ethnicity				
Not a minority	53	74	56	75
Minority	19	26	19	25
Mother's education				
12 years or less	27	43	26	52
>12 years	36	57	24	48
Medicaid status				
Not on Medicaid	24	48	26	58
On Medicaid	26	52	19	42
Degree of hearing loss				
Mild	8	13	7	11
Moderate	17	27	10	16
Moderate-severe	16	25	13	21
Severe	10	16	14	23
Profound	11	18	14	23
Mode of communication				
Oral only	39	54	36	46
Oral and sign language	33	46	42	54
Multiple handicaps				
No other handicaps	37	53	42	59
Additional handicaps	33	47	29	41
Cognitive ability				
Cognitive quotient <80	21	29	44	56
Cognitive quotient ≥80	51	71	34	44
Age at data collection				
13 to 18 months	18	25	10	19
19 to 24 months	22	31	15	25
25 to 30 months	19	26	28	31
31 to 36 months	13	18	25	25

of-hearing children. The program is family focused with a cooperative partnership between the provider and the parents. A developmental assessment protocol consisting of parent questionnaires and an analysis of a videotaped parent-child interaction are used to develop each child's program. Goals and activities are individually and differentially determined according to the child's developmental data rather than being curriculum driven. Services are delivered in the home by a provider who visits the family ~1 hour per week. The vast majority of the service providers have graduate degrees in audiology, speech-language pathology, or deaf education. More than half of the providers have been with the program for 10 years or more. An important component of the program is ongoing, extensive in-service education for the providers in counseling strategies including theories of families systems. This program has been described in further detail by Stredler-Brown and Yoshinaga-Itano.[31]

Children in both age-of-identification groups received ongoing intervention for ~1 hour per week. As stated previously, the vast majority of the children in each group received services from the same intervention program. Thus, once intervention was initiated, there were no differences in either the intensity or type of services provided.

Ethnicity and Socioeconomic Status

Ethnicity data were available for all but 3 of the participants. In the earlier-identified group, 26% of the children were from an underrepresented minority group (primarily Hispanic) and the remaining 74% were Anglo-American. In the later-identified group, 25% of the children were from an ethnic minority group (again, primarily Hispanic).

Socioeconomic status was estimated by examining the level of education of the child's primary caregiver (typically the mother) and the Medicaid status of the family. The primary caregiver's educational level was available for 75% of the participants. The mean educational level of the caregivers of the children in the earlier-identified group was 13.6 years (SD = 2.4 years); for the later-identified group the mean was 13.3 years (SD = 2.3 years). A between-group *t* test indicated no significant difference in the means of the two groups (*t*, 0.62; degrees of freedom [*df*], 111; *P* = .54).

Data could be obtained for 63% of the participants regarding Medicaid status. Of these participants, 52% in the earlier-identified group and 42% in the later-identified group qualified for Medicaid. The proportion of families in each group receiving Medicaid did not differ significantly (*t*, 0.95; *df*, 93; *P* = .35).

Hearing Loss

All of the participants had congenital, bilateral hearing loss. Specific hearing threshold data were available for 120 of the 150 children. In the earlier-identified group, the participants' better ear pure tone average (ie, the average of the hearing thresholds at 500, 1000, and 2000 Hz) ranged from 27 decibels (dB) to 110+ dB (median = 58 dB). For the later-identified group, better ear pure tone averages ranged from 30 dB to 107+ dB (median = 67 dB), with the exception of 1 child who had a pure tone average of 22 dB and mildly decreased hearing in high frequency range.

The participants' severity of hearing loss (based on the pure tone average in the better ear) was categorized as mild (26–40 decibels hearing level [dB HL]), moderate (41–55 dB HL), moderate-severe (56–70 dB HL), severe (71–90 dB HL), or profound (>90 dB HL). The proportion of children in each of these categories for each age-of-identification group is presented in Table 1. The frequency distribution by hearing loss category was not significantly different when comparing the two age-of-identification groups (χ^2 = 3.09; *df* = 4; *P* = .54).

Mode of Communication

Information regarding the mode of communication used by the family was available for all of the participants. In the earlier-identified group, 46% of the children were from families that communicated using a combination of sign language and spoken language; 54% were in families that used spoken language only. In the later-identified group, a combination of sign and spoken language was used by 54% of the families with only spoken language used by 46%. The distribution by mode of communication was not significantly different when comparing the two age-of-identification groups (χ^2 = 0.96; *df* = 1; *P* = .33).

Cognitive Status and Additional Disabilities

The participants' cognitive status was estimated using the Play Assessment Questionnaire.[32] Age scores from this measure were transformed to cognitive quotients (CQs) by dividing the age score by the child's chronologic age and multiplying by 100. The CQs for this group of children ranged from 22 to 141. The mean CQ for the earlier-identified group was 88 with a SD of 23; for the later-identified group, the mean was 76 (SD = 19). A between-group *t* test revealed that the two groups differed significantly in cognitive skills (*t*, 3.52; *df*, 148; *P* < .01). This statistical difference was addressed in two ways. First, CQs were used as a covariate in all analyses. Additionally, comparisons between the earlier- and later-identified groups were conducted separately for the 65 participants with cognitive delay and the 85 participants without cognitive delay.

The presence of disabilities in addition to hearing loss was reported by the parent and the service provider. Forty-seven percent of the children in the earlier-identified group and 41% of the children in the later-identified group were reported to have one or more additional disabilities. The difference between the two groups in the proportion of children with additional disabilities was not significant (*t*, 0.75; *df*, 139; *P* = .45).

Procedures

All of the participants were assessed between the ages of 13 and 36 months. The children were divided into four groups based on their chronologic age at the time of testing. Table 1 presents the number and percentage of children within each age-of-identification group who fell into each of these four age ranges.

As part of a comprehensive developmental evaluation, the primary caregiver of each participant completed the *Minnesota*

Child Development Inventory (MCDI).[33] The 1974 version of this assessment was used for this study because data collection was begun before 1992 when the revised version became available.

The MCDI is a standardized instrument that assesses the development of children from 6 months to 6 1/2 years of age. It is composed of 320 items divided into eight scales that evaluate different areas of development. In the present study, two of these scales, expressive language and comprehension-conceptual, were examined. The expressive language scale consists of 54 items that measure expressive communication from simple gestural, vocal, and verbal behaviors to complex language expression. The comprehension-conceptual scale consists of 67 items that measure language comprehension from simple understanding to concept formulation. Parents complete this assessment by indicating which of the listed behaviors they have observed in their child.

This parent-report measure offers several advantages over administered assessments. First, this methodology takes advantage of parents' extensive knowledge about their child's language ability. Also, the measure is not subject to the influence of factors, such as fatigue or lack of familiarity with the examiner, that frequently limit a young child's performance during an administered assessment.

The reliability or internal consistency of each MCDI scale has been measured by the test's authors for specific age groups using the split-half method.[33] For the expressive language scale, reliability coefficients ranged from 0.54 to 0.92 (median = 0.88). The reliability of this scale for the present sample was computed using Cronbach's α and a coefficient of 0.94 was obtained. For the comprehension-conceptual scale, the test's authors obtained reliability coefficients ranging from 0.43 to 0.93 (median = 0.89) for the normative sample. For the sample of children in this study, a reliability coefficient of 0.95 was obtained.

There are extensive data supporting the concurrent and predictive validity of the MCDI language scales with both typically developing children and with children who have a variety of special needs.[34-37] Significant correlation coefficients of 0.51 to 0.79 have been obtained between the MCDI Expressive Language and Comprehension-Conceptual Scales and the verbal scale of the McCarthy Scales of Children's Abilities.[34-36] Significant correlations also have been found between the MCDI Expressive Language Scale and the Reynell Developmental Expressive Language Scale (r = 0.50) and the MCDI Comprehension-Conceptual Scale and the Reynell Developmental Receptive Language Scale (r = 0.52).[35] Tomblin, et al[37] compared a group of typically developing children's scores on the MCDI language scales with performance on the Sequenced Inventory of Communication Development and to the child's mean length of utterance (MLU) during a spontaneous language sample. All comparisons yielded significant correlations that ranged from 0.34 to 0.68.

Concurrent validity of the MCDI for a subsample of children (n = 109) in the present study was examined by correlating MCDI age scores with the child's MLU during a 25-minute interaction with his or her primary caregiver. Significant correlations ($P < .01$) of 0.76 and 0.78 were obtained between MLU and the expressive language and comprehension-conceptual scales, respectively. Validity was also measured by comparing the total words in the child's expressive lexicon from the MacArthur Communicative Development Inventory[38] with the MCDI language scores. Both the expressive language and comprehension-conceptual scales were significantly related to the MacArthur inventory (n = 136; r = 0.74 and r = 0.76, respectively; $P < .001$).

Statistical Analysis

To examine the participants' language abilities, language quotients (LQs) were derived for each child. These were calculated by dividing the child's age score on each MCDI subtest by his or her chronologic age and then multiplying by 100. Children whose language age matched their chronologic age received an LQ of 100. LQs for children whose language level was below their chronologic age were <100; LQs >100 indicated that the child's language age was greater than his/her chronologic age. Three LQs were obtained for each participant: a) an expressive LQ based on scores from the MCDI Expressive Language Scale; b) a receptive LQ based on scores from the MCDI Comprehension-Conceptual Scale; and c) a total LQ, calculated specifically for this study, which was obtained by averaging each participant's receptive and expressive LQ scores.

Cognitive ability, based on the Play Assessment Questionnaire,[32] was found to have high positive correlations with the participants' MCDI expressive and receptive language scores (r = 0.75, $P < .01$; and r = 0.74, $P < .01$, respectively). Because of this strong relationship between cognitive ability and the outcome measure of this study (ie, language scores) and because the two age-of-identification groups demonstrated significantly different cognitive ability, CQs were used as a covariate in all comparisons between the two groups.

The primary purpose of the statistical analyses in the present study was to compare the language abilities of the earlier- and later-identified groups. The question of whether or not the differences, if they were found, were consistent across a variety of demographic subgroups was also addressed. To obtain this information, eight separate analyses of covariance (ANCOVAs), covarying for cognitive ability, were performed. In each analysis, the total LQs of the two age-of-identification groups was compared. Additionally, each ANCOVA included a main effects comparison between different levels of a specific demographic variable (eg, males versus females). The interaction between the main effect and the effect of the demographic variable was examined to determine if the differences in age of identification were constant across the different levels of the demographic variable (eg, to determine if the age of identification effect existed for both males and females).

To determine if age of identification had a differential effect on children with normal versus low cognitive ability, the effect of age of identification was examined within two cognitive-ability subgroups as well as in the group as a whole. One cognitive-ability subgroup included children with normal cognitive skills and the other included participants with low cognitive skills. A CQ of 80 was selected as the cutoff to categorize participants into a normal- or low-cognition group. Using this criterion, 29% of the children in the earlier-identified group and 56% in the later-identified group were placed in the low-cognitive ability category.

Within each cognitive-ability group, strong positive correlations were obtained between cognitive and language ability (r ranged from 0.73 to 0.75, $P < .01$) across the two cognitive groups and the three language measures. For this reason, cognitive ability continued to be used as a covariate, even when comparisons were made within the normal- or low-cognition groups. Additionally, for each ANCOVA, the cell means were calculated adjusting for cognitive ability to protect against possible imbalances in the specific cognitive scores of the children in the earlier- and later-identified groups.

This investigation was approved by the Human Subjects Review Board at the University of Colorado–Boulder.

TABLE 2. Results for Analyses of Covariance for Total Group: Language Quotient Scores by Age of Identification of Hearing Loss

Language Scale	Age of Identification	Adjusted Mean	Standard Deviation	Effect for Age of Identification	
				$F[1,147]$	P
Receptive	By 6 months	79.6	25.8	25.4	<.001
	After 6 months	64.6	20.9		
Expressive	By 6 months	78.3	26.8	25.8	<.001
	After 6 months	63.1	19.8		
Total language	By 6 months	79.0	25.6	29.5	<.001
	After 6 months	63.8	19.3		

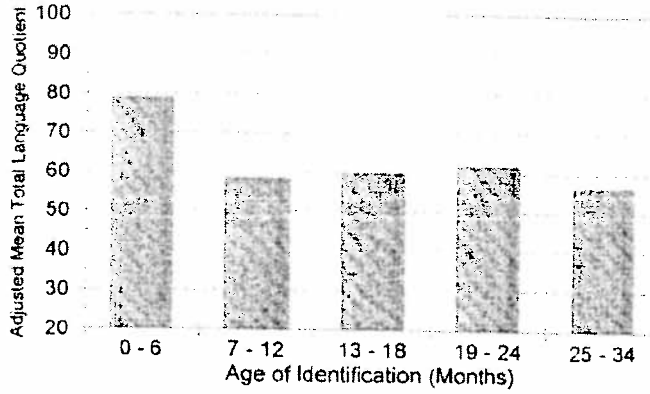

Fig 1. Adjusted mean total language quotients for groups based on age of identification of hearing loss.

Pure Tone Average:	63	62	80	72	64
Cognitive Quotient:	88	74	82	76	71

RESULTS

Total Group

Children with hearing losses identified by 6 months of age had significantly higher LQs than those children whose hearing losses were identified after 6 months of age. This effect was found for their receptive LQs ($F[1,147] = 25.4$; $P < .001$), expressive LQs ($F[1,147] = 25.8$; $P < .001$), and total LQs ($F[1,147] = 29.5$; $P < .001$). Children who were identified earlier had adjusted mean LQs of 79.6 (SD = 25.8) for receptive language, 78.3 (SD = 26.8) for expressive language, and 79.0 (SD = 25.6) for total language. Children who were identified after 6 months of age had adjusted mean LQs of 64.6 (SD = 20.9) for receptive language, 63.1 (SD = 19.8) for expressive language, and 63.8 (SD = 19.3) for total language (see Table 2).

The average age of identification for children in the later-identified group ranged from 7 to 34 months (median = 16 months). To examine the effect of age of identification on these children, the participants were divided into four age-of-identification groups: a) 7 to 12 months (n = 25), b) 13 to 18 months (n = 23), c) 19 to 24 months (n = 16), and d) 25 months or later (n = 14). Adjusted mean expressive LQs by group were: a) 58.5 (SD = 21.2) b) 58.2 (SD = 18.4), c) 60.5 (SD = 20.3), and d) 55.8 (SD = 20.2). Adjusted mean receptive LQs by group were: a) 57.8

TABLE 3. Results of Analyses of Covariance for Children With Normal Cognition: Language Quotient Scores by Age of Identification of Hearing Loss

Language Scale	Age of Identification	Adjusted Mean	Standard Deviation	Effect for Age of Identification	
				F[1, 82]	P
Receptive	By 6 months	92.2	19.9	24.5	<.001
	After 6 months	71.7	19.7		
Expressive	By 6 months	90.5	21.9	25.8	<.001
	After 6 months	68.7	20.3		
Total language	By 6 months	91.3	19.8	29.6	<.001
	After 6 months	70.2	18.5		

TABLE 4. Results for Analyses of Covariance on Total Language Quotient by Demographic Variable and Age of Identification of Hearing Loss for Children With Normal Cognition

	n	Age of Identification			Demographic Measure			Interaction of Age of Identification and Demographic Measure		
		F	df	P	F	df	P	F	df	P
Gender	85	30.6	1, 80	<.01†	4.2	1, 80	.04*	1.0	1, 80	.33
Ethnicity	85	23.5	1, 80	<.01†	3.9	1, 80	.06	0.1	1, 80	.75
Mother's education	67	17.7	1, 62	<.01†	0.1	1, 62	.79	0.2	1, 62	.67
Medicaid recipient	54	4.8	1, 49	.03*	0.01	1, 49	.93	0.4	1, 49	.50
Degree of hearing loss	74	15.0	1, 63	<.01†	0.4	4, 63	.79	0.4	4, 63	.84
Mode of communication	85	28.5	1, 80	<.01†	3.7	1, 80	.06	0.01	1, 80	.92
Multiple handicaps	81	21.9	1, 76	<.01†	0.2	1, 76	.65	0.6	1, 76	.45
Age at data collection	85	30.3	1, 76	<.01†	2.2	3, 76	.09	0.2	3, 76	.89

* $P < .05$.
† $P < .01$.

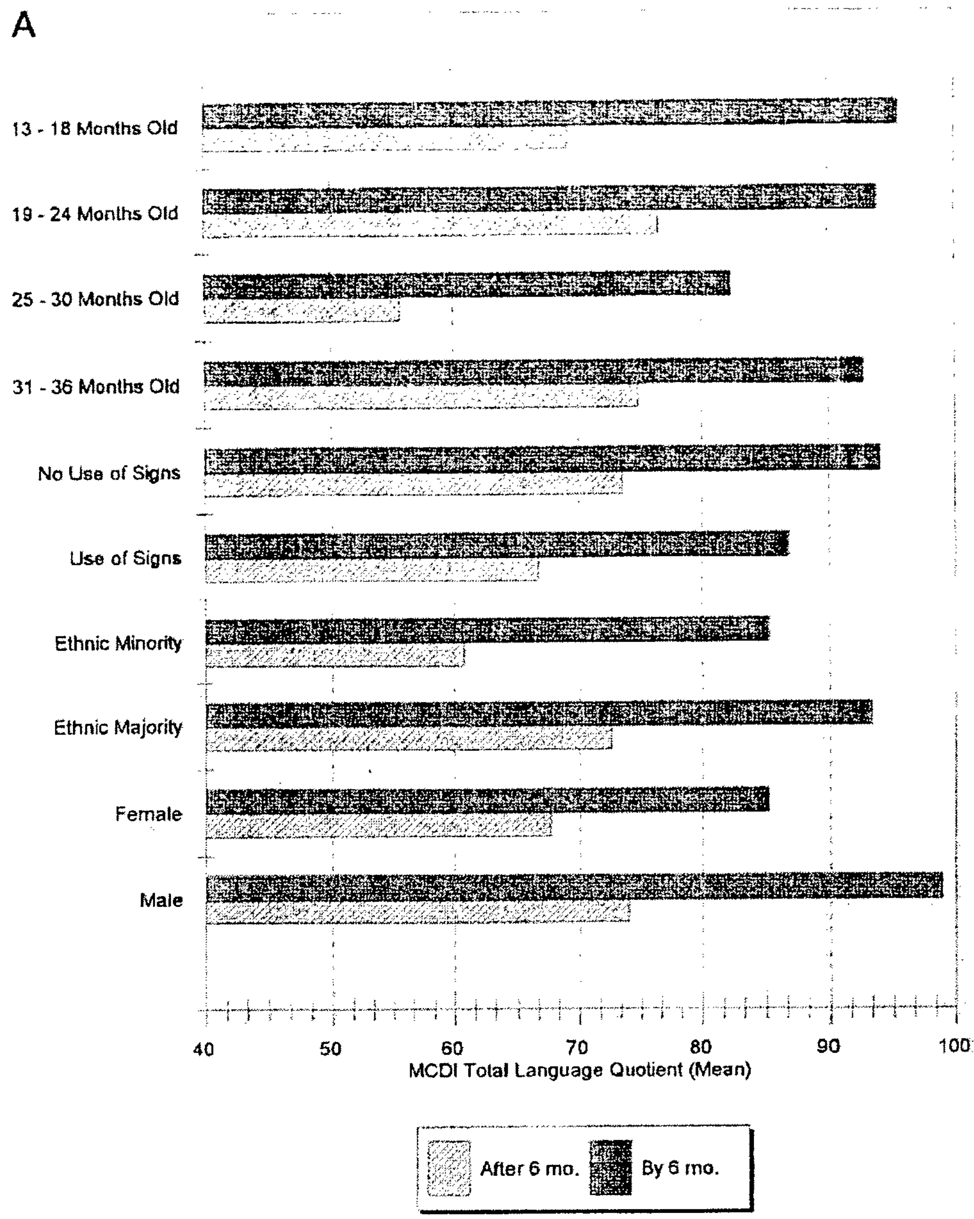

Fig 2. A, Adjusted mean total language quotients for the earlier- and late identified groups by demographic category for children with normal cognition. B, Adjusted total mean language quotients for the earlier- and later-identified groups by demographic category for children with normal cognition.

(SD = 24.0), b) 61.6 (SD = 21.2), c) 62.9 (SD = 15.7), and d) 57.1 (SD = 19.6). Adjusted mean total LQs were a) 58.2 (SD = 21.3), b) 59.9 (SD = 18.6), c) 61.8 (SD = 17.3), and d) 56.5 (SD = 19.1). Total LQs for each group are presented in Fig 1. The mean LQs for the four later age-of-identification groups were compared using a separate univariate ANCOVA, with CQs as the covariate, for each of the three language measures (receptive, expressive, and total). In all three analyses, no significant differences in language ability were found among the four later age-of-identification groups (expressive language: $F[3,73] = 0.18$, $P = .91$; receptive language: $F[3,73] = 0.42$, $P = .74$; total language: $F[3,73] = 0.29$, $P = .84$). To examine the relationship between LQs and age of identification in the later-identified group further, Pearson product moment correlations were calculated. No significant correlations were found for these later-identified children between age of identification and any of the three LQs (expressive language: $r = -0.06$, $P = .64$; receptive language: $r = -0.06$, $P = .60$; total language: $r = -0.06$, $P = .60$).

Children With Normal Cognitive Ability

Children with normal cognitive ability whose hearing losses were identified by 6 months of age had significantly higher LQs than children with normal cognitive ability whose hearing losses were identified after 6 months of age. This effect was found for their receptive LQs ($F[1.82] = 24.5$, $P < .001$), expressive LQs ($F,[1,82] = 25.8$, $P < .001$), and total LQs ($F[1.82] = 29.6$, $P < .001$). Children who were identified earlier had adjusted mean LQs of 92.2 (SD = 19.9) for receptive language, 90.5 (SD = 21.9) for expressive language, and 91.3 (SD = 19.8)

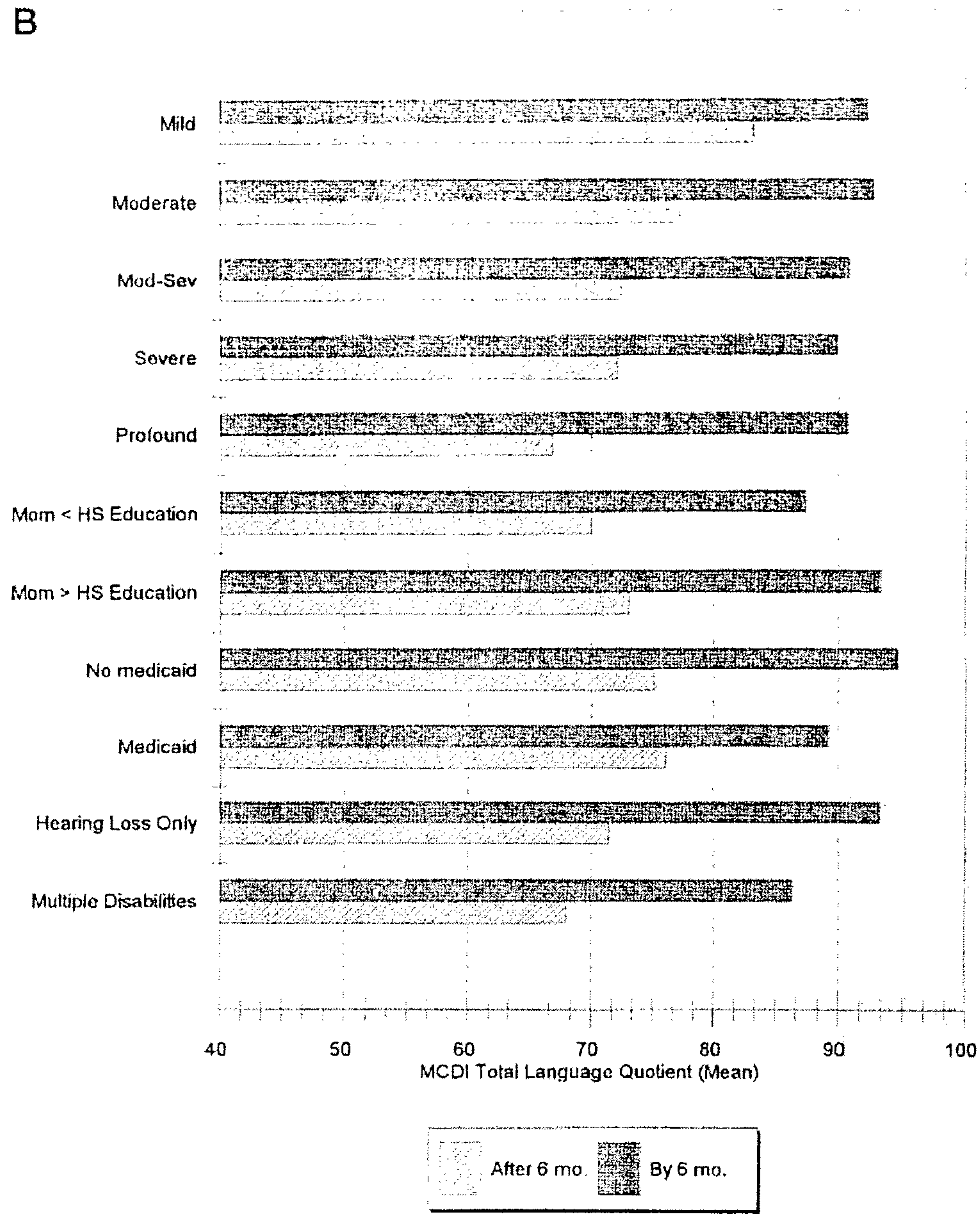

Fig 2. Continued.

for total language. In contrast, the later-identified group had adjusted mean LQs of 71.7 (SD = 19.7) for receptive language, 68.7 (SD = 20.3) for expressive language, and 70.2 (SD = 18.5) for total language (see Table 3).

To determine if earlier identification was associated with higher total LQs only for children with specific demographic characteristics, the effect was examined in a variety of subgroups of the current sample. This analysis was accomplished by conducting a series of eight two-way ANCOVAs with CQs used as the covariate. In each ANCOVA, the main effect of age of identification was tested. The second main effect tested was a demographic variable frequently associated with language ability. Specifically, the effect of one of the following demographic variables was assessed in each of the eight ANCOVAs: gender, minority status, maternal level of education, Medicaid status, degree of hearing loss, communication mode, presence of additional disabilities, and participants' age at the time of testing. A significant main effect for age of identification was found for all eight ANCOVAs (see Table 4 for specific *F*, *p*, and *n* values). Of the eight demographic variables tested, only gender yielded a significant main effect with males obtaining significantly higher total LQs than females ($F[1,80] = 4.2$, $P < .05$). Further analysis revealed that the MCDI adjusted age scores by gender because in the normative sample for this test, males demonstrated slower language development within this age range. Thus, the same raw score yielded a higher language age for a male than for a female. No significant differences were found between the raw scores of the female participants in

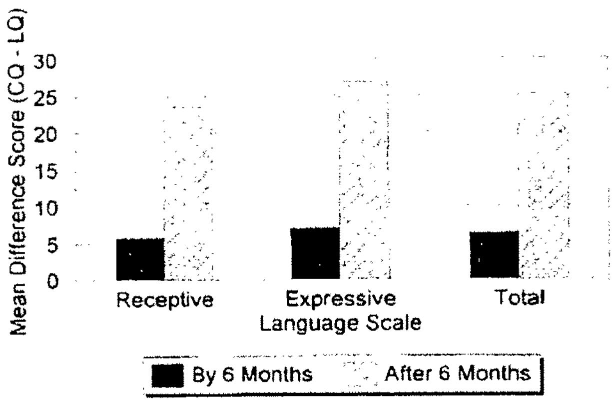

Fig 3. Discrepancy between cognitive quotient and language quotient by age of identification of hearing loss for children with normal cognition.

this study and the male participants (receptive language: *t*, 0.37; *df*, 148; *P* = .72; expressive language: *t*, 0.18; *df*, 148; *P* = .86; total language: *t*, 0.27; *df*, 148; *P* = .79). In all eight ANCOVAs, there was no significant interaction between age of identification and the demographic variable. Thus, the age of identification effect was consistent across all of the demographic subgroups tested. These results are illustrated graphically in Figs 2A and 2B where it also can be seen that for each demographic subset of the earlier-identified group the mean LQs were within the normal range (mean LQs = 82.4 to 98.8).

Hearing children typically demonstrate language skills that are commensurate with their cognitive abilities. This relationship has not been found among children with hearing loss. Significant differences between performance intelligence and language ability consistently have been found for school-aged children with significant hearing loss.[9,39,40] To examine this relationship in the two age-of-identification groups, the participants' LQs were subtracted from their CQ. Depending on the LQ used (ie, receptive, expressive, or total), these mean difference scores ranged from 5 to 7 quotient points for the earlier-identified group and from 24 to 26 points for the children who were identified later (see Fig 3). The cognitive-linguistic difference scores were used in a 2 × 3 mixed-design multivariate analysis of variance. For this analysis, age of identification was the between-subjects factor and type of language measure used in the difference calculation (receptive, expressive, or total) was the within-subjects factor. This analysis resulted in a large effect by age of identification ($F[1,83] = 23.5$, $P < .001$) and no significant effect for type of language measure ($F[2,166] = 2.15$, $P = .12$). The interaction of age of identification by type of measure was not significant ($F[2,166] = 0.5$, $P = .6$) indicating that the age of identification effect was consistent across the three (receptive, expressive, and total) cognition-language difference scores. The large difference between the later-identified children's CQ and LQ (CQ − LQ) indicates that the language skills of these children's are much poorer than would be expected given their cognitive ability.

Children With Low Cognitive Ability

Children with CQs below 80 whose hearing losses were identified by 6 months of age had an adjusted mean receptive LQ of 60.4 (SD = 21.4), an expressive LQ of 58.8 (SD = 20.9), and a total LQ of 59.6 (SD = 20.6). These means contrast with the means for the later-identified group that were 51.8 (SD = 18.9) for receptive language, 51.7 (SD = 17.5) for expressive language, and 51.7 (SD = 17.3) for total language (see Table 5). Differences between the two age-of-identification groups were not statistically significant when receptive or expressive LQs were used as the dependent measure (receptive language $F[1,62] = 3.7$, $P = .06$; expressive language: $F[1,62] = 3.0$, $P = .09$). When total language score was the dependent variable, the age-of-identification effect was significant ($F[1,62] = 3.8$, $P = .05$).

Similar to the results for children with normal cognitive ability, the discrepancy between the participants' CQ and LQ was significantly higher for the later-identified group ($F[1,63] = 4.31$, $P < .05$). As shown in Fig 4, the earlier-identified group had LQs that were remarkably similar to their CQs; the mean difference in the two quotients was <3 points. In the later-identified group, the mean gap between the children's CQ and LQ was 10 points. Thus, the earlier-identified group performed linguistically as well as would be expected given their cognitive ability, whereas the later-identified children demonstrated

TABLE 5. Results for Analyses of Covariance for Children With Low Cognition: Language Quotient Scores By Age of Identification of Hearing Loss

Language Scale/ Age of Identification	Adjusted Mean	Standard Deviation	Effect for Age of Identification	
			F[1, 62]	P
Receptive				
By 6 months	60.4	21.4	3.7	.06
After 6 months	51.8	18.9		
Expressive				
By 6 months	58.8	20.9	3.0	.09
After 6 months	51.7	17.5		
Total language				
By 6 months	59.6	20.6	3.8	.05
After 6 months	51.7	17.3		

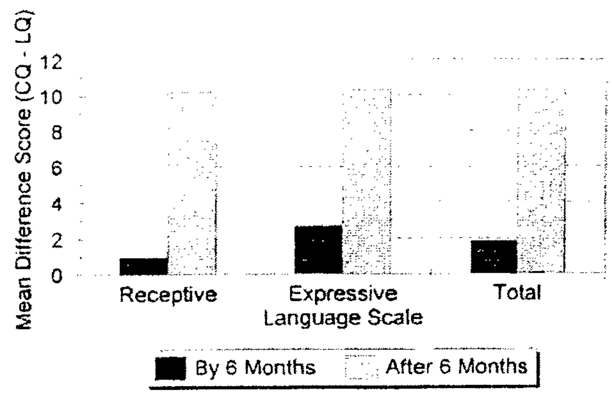

Fig 4. Discrepancy between cognitive quotient and language quotient by age of identification of hearing loss for children with low cognition.

language skills that were below cognitive-level expectations.

Interestingly, for those participants who were tested at 31 to 36 months age, the mean total LQ of the earlier-identified low-cognition group ($n = 6$) was almost identical with the mean of the children with normal cognition who were identified later ($n = 8$). As shown in Fig 5, the mean total LQ for both of these groups was between 71 and 72.

DISCUSSION

In this study, a group of children whose hearing losses were identified by 6 months of age demonstrated significantly better receptive and expressive language skills than did children whose hearing losses were identified after the age of 6 months. This language advantage was evident across age, gender, socioeconomic status, ethnicity, cognitive status, degree of hearing loss, mode of communication, and presence/absence of other disabilities. The language difference between the two age-of-identification groups was so large that the mean performance of the earlier-identified children was almost a full SD higher than the mean performance of later-identified children.

In this study, there was no significant difference between the earlier- and later-identified children on a wide variety of demographic variables frequently associated with language ability. In addition, on the average, both groups of children received intervention services within several months of the identification of their hearing loss. These services were provided by the same agency for the vast majority of children in both groups, and, once intervention was initiated, both groups received the same type and intensity of service. Despite the many similarities between the two groups, there were two identified variables on which the groups differed, ie, age of identification (and subsequent intervention) and cognitive ability. Differences in the participants' cognitive abilities were controlled statistically in all analyses. Thus, the remaining variable (age of identification and subsequent intervention) must be considered as a possible explanation for the language differences noted at 1 to 3 years of age.

To provide the most solid evidence that early identification and subsequent intervention impacts later language ability, a controlled, prospective investigation with random assignment to early- versus late-identified groups and treatment versus no-treatment groups might be proposed. Presently, such a study is not feasible for several reasons. First, random assignment to groups based on time of identification is not possible in an increasing number of states because of recent legislative mandates to screen the hearing of all newborns. Even in those states without universal hearing screening programs, parental cooperation for such a study is likely to be quite low. Under the Individuals with Disabilities Education Act, families are entitled to a timely evaluation if they suspect their child has a disability. Once parents become suspicious that their child has a hearing loss, it is unlikely they would be willing to delay an evaluation even if they previously had consented to being placed in a late-identification group.

Soliciting participation in a study that might result in assignment to a no-treatment (or delayed-treatment) group also is likely to meet with substantial parental resistance. This is because, in addition to timely assessment, the Individuals with Disabilities Education Act stipulates the provision of prompt intervention services after a disability is identified. It is likely that most parents would not be willing to delay these federally-guaranteed services for their child in the interest of research.

Because of the obstacles to randomly assigning children to early- and late-identification/intervention groups, the topic of early identification and intervention must be explored through descriptive studies using naturally occurring groups of children. The results of such descriptive studies become more powerful when they are replicated by a variety of different researchers with independent samples of children. Such is the case with the present question. The language advantage reported in this study for children who were identified earlier is consistent with several previous studies on the early identification of hearing loss. White and White,[26] Robinshaw,[28] Moeller,[30] and Apuzzo and Yoshinaga-Itano[29] all

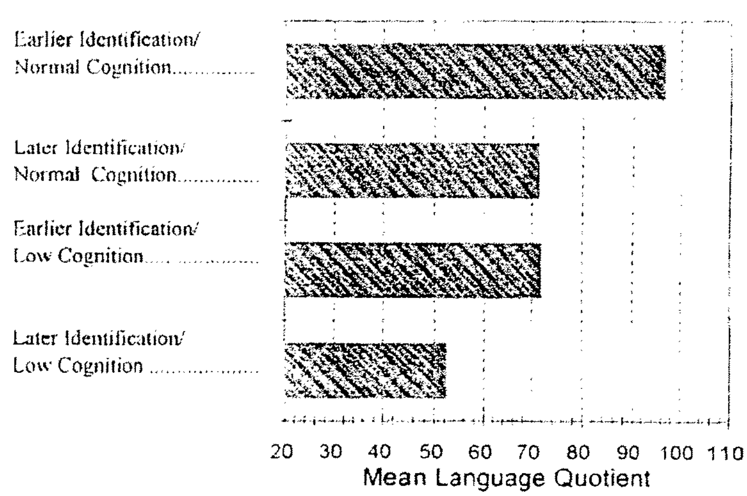

Fig 5. Mean total language quotient scores at 31 to 36 months by age of identification of hearing loss and cognition.

have reported significantly better language scores for children whose hearing losses were identified earlier.

In the present investigation, and in all four studies documenting a language advantage for the earlier-identified group, children received early intervention services shortly after their hearing losses were identified. It is unlikely that language differences of the magnitude documented in these studies would occur simply by identifying hearing loss early; early identification alone is unlikely to result in improved outcomes if it is not followed by early intervention.

Research on school-aged children with severe-to-profound hearing losses indicates a 40-point discrepancy between performance intelligence scores (mean of 100) and verbal intelligence scores (mean of 60)[9,39,40]; even academically successful deaf students demonstrate a 20-point discrepancy. It is interesting that a cognitive-language quotient discrepancy was already present by 3 years of age in the later-identified children in this study, raising the possibility that the cognitive-linguistic gap previously reported in school-aged children may have its roots in the first year of life.

In the four previous investigations that have noted better language skills in early-identified children, the average age of identification for the early group was below 12 months of age (with three of the four studies defining early identification as before 3 to 6 months of age). In the present study, there was no significant difference in language scores between four subgroups of later-identified children who were divided sequentially according to age of identification (from 7 months to greater than 25 months of age). This may explain the results of a previous study that examined the contribution age of intervention makes to later language ability and failed to find any significant contribution.[27] In that study, 91% of the children began intervention some time before 3 years of age. Specific information regarding the distribution by age of intervention was not provided; however, unless a large proportion of the children began intervention in the first 6 months of life, this study is consistent with the results of the present investigation. That is, the present findings, and the pattern that has emerged from previous studies, suggest that for an earlier-identified group to demonstrate significantly better language skills than a later-identified group, identification must truly occur early (ie, within the first 6 months of life).

Before the advent of universal newborn hearing screening programs, identifying hearing loss by 6 months of age was rarely accomplished. Parents generally do not suspect a hearing loss until their child fails to meet important speech and language milestones at 1 to 2 years of age. Also, screening programs that only test infants who present with one or more risk factors for hearing loss are typically testing only ~50% of children who actually have a hearing loss.[1,3,41,42] These factors have resulted in an average age of identification of 11 to 19 months for children with known risk factors for hearing loss[2,17,42-44] and 15 to 19 months for children without apparent risk.[17,43,44]

Taken as a group, previous and present research findings suggest that the first year of life, especially the first 6 months, is critical for children with hearing loss. When hearing loss was identified and treated by this time, several independent researchers have reported that, as a group, children demonstrated average language scores that fell within the normal range when they were 1 to 5 years old.[28,30] This finding is encouraging and suggests that early identification and subsequent intervention is associated with improved language development in deaf and hard-of-hearing children. If this is the case, it is critical that all infants with hearing loss be identified by 6 months of age and receive early intervention; universal newborn hearing screening would be an excellent vehicle for achieving this goal.

ACKNOWLEDGMENTS

This study was supported by the National Institutes of Health (contract number NO1-DC-4-2141), Maternal and Child Health, the Colorado Department of Education, the University of Colorado-Boulder, and the Colorado Department of Public Health and Environment.

We wish to acknowledge the contributions of following individuals to this project: Arlene Stredler-Brown, Mah-rya Apuzzo, Deborah DiPalma, Amy Dodd, Colette Roy, Joan McGill Eden, Kathy Watters, Colorado Home Intervention Program regional coordinators, Colorado Home Intervention Program parent facilitators, and the participating families.

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ORPHAN FACTORY PLANNED

Plans to treat HIV-infected women only during pregnancy and not afterwards were attacked as far too limited . . . Many of the mothers may soon die of AIDS, the critics said, and the United Nations (UN) plan will create an orphan factory.

Altman LK. UN plans to treat 30,000 HIV-infected pregnant women. *New York Times*. June 30, 1998

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BENEFITS OF EARLY INTERVENTION FOR CHILDREN WITH HEARING LOSS

Christine Yoshinaga-Itano, PhD

THE ROLE OF DEGREE OF HEARING LOSS AND LANGUAGE DEVELOPMENT

Bilateral sensorineural hearing loss has been associated with significant language delays and disorders when comparing language development of children with educationally significant hearing loss with those who have normal hearing. These language developmental differences have been described at all age levels from early childhood through adulthood. Very little language growth has been shown between the ages of 11 and 18 years of age. The language delays have been characterized by plateaus in achievement on standardized instruments at the third to fourth grade levels for children with severe to profound hearing loss, and at the sixth grade level for children with mild to severe hearing loss.[1,3,6]

Prior to universal newborn hearing screening programs, the average age of diagnosis of hearing loss was reported to be between 18 and 24 months of age. With average delays in onset of intervention, many children were 2½ to 3 years of age before they began to learn language. As a

The research results were supported by the National Institutes of Health (contract number NO1-DC-4-2141), Maternal and Child Health (MCJ-08NHS8-03), the Colorado Department of Public Health and Environment, the Colorado Department of Education, and the University of Colorado, Boulder, Colorado.

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result of universal newborn hearing screening programs, there is a growing population of newly-identified infants with sensorineural hearing loss.

EARLY IDENTIFICATION OF HEARING LOSS AND LANGUAGE DEVELOPMENT

Yoshinaga-Itano et al[19] reported the language development of 150 children between the ages of birth and 36 months of age. Seventy-two children had hearing loss identified prior to 6 months of age and were placed into intervention services at an average of 2 months post diagnosis. Seventy-eight children had their hearing losses identified from 7 months to 30 months of age. Prior to universal newborn hearing screening, the average reported age of identification for children with educationally significant hearing loss was reported to be approximately 30 months of age. Controversy concerning impact of early identification of hearing loss had been raised because of inconclusive evidence.

The early- and later-identified children in the Yoshinaga-Itano et al[19] study were balanced by age at which testing occurred, degree of hearing loss, gender, cognitive status, ethnicity, socio-economic status (as measured by maternal level of education and Medicaid status), mode of communication, and presence of secondary disability. These variables have been reported in the literature to impact language development of both children with hearing loss and those with normal hearing. The later-identified children were selected and matched to the early-identified group based upon their demographic characteristics. There were approximately 500 later-identified children in the database at the time. Additionally, the language quotients ([language age divided by chronologic age] × 100) were not significantly different for any comparisons for each of the demographic variables, that is, by degree of hearing loss, by gender, or by age at testing, with the exception of cognitive status. Early-identified children had significantly higher cognitive development than later-identified children. Therefore, all analyses between early- and later-identified children were done with cognitive status covaried.

Language Measure

The language development assessed both general receptive and expressive language abilities as measured by the Comprehension-Conceptual and Expressive Language subtests of the Minnesota Child Development Inventory (MCDI).[4] Validity and reliability of the MCDI was demonstrated in this population by comparisons with the MacArthur Communicative Development Inventory, and mean length of utterance from a spontaneous language sample between parent and child.

The early-identified children with both normal cognitive development and low cognitive ability had significantly higher language developmental quotients than the later-identified children. The children with cognitive delays ranged from developmental quotients (DQ) from the low 20s to the high 70s. Many of these children had disabilities in addition to hearing loss, often significant neurologic and cognitive involvement. Because development is very delayed in this population, it was noteworthy that a significant difference between early- and later-identified children could be demonstrated. Children with normal cognitive development who were early-identified had language DQ within the normal range of development, with an average DQ of 90. Typically, young children with significant hearing loss are not assessed using developmental assessments standardized on the typically developing hearing population because mean language developmental levels have been below the tenth percentile of the normal distribution.

Degree of Hearing Loss

The advantage of early-identification with intervention prior to 6 months of age was present for each degree of hearing loss: mild, moderate, moderate-severe, severe, and profound. One of the most surprising findings in the Yoshinaga-Itano et al[19] study was the lack of relationship between degree of hearing loss (mild through profound bilateral sensorineural hearing loss) and language development among early-identified children (identification and intervention prior to 6 months of age) between the ages of birth and 36 months of age. The traditionally significant differences in the language development of children with mild through profound bilateral sensorineural hearing loss were found among the later-identified children (identification and intervention after 6 months of age). As shown in Figure 1, no significant differences by hearing loss were found for early-identified children. Children with mild through profound hearing loss, identified prior to 6 months of age and receiving intervention within 2 months of diagnosis, were indistinguishable by language quotients.

Yoshinaga-Itano and Apuzzo[16] demonstrated that this lack of relationship between degree of hearing loss and language development among early-identified children (high risk registry rather than universal newborn hearing screening) also was found when receptive and expressive vocabulary was measured by the MacArthur Communicative Development Inventories. There were no significant differences in either receptive or expressive vocabulary sizes by degree of hearing loss categories for the early-identified group.

Age at Testing

Different children were tested at four test ages: 12 to 18 months, 19 to 24 months, 25 to 30 months, and 31 to 36 months. No significant differences in the early-identified group by age of testing were found. The

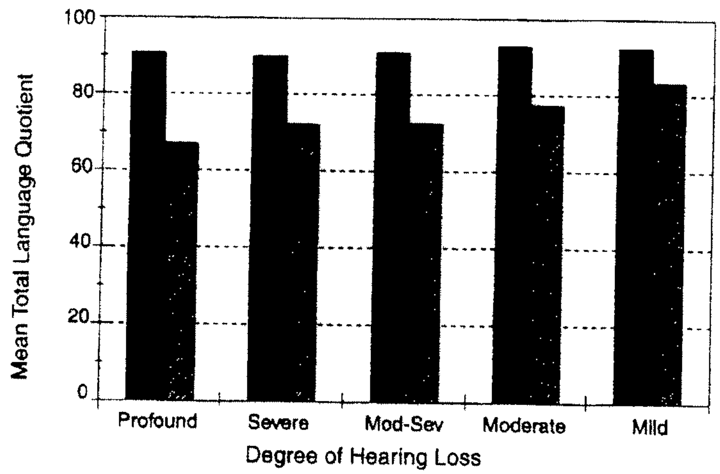


Figure 1. Average total language quotient for children with normal cognition by category of hearing loss and age of identification of hearing loss. Using covariance, the means have been adjusted for minor differences in cognitive skills. Solid bar = by 6 months of age; shaded bar = after 6 months of age. (*From* Downs MA, Yoshinaga-Itano C: The efficacy of early identification and intervention for children with hearing impairment. Pediatr Clin North Am 46:79–87, 1999; with permission.)

early identification advantage was present at each test age. The impact of early identification of hearing loss did not increase or decrease with age, but remained constant. Yoshinaga-Itano and Coulter[17] reported a preliminary pilot study of 125 preschool-aged children. The early identification effect remains constant through 5 years of age when children are ready to enter kindergarten. Moeller[8] reported a longitudinal, rather than cross-sectional, study of 150 deaf and hard of hearing children followed from 12 months through 7 years of age. The early-identified group maintained their language advantage to 7 years of age. Because the early identification effect is found at the youngest age of testing, it is hypothesized that early identification accompanied by early intervention prevents significant developmental delay from arising.

Gender

The early identification effect was found for both males and females. Children with normal hearing between birth and 36 months of age evidence differences in language development by gender. Typically, female children have significantly better language development than males. In this study, male children had better language development than female children. In an effort to understand this finding, these differences were further explored. The MCDI yields a different language age for the same raw score for a female as compared to a male. Further exploration revealed

that no significant differences in the raw scores existed, raising the possibility that the intervention provided could potentially change the gender effect, and that gender differences in language development could be determined environmentally.

Ethnicity

Twenty-five percent of both the early-identified and the later-identified children were of Hispanic descent. The early identification effect was found for both Hispanics and white populations. No significant differences in the language quotients of the Hispanics and white population were found. School-age data on deaf and hard of hearing children indicate that Hispanic children who are deaf and hard of hearing have significantly lower reading achievement than white children who are deaf and hard of hearing.[3]

Maternal Level of Education

Maternal level of education was used as one measure of socio-economic status. This variable has been a predictor of language development in children with normal hearing at this age level. Typically, the higher the maternal level of education, the higher the language development of the child. The early identification effect was present for all children regardless of the maternal level of education. No significant difference in the language development of children whose mothers had high versus low levels of education was found when children had early-identified hearing loss.

Medicaid Status

The early identification effect was found for children whose families qualified for Medicaid as well as for those whose families did not qualify. No significant differences in language quotients between families on Medicaid versus families who were not were found.

Mode of Communication

The early identification effect was found for children whose families used oral-aural methods of communication, as well as those who used sign language, often in combination with oral-aural methods. No significant differences in the language development of children who communicated through oral-aural means only and those who communicated through sign language were found.

Presence of Secondary Disability

The early identification effect was found for children with hearing loss only as well as for those with secondary disabilities. This result is comparable to the early identification effect for children with low cognitive ability. There are some secondary disabilities, however, that are not associated with cognitive delays, which often are associated with language delay, such as children with orthopedic or visual disability. Figures 2A and 2B display the early identification relationship for all demographic comparisons.

Cognitive Ability

Cognitive ability, as measured by symbolic play, was significantly related to language development. Children with both normal and low cognitive ability who were early-identified had language ability similar to their cognitive development. Children with both normal and low cognitive ability had significant discrepancies between their cognitive quotients and their language quotients. A comparable analogy would be the school-age population and the discrepancies found between performance intelligence quotients and verbal intelligence quotients. Figures 3 and 4 represent the small difference between cognitive ability and language ability for the early-identified group, and significant differences for the later-identified group. The early-identification effect was found for both children with normal cognitive ability and those with low cognitive ability.

Cognitive Ability and Age of Identification

Cognitive ability and age of identification of hearing loss are taken into consideration for the 31- to 36-month age group, and language quotients of early-identified children with normal cognitive ability were best followed by language quotients of later-identified children with normal cognitive ability. Language quotients of early-identified children with low cognitive ability, however, were remarkably similar to the later-identified children with normal cognitive ability. Figure 5 depicts the startling finding that children who are later-identified with normal cognitive ability have language development that is almost identical to children who are early-identified, but with significantly lower cognitive skills.

Subgroups Within the First 6 Months

Among the 72 children identified with hearing loss prior to 6 months of age, no significant difference was found in the language development

of children identified between birth and 2 months of age, 3 and 4 months, and 5 and 6 months of age. Clinical data suggest that children without secondary health problems, such as middle ear involvement, or other medical involvement, typically are identified earliest.

Later-Identification Groups

Among the 78 later-identified children, no significant differences in language development were found when comparing children identified between 7 to 12 months, 13 to 18 months, 19 to 24 months, and 25 to 30 months of age. In general, their language quotients were at a DQ of 70, as compared to the early-identified children with an average DQ of 90. Figure 6 depicts the similarity in language quotients. The difference between the early-identified group and the later-identified group appears to be precipitous, rather than gradual. Early-identification in this study was a dichotomous variable, prior to 6 months versus after 6 months, rather than a continuous variable, 6 months identification being preferable to 12 months identification, but 12 months being preferable to 24 months. Why the early-identification variable was not a continuous variable is not known yet. Perhaps language stimulation within the first 6 months of life is necessary for particular neural development to occur. A small percentage of the later-identified group has development similar to the early-identified group, approximately 16%. In addition, longitudinal data indicate that some of the children with significant developmental delays are able to later close the developmental gap by demonstrating language gains that are significantly greater than children with normal hearing.

Language development proceeds in a logarithmic fashion. Although children at 12 months of age may only have a dozen words in their productive vocabulary, and 50 to 100 words at 18 months of age, the average child has from 400 to 700 words at 2½ years of age. The rate of learning during each 6-month period must escalate in a multiplicative fashion in order for the child to maintain development within the normal range.

Vocabulary Development

The early identification effect also can be found in productive vocabulary as measured by the MacArthur Communicative Development Inventory. Children with normal cognitive ability who have early-identified hearing loss have significantly larger productive vocabulary lexicons than those who are later-identified. This effect is found for both children with normal cognitive ability as well as those with low cognitive ability. In the birth through 36-month age level, no impact by hearing loss was found. The vocabulary size of early-identified children with mild and moderate hearing loss is not significantly different from those children with severe and profound hearing loss.[7]

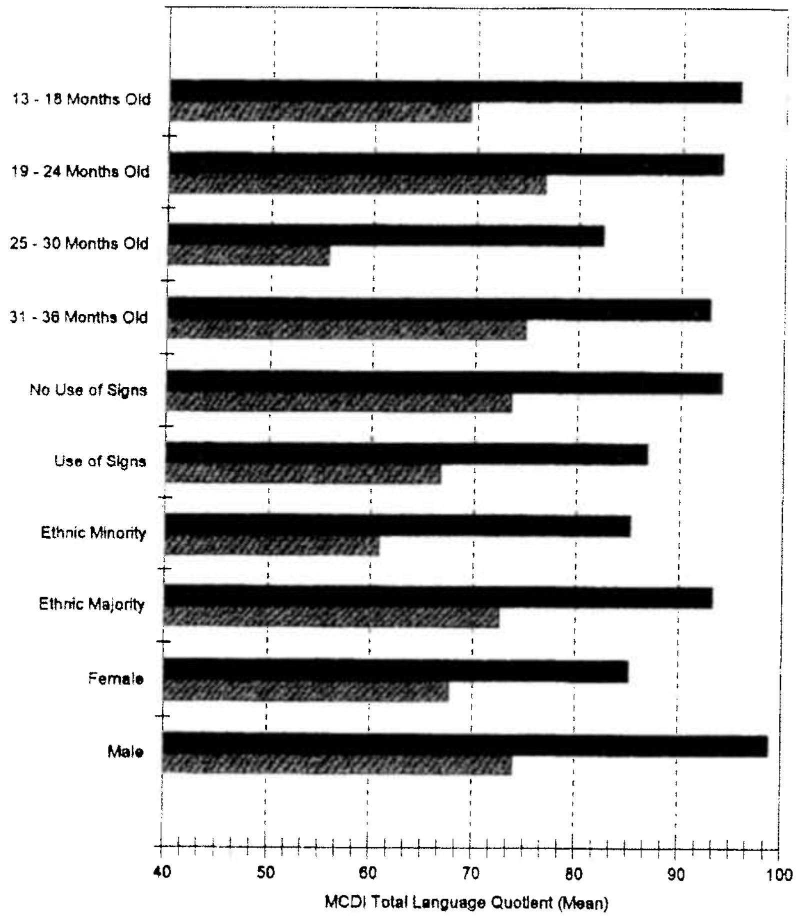


Figure 2. Adjusted mean total language quotients for the earlier and later identified groups by demographic category for children with normal cognition. Solid bar = by 6 months of age; shaded bar = after 6 months of age. (Reproduced by permission of Pediatrics, Vol. 102, pages 1161–1171, Copyright 1998.)

Illustration continued on opposite page

Speech Characteristics and Hearing Loss

Jensema et al[5], in a study of 978 students, found that 86% of students with better ear pure tone averages (PTA) less than 70 dB, 55% of students with PTAs between 71 and 90 dB, and 23% of students with PTAs greater than 90 dB had intelligible or very intelligible speech. For students with

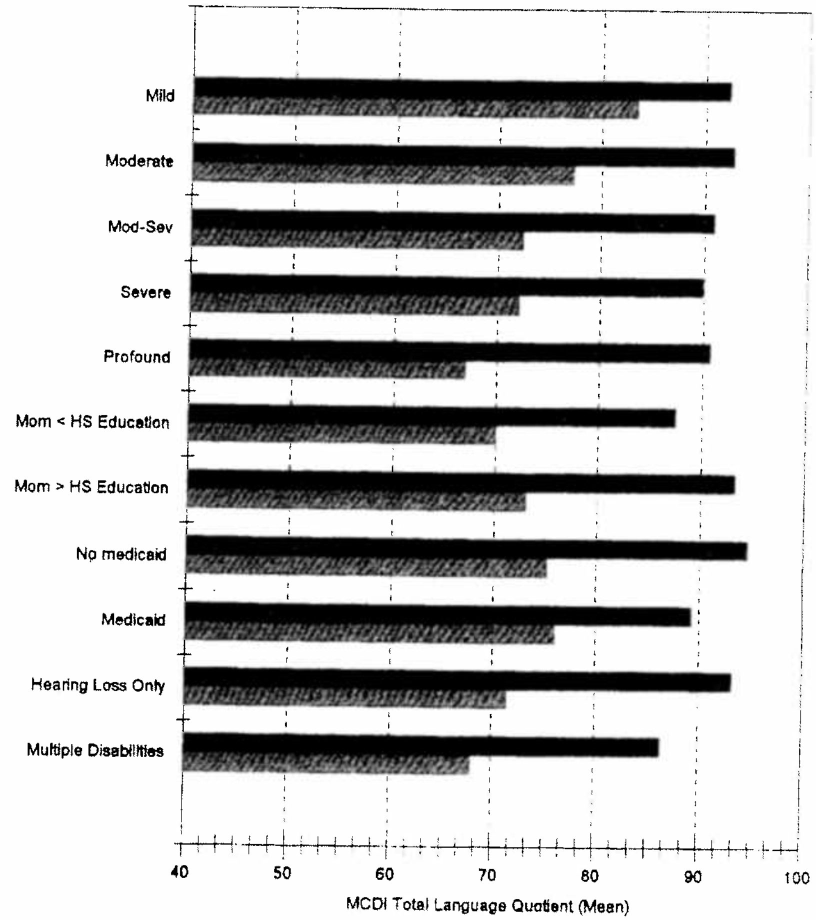


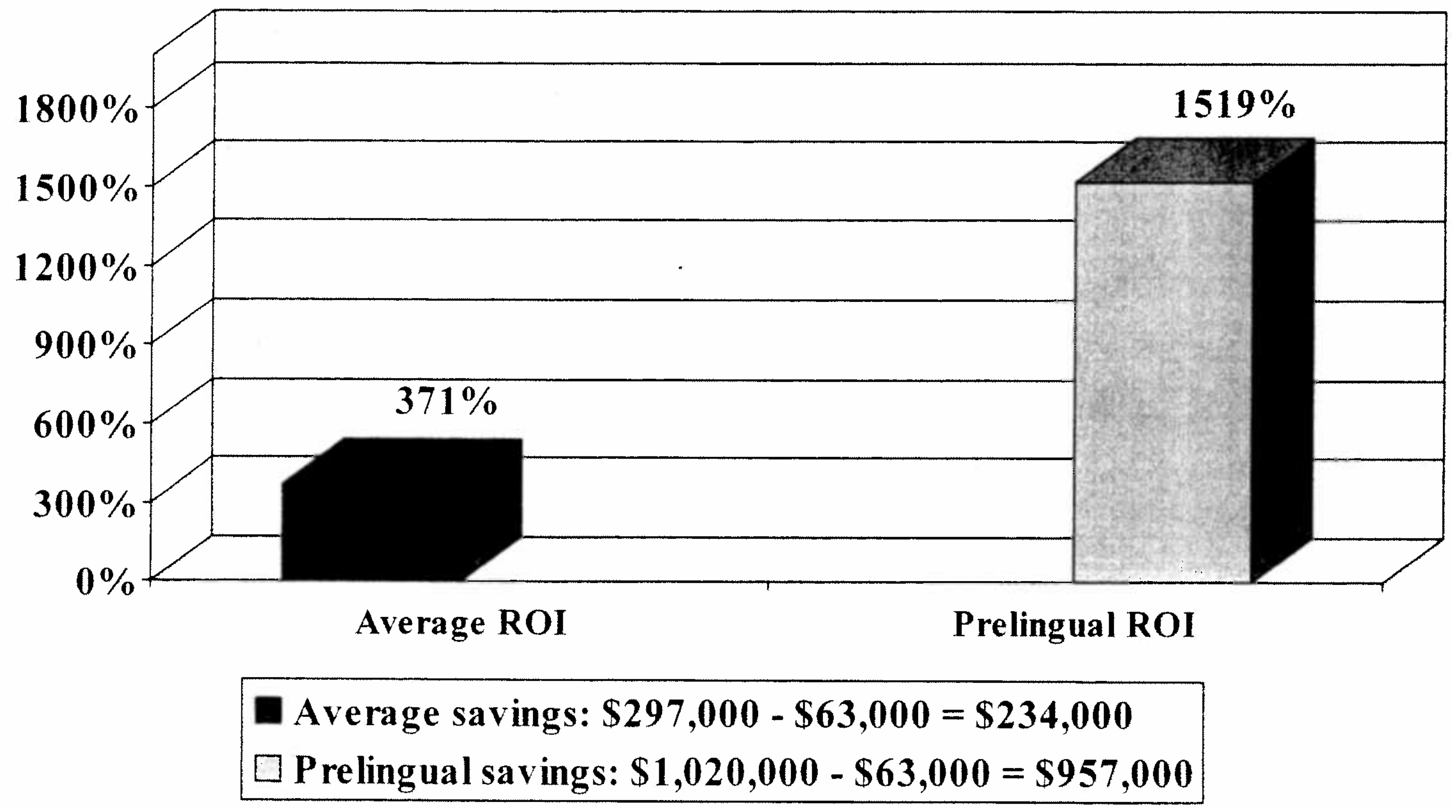
Figure 2 (*Continued*).

PTAs 80 dB or greater, speech intelligibility was not predicted by degree of hearing loss. Yoshinaga-Itano and Downey[18] reported similar results for a population of over 360 students between the ages of 7 and 18 years of age. Speech intelligibility has been found to increase for all degrees of hearing loss until approximately 8 to 10 years of age.[5] After that time, the research indicates that the mean of the population does not increase from this plateau through 18 years of age. These findings seem to indicate that the primary growth in speech for children with significant hearing loss regardless of degree occurs prior to 7 years of age.

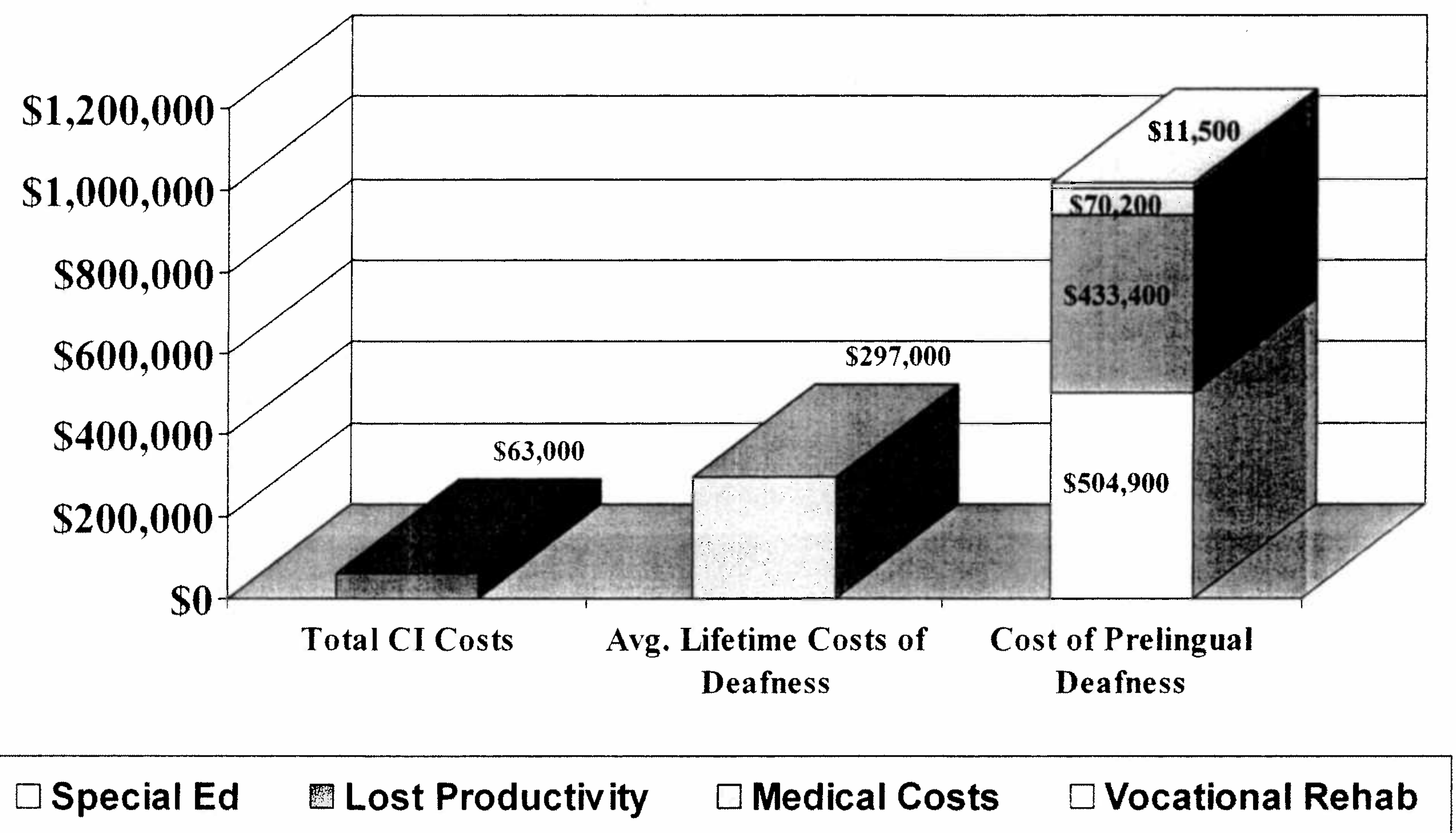
WISCONSIN STATE LEGISLATURE

Cochlear Implants: Return on Investment

Investing the medical costs of cochlear implantation results in a significant return-on-investment to society.

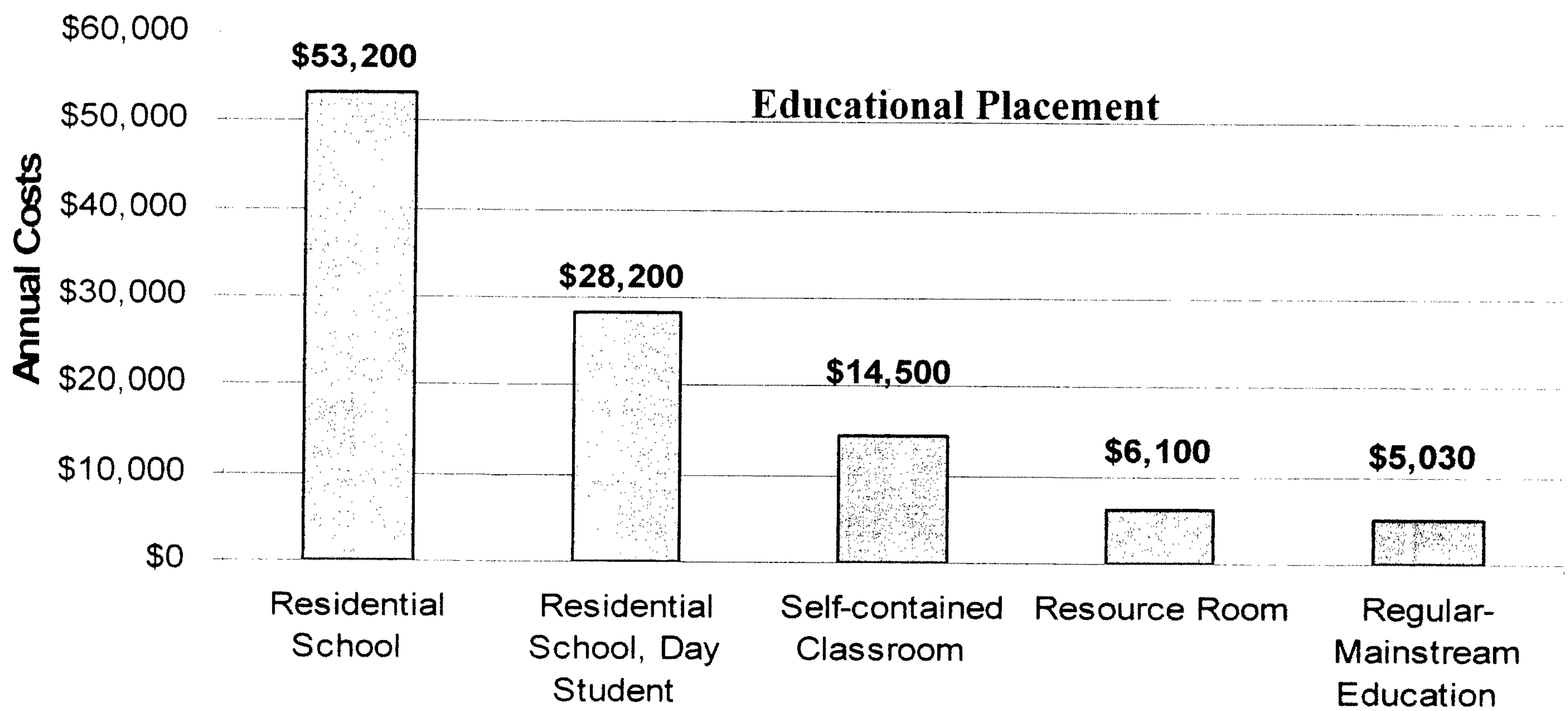


Cost of Cochlear Implants Vs Lifetime Costs of Deafness



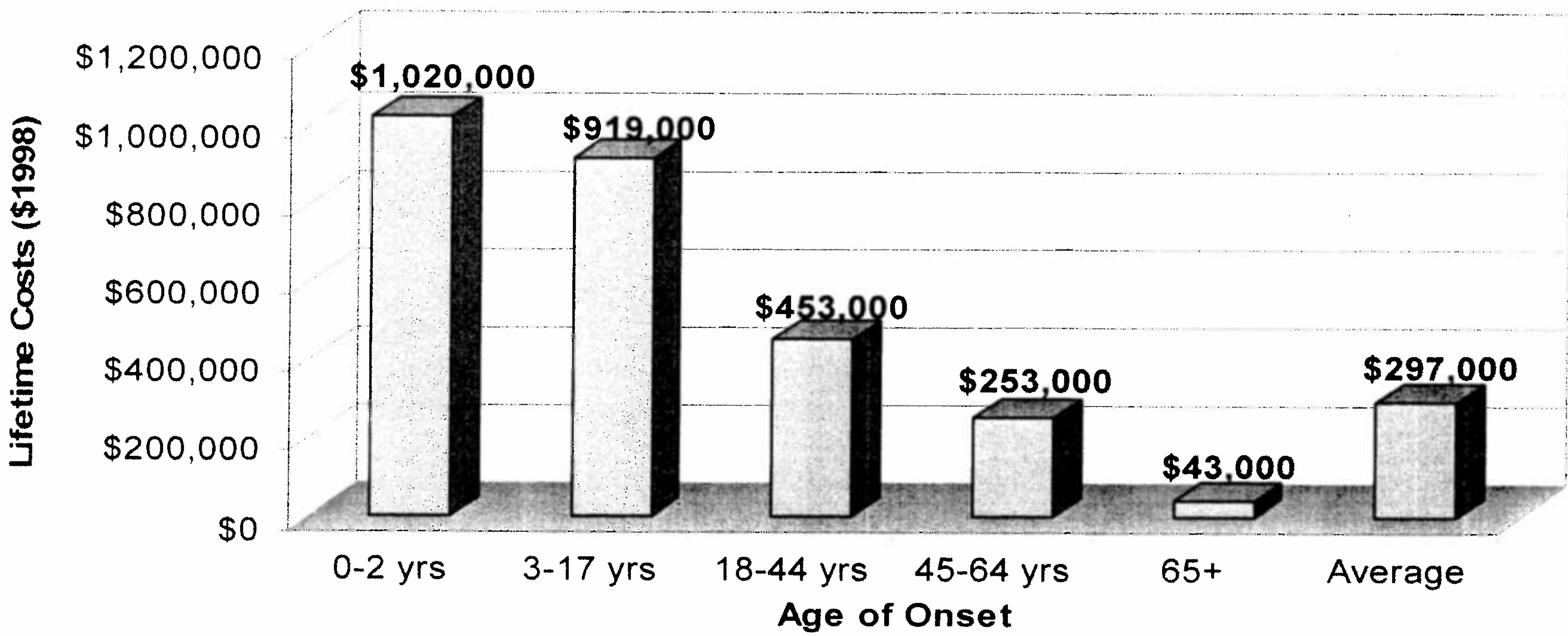
Source: Project HOPE, Policy Analysis Brief, April, 2000; and *JAMA*, Vol. 284, No. 7, August 16, 2000

Annual Educational Costs



Source: Department of Education's Office of Special Education and Rehabilitative Services; *Annual Report to Congress on the Implementation of Individual's with Disabilities Education Act, 1997.*

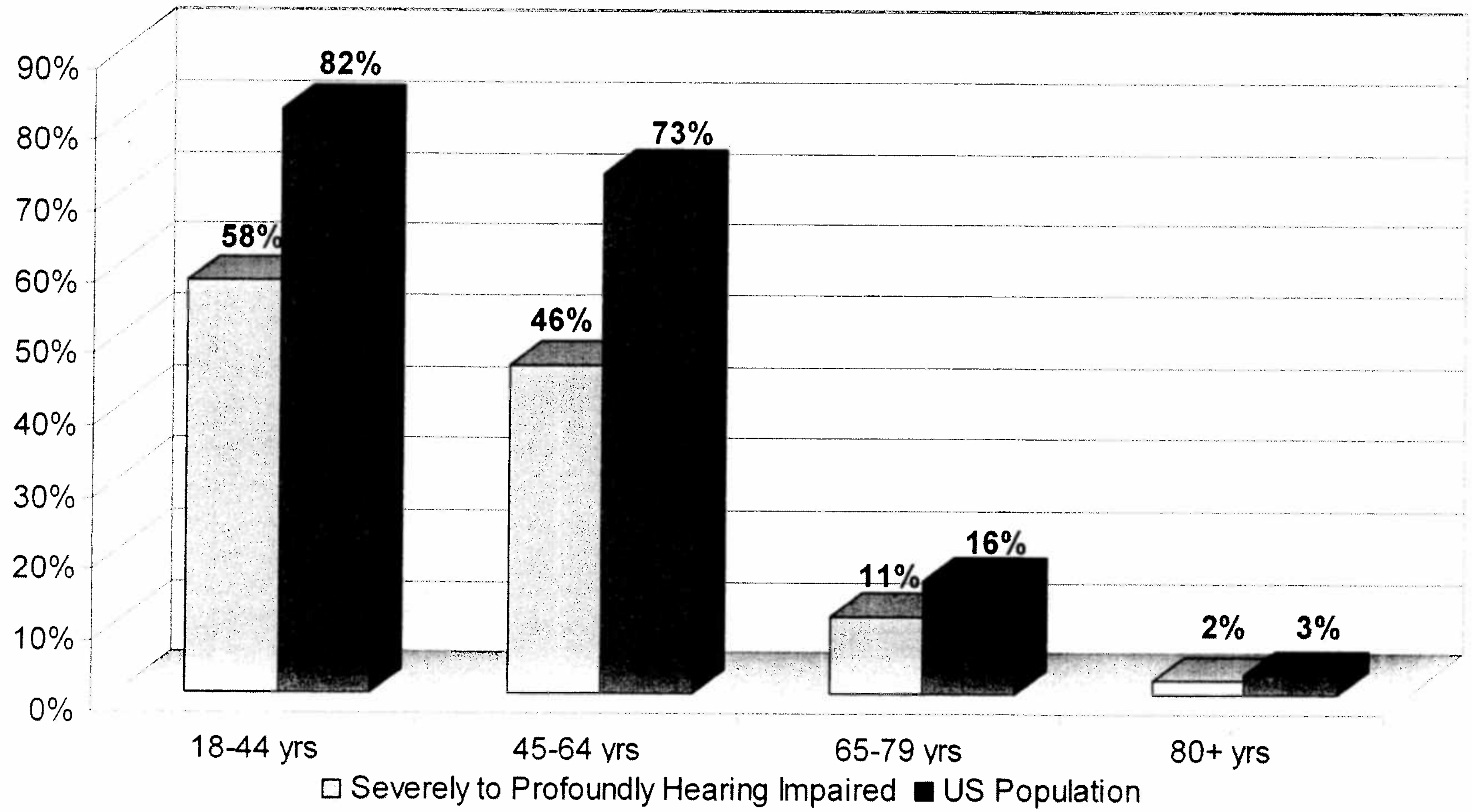
Costs by Age of Onset



Source: Project HOPE calculations from the 1990-91 National Health Interview Survey and U.S. Census, 1991
All Costs are inflated to 1998 dollars using the Urban Consumer Price Index

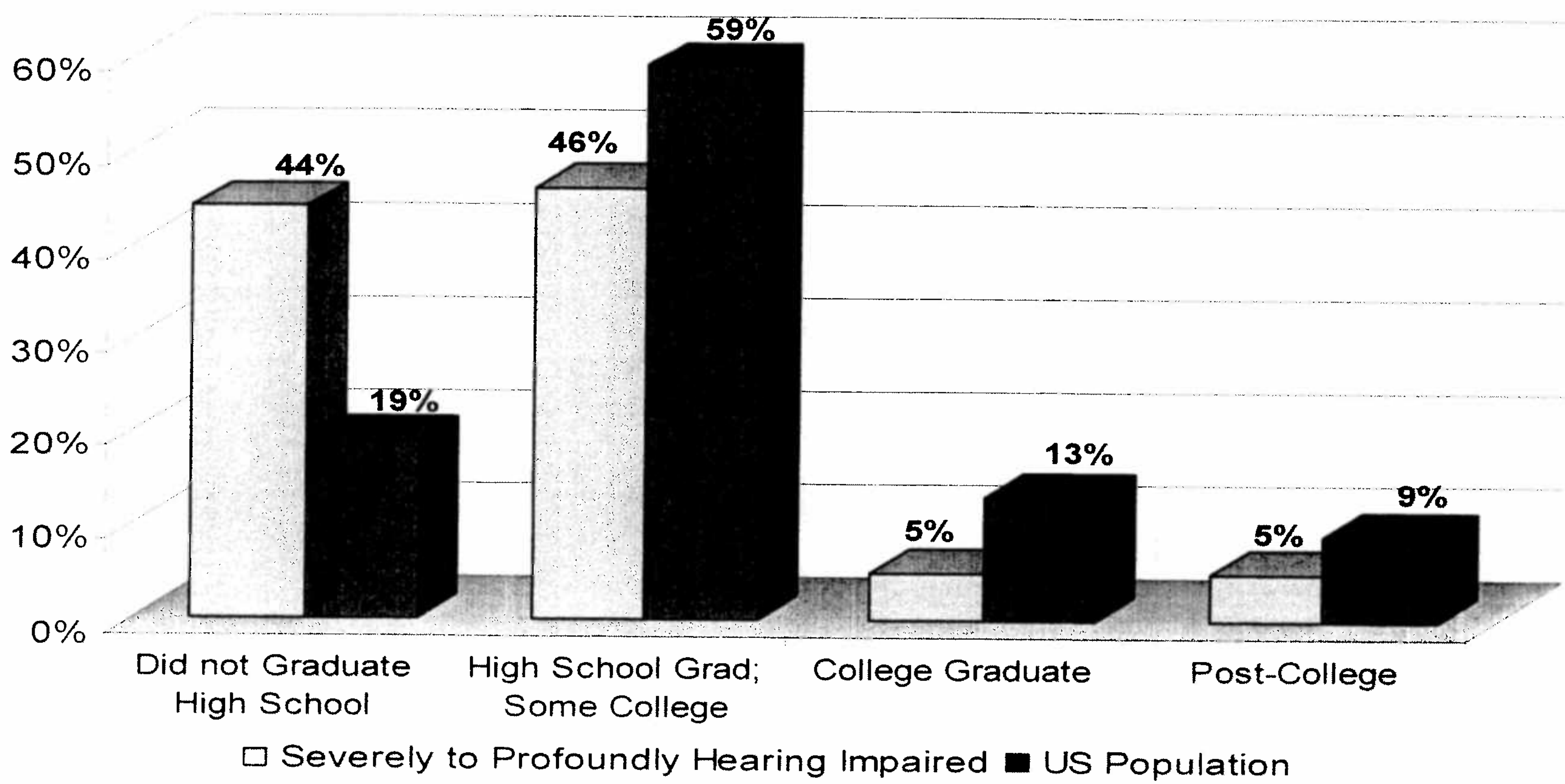
Societal Impact: Labor Force

42% of the severe to profound hearing loss population, between the ages of 18-44 years, are not working.



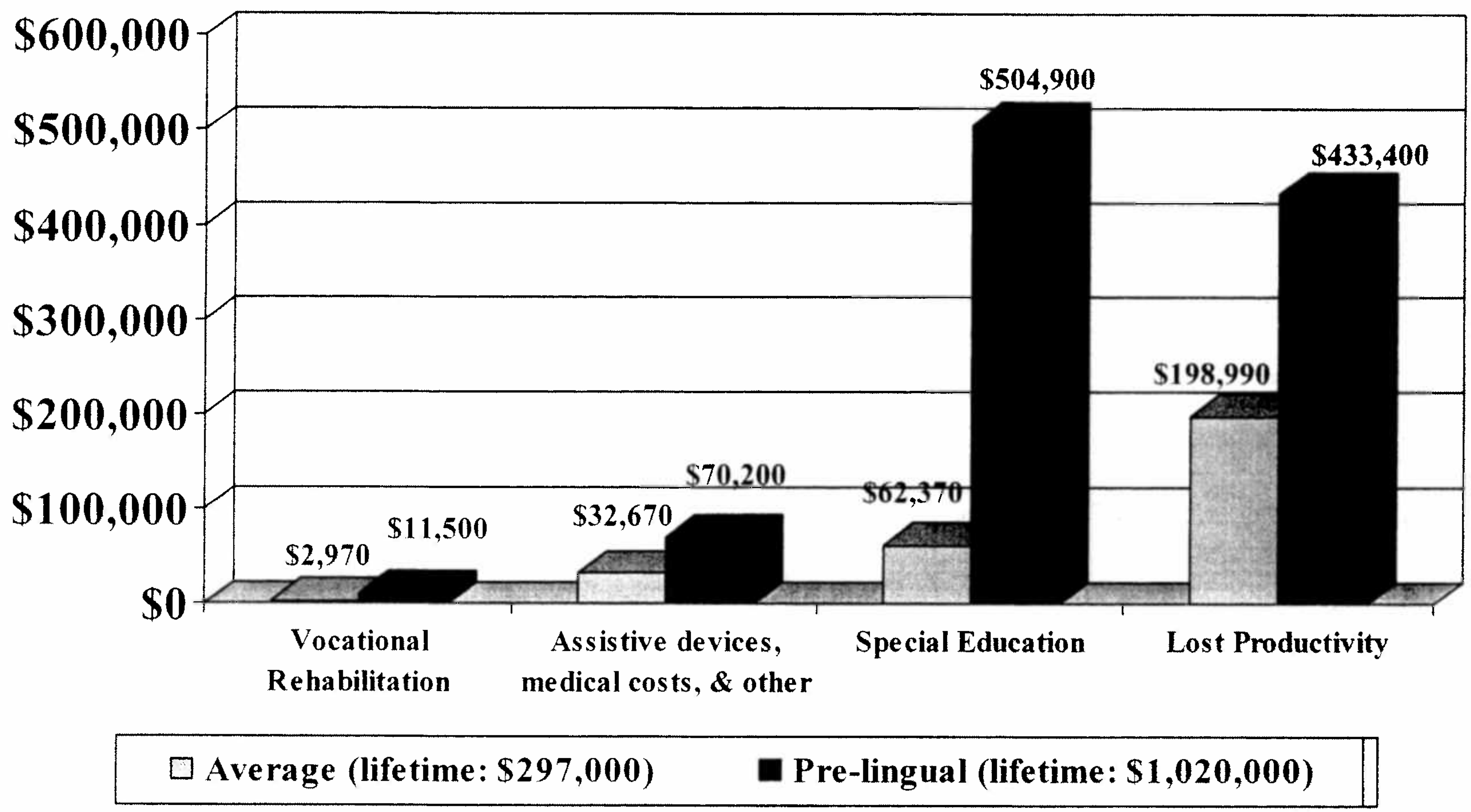
Source: Project HOPE calculations from the 1990-91 National Health Survey

Societal Impact: Education Level



Source: Project HOPE calculations from the 1990-91 National Health Survey

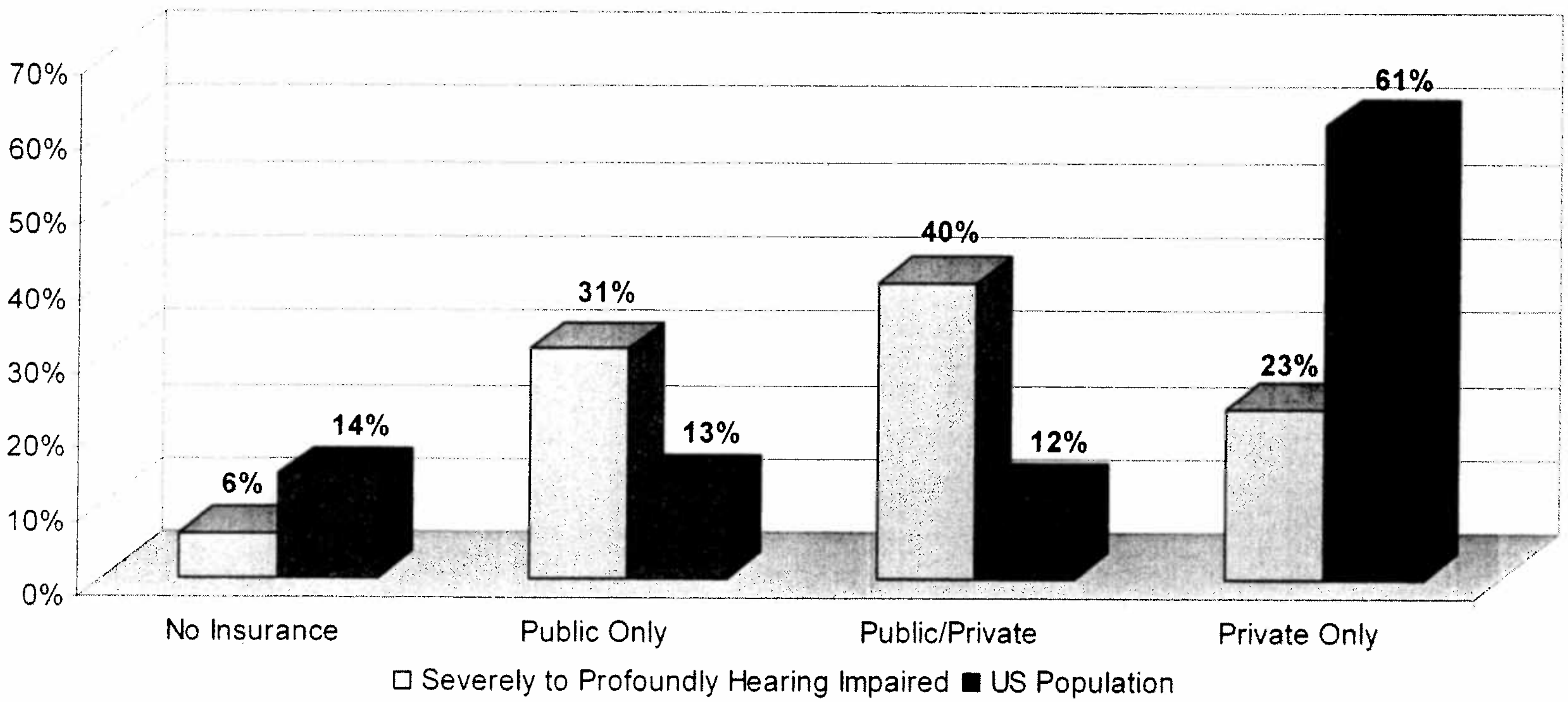
Lifetime Costs of Deafness



Source: Project HOPE, Policy Analysis Brief, April, 2000

Societal Impact: Insurance Coverage

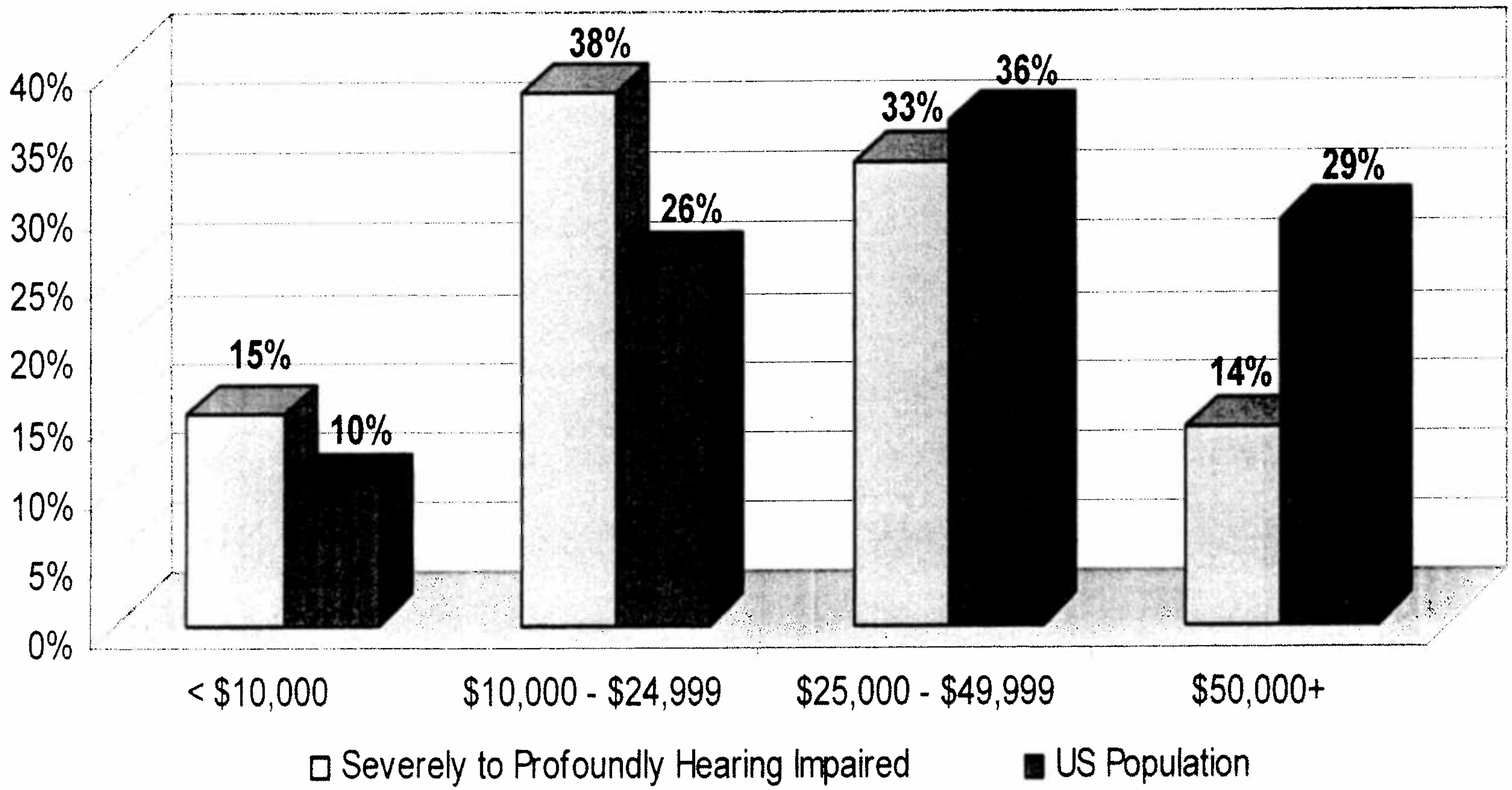
Most of the severe to profound hearing loss population is covered exclusively under public insurance programs such as Medicare and Medicaid



Source: Project HOPE calculations from the 1990-91 National Health Survey

Societal Impact: Income Level

Over half of the severe to profound hearing loss population have family incomes of less than $25,000



Source: Project HOPE calculations from the 1990-91 National Health Survey

COCHLEAR IMPLANTS: A SOUND INVESTMENT

Severe to profound hearing loss impacts both the *social* welfare system and the *medical* care system

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Language of Early- and Later-identified Children With Hearing Loss

Christine Yoshinaga-Itano, Allison L. Sedey, Diane K. Coulter and Albert L. Mehl

Pediatrics 1998;102;1161-1171
DOI: 10.1542/peds.102.5.1161

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ly-intervention services are variables that need to be considered when interpreting results.[59,60] Like earlier studies, this study has a confound in that later-enrolled groups received less intervention service than the earlier-enrolled children. However, the findings of this study suggest that late identification (resulting in late access to service) is associated with significant language delays that are difficult to resolve by age 5 years for most children with hearing loss. It may be argued that late identification simply leaves insufficient time to address the language needs of children so that they are linguistically prepared for school entry. Children who enter school with significant delays in language skills are at a distinct disadvantage and may encounter difficulties in academics, social–emotional development, and self-esteem.

Children in the best circumstances in this study attained only low average scores in verbal reasoning. This result may reflect consequences of limitations in early access to language models. Some have conjectured that the first 6 months of life may represent a particularly sensitive period of development.[1] The consequences of limited exposure to language during this time are not yet understood.

It is also important to consider that the majority of children in this study were not identified through newborn-hearing screening mechanisms. The average age of identification was 18 months and the average age of enrollment in services was a discouraging 22 months. Furthermore, only 24 of 112 subjects in this study were identified before 11 months of age and of those, only 20 were identified before 6 months of age. This study needs to be replicated with a population including a larger cohort of children identified through newborn-screening programs. It is possible that the influence of age of identification will be found to be even greater as more children gain access to early intervention through universal newborn-hearing screening programs. The findings of this study also support the argument that high-risk-screening approaches are ineffective in identifying the full population of children needing early intervention services. In summary, there is need for proactive management. Children will benefit from early identification that is paired with comprehensive interventions that actively involve family members.

APPENDIX

Early Intervention Efficacy Project: Family Participation Rating Scale

In an effort to understand variables that influence the progress of young deaf/hh children, I am attempting to characterize the quality/level of family participation that existed in individual children's programs in our community. I am asking that 2 educators who worked directly with the families involved assign a rating to describe the level of family involvement. To aid this process, I have provided a verbal case description that represents each rating of 1 to 5. On this continuum, a rating of 1 represents limited involvement (far below average). A rating of 5 represents ideal involvement. You will notice on the rating form there is a place to indicate how well you recall the family (eg, you are indicating how confident you feel in assigning a rating). You are asked to indicate if your recall is good, okay, or questionable. If you believe that you are not familiar enough with a particular family, then do not assign a rating at all.

Rating Scale Descriptors

Rating of 5 (Ideal Participation)

Family seems to have made a good adjustment to the child's deafness. The family is able to put the child's disability in perspective within the family. Family members actively engage in sessions. They attend sessions and meetings regularly and pursue information on their own. They serve as effective advocates for their child with professionals/school districts, etc. Family members become highly effective conversational partners with the child and serve as strong and constant language models. Family members become fluent/effective users of the child's mode of communication. They are capable of applying techniques of language expansion. Extended family members are involved and supportive.

Rating of 4 (Good Participation)

Family members make a better than average adjustment to the child's deafness. Family members regularly attend parent meetings and sessions. Parents take an active role (perhaps not the lead) in Individual Family Service Plans and Individual Education Plans. Family members serve as good language models for the child and make an effort to carry over techniques at home. Some family members have fairly good facility in the child's communication mode and/or in techniques for language stimulation. Efforts are made to involve extended family members.

Rating of 3 (Average Participation)

Family is making efforts to understand and cope with the child's diagnosis. Family members participate in most sessions/meetings. Busy schedules or family stresses may limit opportunities for carryover of what is learned. Family may find management of the child challenging. Family attends Individual Family Service Plan and Individual Education Plan meetings but may rely primarily on professional guidance. Family attempts to advocate but may be misdirected in some of their efforts. Selected family members (eg, mother) may carry more than their share of responsibility for the child's communicative needs. Family members develop at least basic facility in child's communication mode. Family members are willing to use language expansion techniques but need ongoing support and direction.

Rating of 2 (Below Average)

Family struggles in acceptance of the child's diagnosis. The family may be inconsistent in attendance. They may be inconsistent in maintaining the hearing aids and keeping them on the child outside of school. They may have some significant life stressors that interfere with consistent carryover at home. Management of the child presents daily challenges to the family. Communicative interactions with the child are basic. Family lacks fluency in the child's mode of communication.

Rating of 1 (Limited Participation)

Family faces significant life stresses that may take precedence over the child's needs (eg, domestic abuse, homelessness). Family has limited understanding of deafness and its consequences for the child. Participation may be sporadic or less than effective. Parent/child communication is limited to very basic needs.

ACKNOWLEDGEMENTS

This study was supported in part by National Institutes of Health (NIDCD) Grant P60 DC00982.

I gratefully acknowledge Drs Brenda Schick, Patricia Stelmachowicz, and Michael Gorga for their mentoring and for their critical review of the draft manuscript.

I thank Dr Russell W. Smith for his guidance and review of the statistical methods implemented in this study.

I am grateful to Kathryn Beauchaine for her assistance in gathering audiological records, Sharon Wood for editorial feedback, Beth O'Connor for assistance with figure preparation, and the parent/infant educators and clinicians at Boys Town National Research Hospital and the Omaha Hearing School for their assistance in data collection.

I also thank 3 anonymous reviewers for their helpful suggestions.

TABLE 4. Zero-Order Correlations Between Background Variables and Verbal Reasoning

	n	Verbal Reasoning	PTA	Nonverbal IQ	Family Involvement	Age† Enrolled
Verbal reasoning	80		−.251	.161	.610*	−.310*
PTA	80			−.088	.046	.006
Nonverbal IQ	63				.227	−.067
Family involvement	80					−.276
Age enrolled	80					

* $P < .01$.
† Age enrolled was the age at which children began in the early intervention program. Children typically entered the program shortly after amplification was fit or were in the process of amplification fitting at the time of enrollment.

particularly poor language outcomes at 5 years of age. Children from at-risk families may be particularly susceptible to the consequences of later identification and enrollment.

The results underscore the point that the best outcomes are attained when families become involved and when intervention is initiated early. The early provision of intervention services may provide families the support they need to become actively involved in promoting the child's linguistic development. More in-depth understanding of the ways in which specific family factors interact with other background variables (such as age of enrollment) will inform early intervention practices. For example, the possible contribution of socioeconomic status to level of family involvement should be explored in future studies. Calderon[58] recently reported from a study of 28 deaf/hh children that socioeconomic status was a marginally significant predictor of maternal communication. She hypothesized that mothers from higher socioeconomic conditions may have access to more resources that support their development of communicative skills with the child.

In the present study, 47% of the families enrolled were rated as above average to ideal in their involvement in the intervention program. It is unclear how representative this population of families is of populations in other areas of the country. In some ways, this population may be atypical in that some families moved to the community to access services for their profoundly deaf children. This may have contributed to the greater number of profound children in the sample and some bias toward highly motivated families within the group.

It should be noted that children from families rated average or below in this sample obtained language scores at age 5 years that fell consistently below the average range. This suggests the need to involve families in intervention to foster optimal outcomes. This conclusion is supported by the findings of Calderon[58] cited above. She found that school-based parental involvement (eg, participation in individual educational plan meetings, parent meetings, etc) predicted early reading skills. However, maternal communicative skills were even more predictive of language and literacy. She emphasized that maternal communicative skill is a strong aspect of parental involvement, given that a parent must be highly involved to develop effective mutual communication with a deaf/hh child. In the present study, the family involvement rating scale incorporated both notions of participation in program-related meetings and quality of communicative interactions with the child. The present study supports the conclusion of Calderon[58] that professionals should actively involve parents with the goal of enhancing their communicative skills with the child.

Prospective research is needed to examine how interventions can be configured to result in active participation from the majority of enrolled families. It has also been pointed out that children who are identified late receive a limited duration of early intervention services in comparison to early-identified peers with hearing loss.[37] The results of the present study suggest that starting intervention late is not optimal for children or families.

A limitation of the present study is that language was examined only in relation to vocabulary and verbal reasoning skills. Language involves a host of skills in the areas of syntax, semantics, pragmatics, and phonology. Vocabulary and verbal reasoning skills were a highly specific focus of the 2 intervention programs studied. The results do not address qualitative differences that may exist between the participants and their hearing peers on these or other language measures. Cautious interpretation of performance comparable to hearing peers is warranted and prospective studies that include fine-grained analysis of language in matched comparison groups are needed. Prospective study of the family involvement variable with more refined tools, which include further construct specification, is also needed.

This study also found that degree of hearing loss was not a significant predictor of language outcome. This finding may have been influenced by the composition of the study population, which was skewed toward greater degrees of hearing loss. However, other authors have also reported the minimal contribution of this variable to child language scores.[1,4] It may be the case that with appropriate interventions, degree of hearing loss becomes a relatively minor predictor, at least for global measures of language performance. It is likely that speech production abilities may be influenced by degree of hearing, but such measures were not included in this analysis.

It should also be noted that a difficult-to-control confounding factor exists in studies that compare early- and late-identified children. Later-identified children and their families spend less time in intervention (eg, less time with amplification, shorter duration of service delivery) than their early-identified counterparts. Duration, intensity, and quality of ear-from 80 to 99. Visual inspection of the results for children in the category of high levels of family involvement shows the strong contribution of this variable to outcome. These children's mean scores did not fall below the average range. Children who have the combined benefits of early enrollment and strong family involvement ratings were consistently the strongest performers (mean score = 99).

Verbal Reasoning

Verbal reasoning skills were assessed at 5 years of age in a representative subgroup of 80 of the study participants. Figure 3 illustrates the descriptive results for the participants. For purposes of data reduction, they are grouped by age of enrollment, in the same manner as Fig 1. Their performance on the abstract level of questions from the PLAI is compared with 25th and 50th percentile scores (low average and average) for hearing children of kindergarten age (5 years, 0 months to 5 years, and 11 months of age). Test items were classified as abstract based on guidelines from the test developer and represent the most stringent criteria for comparison. Only the earliest-enrolled children performed within the low average range (mean = 1.43) or at the 25 percentile compared with hearing peers. Children who were latest enrolled obtained scores on average that reflected considerable difficulty responding to any of the reasoning-based questions, and well below the hearing students' scores.

Correlations Between Verbal Reasoning and Other Background Variables

Table 4 includes correlations between background variables and verbal reasoning performance. A significant positive correlation was found between family involvement and verbal reasoning (r = .610; P < .01) and a significant negative correlation was found between age of enrollment and verbal reasoning scores (r = −.310; P < .01).

Children from families rated as above average in

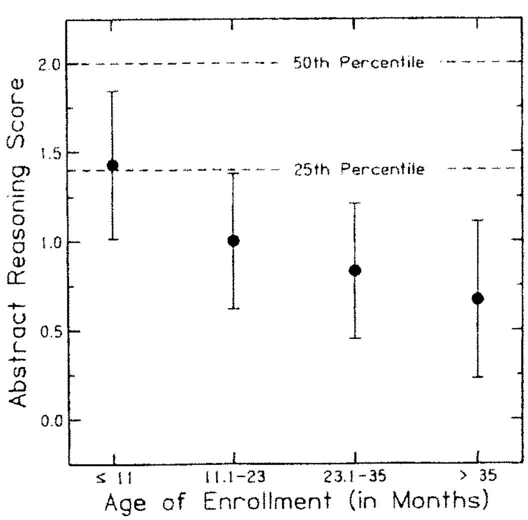

Fig 3. Means and 95% confidence intervals of verbal reasoning results for the most abstract level of questioning, grouped by age of enrollment. The dashed lines signify the scores representing the 25th and 50th percentile scores for normal hearing children.

involvement obtained a mean score of 1.5 on abstract reasoning. Conversely, children from families rated below average received a mean score of .31 on this measure. These findings are comparable to the results for vocabulary, again suggesting the importance of the contributions of family involvement in intervention. The findings also suggest that even in the best circumstances (eg, early enrollment and above average or ideal family involvement) the children achieved abstract reasoning scores considered low average compared with their hearing peers. This result reflects important qualitative differences between these 2 groups of children.

DISCUSSION

In general the findings of this study are similar to those of Yoshinaga-Itano et al,[1] suggesting that early enrollment in intervention contributes to positive outcomes in language development. Children enrolled before 11 months of age had stronger vocabulary and verbal reasoning skills at 5 years of age than did later-enrolled children. These early-enrolled children obtained mean scores in vocabulary at 5 years of age that were within the average range compared with hearing age-matched peers. In contrast, average vocabulary scores for later-enrolled children (eg, >24 months old) were 1.0 to 1.5 SD below their hearing peers. These effect sizes are similar to those reported by Yoshinaga-Itano et al.[1] Such delays can be expected to interfere with academic development and understanding in the classroom.

In the present study, early enrollment in services was also associated with better verbal reasoning skills at 5 years of age. Children who were enrolled by 11 months of age scored within the low average range (25th percentile) in comparison to hearing peers when asked to respond to the most abstract reasoning questions on the PLAI (eg, "Why, what will happen if. . . ?"). Given the importance of both vocabulary and verbal reasoning skills for literacy development, these findings support the value of identifying and enrolling children early in life.

It was found that the factors of family involvement and age of enrollment explained significant amounts of variance in language scores. These findings point to the importance of both variables and to the strong contributions families make to outcomes for children. Some professionals have questioned whether late-identified children will simply catch-up after the initiation of intervention services. The results of this study suggest that strong levels of family involvement can buffer the effects of late enrollment to some degree. As shown in Fig 2, the impact of late enrollment on vocabulary skills is less in cases where family involvement was rated 4 to 5. Children in this study who showed a pattern of catching up were from the most involved families.

Figure 2 also shows that early enrollment makes a positive difference in vocabulary scores at age 5 years across all levels of family involvement. Earliest-enrolled children consistently performed better than later-enrolled children, regardless of the level of the family rating. However, the interaction of late enrollment and limited family support resulted in

TABLE 2. Zero-Order Correlations Between Background Variables and Vocabulary

	n	PPVT	PTA	Nonverbal IQ	Family Involvement	Age of Enrollment
PPVT	112		−.033	.289*	.646*	−.464*
PTA	112			.018	−.012	−.111
Nonverbal IQ	84				.223	−.092
Family involvement	100					−.204
Age of enrollment	112					

* $P < .01$.

There was also a significant correlation between nonverbal intelligence and vocabulary ($r = .289$; $P < .01$), and as noted above, a statistically significant negative correlation was found between age of enrollment and vocabulary scores ($r = -.464$; $P < .01$). Degree of hearing loss was not significantly related to vocabulary performance ($r = -.033$).

Regression Analyses

To explore further the relationships between family involvement, age of enrollment, nonverbal intelligence, and vocabulary skills, a series of linear hierarchical multiple regressions were conducted. Before formal analysis, the relationships were tested for evidence of nonlinear components (cubic, quadratic relationships) and were found to be linear. In the regression analysis, the variable of interest is intentionally excluded at step 1, and is then entered at step 2 to examine the unique variance it contributes, while controlling for the other factors. Based on the correlational results, family involvement, nonverbal intelligence, and better ear PTA were entered into the multiple regression as 1 step, with vocabulary as the dependent variable. These factors together accounted for 44.0% of the variance in children's vocabulary scores ($R^2 = .440$; $F[3,79] = 19.93$; $P < .01$). Once age of enrollment was entered, all 4 variables accounted for a total of 55.5% of the variance in children's vocabulary scores ($R^2 = .555$; $F[4,75] = 23.346$; $P < .01$). R^2 change (.114) was significant (F change = 19.237; $P < .01$) at step 2, indicating a significant contribution of unique variance (11.4%) by the age of enrollment factor over and above the other factors.

In further regressions, the variables of family involvement, nonverbal intelligence, and better ear PTA were systematically separated out to determine the unique variance each contributed to vocabulary scores. Of all the variables, family involvement contributed the most unique variance (35.2%; R^2 change = .352; F change = 58.70; $P < .01$). A small amount of unique variance was accounted for by nonverbal intelligence (R^2 change = .025; F change = 4.211; $P = .044$). Better ear PTA did not contribute independent of the other factors included in the regressions (R^2 change = .002; F change = .37; $P = .548$). Table 3 summarizes the results of the regression models, showing the unique contributions of the independent variables.

Analysis of Combined Effects on Vocabulary

For the children in this study, there seems to be an important interaction between the factors of age of enrollment and family involvement. Figure 2 illustrates vocabulary scores as a function of both of the contributing variables. The impact of latest identifications is particularly dramatic for children who have average to low average family involvement ratings. The mean vocabulary scores for children in this situation ranged from 56.5 to 62.5, or >2 SD below age expectations. Fig 2 also illustrates that early enrollment in services was of benefit to language learning, even with limitations in family involvement. The mean scores for early-identified children with various family involvement ratings ranged

TABLE 3. Summary of Regression Models for Age of Enrollment, Family Involvement, Nonverbal Intelligence, and Better Ear PTA With Vocabulary as the Dependent Variable

Independent Variables	Vocabulary			
	R^2 Change	F Change	Significance of F Change	Partial Correlations
Age of enrollment	.114	19.24	.000	−.452
Family involvement	.352	58.70	.000	.615
Nonverbal intelligence	.025	4.21	.044	.196
Better ear PTA	.002	.37	.548	−.100

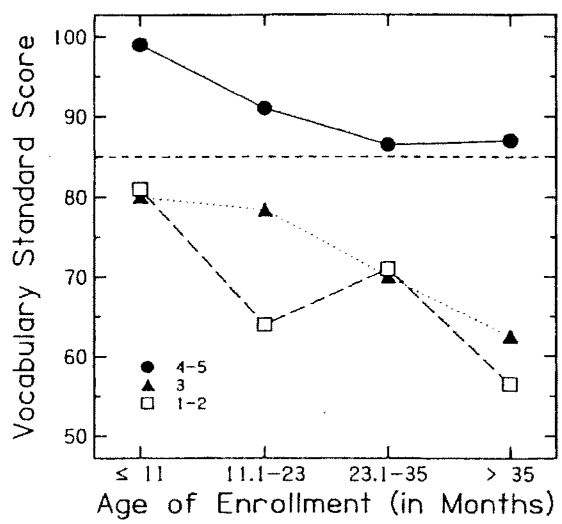

Fig 2. Mean vocabulary scores plotted as a function of the two key variables, age of enrollment and family involvement ratings. The area above the horizontal dashed line represents the lower end of the average range for normal hearing students (average range is 100 ± 15). The rating 4 to 5 (filled circle) represents the highest levels of family involvement; 3 (filled triangle) represents average family involvement; 1 to 2 (open square) represents below average family involvement.

Did clues available in signs bias responses on this multiple choice test?). In 92% of the cases, subjects' scores were lower on the PPVT than on the EOWPVT, making the PPVT a more conservative estimate of performance overall. In addition, the PPVT was correlated with global measures of receptive and expressive language, using the Preschool Language Scale-III[53] or the Reynell Developmental Language Scale[54] scores. Significant positive correlations were obtained between the PPVT and receptive language ($r = .80$; $P < .01$) and expressive language ($r = .74$; $P < .01$) measures. The test authors note that for hearing children, the PPVT correlates most highly with other measures of vocabulary and moderately well with tests of verbal intelligence.[47]

Verbal Reasoning Skills

Verbal reasoning skills were examined with the Preschool Language Assessment Instrument (PLAI).[55] This instrument was designed to assess children's ability to answer questions and to respond to demands that range from simple (eg, What is this?) to abstract (eg, Why can't the boy fit this piece into the puzzle?). This test had been administered to a representative subgroup of 80 of the study participants. Children in this subgroup of 80 had mean scores on all independent variables that closely approximated the total subject group. Children's responses were scored for accuracy and quality according to test guidelines. Scores from participants in this study were compared with performance data provided by the test developers on 120 normal hearing preschoolers, who ranged in age from 3 to 5 years.

Family Involvement Rating

A rating scale was developed to characterize the quality of family participation in the intervention program. Family involvement was rated retrospectively by early interventionists who had extensive contact (eg, twice weekly home visits, weekly parent meetings over a period of at least 2 years, and often over 4 years) with the families in the study. Each family received a global rating from 1 to 5 to reflect their participation in the intervention program. Raters were given specific descriptions of characteristics representing each category, before assigning their ratings (see "Appendix") and were asked to consider issues such as familial adjustment, session participation, effectiveness of communication with the child, and advocacy efforts in assigning their ratings. Scores were assigned as follows: 1 = limited participation; 2 = below average participation; 3 = average participation; 4 = good participation; and 5 = ideal participation. At least 2 interventionists who worked directly with the family were asked to independently rate the levels of participation they had experienced with the family.

Judgments were compared for interrater reliability. Complete agreement was found when both raters assigned the same point score. Categorical agreement was found when raters accurately placed families into 1 of 3 categories (eg, 1–2 = below average; 3 = average; 4–5 = above average). That is, raters agreed on the category of assignment (and did not deviate by 2 or more points). Judges were also asked to indicate their confidence in their ratings (eg, by circling on the form questionable, okay, or good). Any ratings judged as questionable were eliminated, leaving 100 ratings for analysis. Cohen's κ was calculated to examine interrater reliability for interventionists working in the auditory/oral and TC programs. Coefficients for exact agreement were $\kappa = .802$ for the oral program and $\kappa = .896$ for the TC program; categorical agreements were $\kappa = .882$ for the oral program and $\kappa = .94$ for the TC program. In the entire dataset, only 2 sets of judgments deviated by 2 points on the scale. For the regression analysis, rater disagreements were handled by assigning the average of the scores of the 2 judges (eg, judgments of 1 and 2 resulted in a rating of 1.5).

Statistical Analyses

Multiple regression models[56] were used in this study to explore the collective and separate effects of the various factors on children's language outcomes at 5 years of age.

RESULTS

Vocabulary Skills

A statistically significant negative correlation of $r = -.46$ ($P < .01$) was found between the variable of age of enrollment and vocabulary skills measured at 5 years of age. Thus, earlier enrollment in intervention services was associated with significantly stronger language outcomes at 5 years of age. Fig 1 illustrates the means and SDs for children entering at various stages along the age of enrollment continuum. On the PPVT, a standard score of 100 is considered average with an SD of ± 15 (eg, standard scores ranging from 85 to 115 are considered to be within the limits of the average range).

Notably, there is a systematic decline in the mean vocabulary standard score with increasing ages of enrollment. Effect sizes were calculated to represent the magnitude of this finding.[57] The results indicated an effect size difference of .69 between children enrolled before 11 months of age and those enrolled between 11.1 and 23 months of age. The effect sizes increased as the earliest-enrolled children are compared with later enrollees, with differences of .99 and 1.6, respectively. Furthermore, the earliest-enrolled children performed in the average range on the vocabulary measure, compared with normally hearing 5 year olds, regardless of degree of hearing loss (mean PPVT score = 94; standard error = 3.1).

However, it is also obvious from Fig 1 that there is considerable variability in individual performances along the age of enrollment continuum. It was of interest to determine what factors may account for such wide variability. As a first step in understanding the relationships among the variables, correlations between vocabulary and a variety of other measures were examined.

Relationships Between Vocabulary and Other Measures

Table 2 shows the Pearson product moment zero-order correlations between the child and family background variables and the children's vocabulary scores on the PPVT. Of the variables examined, the strongest significant correlation was found between family involvement and vocabulary ($r = .646$; $P < .01$). This suggests that the more involved the family with the child's intervention program, the higher the child's vocabulary scores were at 5 years of age.

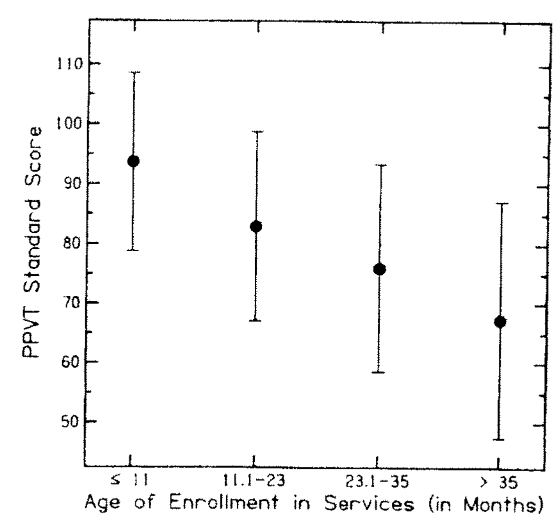

Fig 1. Means and SDs of PPVT scores for subjects as a function of age of enrollment in intervention.

TABLE 1. Demographic Characteristics of Study Sample

Characteristic	No.	Mean	SD	Range
Age of identification*	112	1.55	1.10	.00–4.53
Age at entry*	112	1.83	1.13	.03–4.53
Degree of hearing loss (in dB)	112	77.75	24.20	25–120
Mild (21–40 dB)	9	30.84	5.43	25–40
Mild to moderate (41–55 dB)	17	48.80	4.33	41–55
Moderate (56–70 dB)	19	63.61	3.83	56–70
Severe (71–90 dB)	20	80.51	5.09	71–88
Profound (91 dB +)	47	101.90	5.56	91–120
Nonverbal IQ	84	102.27	14.16	70–147
Ages of enrollment* by category				
0–11 mo (.0–.92 y)	24	.45	.27	.03–0.91
11.1–23 mo (.93–1.92 y)	42	1.39	.29	.93–1.90
23.1–35 mo (1.93–2.92 y)	24	2.37	.31	1.95–2.90
35.1+ mo (2.93+ y)	22	3.61	.48	3.00–4.53

* Ages of identification and enrollment are expressed in years/portions of years.

parental self-referral. They ranged in age of identification from the second day of life to 54 months of age, with a mean of 1.55 years (18 months). Age at amplification and enrollment in intervention services ranged from .03 year (<1 month) to 4.53 years (54 months), with a mean of 1.83 years (22 months). The average time that elapsed between age of identification and initiation of services across the group of children was 3 months.

Degree of Hearing Loss

All of the children had congenital, bilateral sensorineural hearing loss. Table 1 includes the number of participants within each hearing loss category. Unlike the typical population of children with hearing loss,[39] this distribution has a larger than expected number of children in the profound category and relatively few children in the mild hearing loss category. All children in the study used binaural personal amplification at home and frequency modulated (FM) amplification when involved in preschool services (3–5 years of age), according to school and audiological records.

Intervention Program

All children in this study were enrolled in DEIP[40,41] for 6 months after identification of hearing loss. This multidisciplinary, family-centered program is designed to support families of recently diagnosed children in identifying needs and making decisions related to intervention options. Once a family completes the initial intervention in DEIP, they are referred to the early intervention program determined to be the most appropriate to meet the needs of the child and family. In the population of children in this study, 110/112 (98%) went on from DEIP to 1 of 2 local early intervention programs that provided services from birth to 5 years of age. Of this group, 59 attended an auditory/oral program and 51 attended a total communication (TC) program. Both programs were specifically designed for deaf/hh children and implemented similar curricular approaches for language intervention. The remaining 2 children lived in rural communities and were served by the auditory/oral program on an outreach basis.

During early intervention, families received 1 to 2 home visits weekly in addition to involvement in a parent support group. Families learning to sign also had weekly family sign classes available. The average duration of the family's enrollment in the birth to 3 years of age intervention program was 15 months. The minimum participation in the birth to 3 years of age program was 0 (in cases of late identification after 36 months of age) and the maximum participation was 35 months. After birth to 3 years of age services, all children attended preschool programs that met daily (3–5 years of age) in 1 of the 2 previously described intervention programs. Attendance records were used to quantify each family's participation in these services.

Procedures

Audiological Measures

Comprehensive audiological evaluations were completed on the children in this study at a minimum of 6-month intervals during their time in the intervention program. Pure tone thresholds were obtained with TDH-49 earphones (Telephonics Corp, Huntington, NY) or ER-3A insert phones (Etymotic Research, Indianapolis, IN) for the frequencies 250 through 8000 Hz bilaterally. The children also received regular listening checks of their amplification by trained teachers and electroacoustic monitoring of personal amplification and FM systems during audiologic evaluations. Better ear PTAs were calculated for the thresholds of 500 Hz, 1 kHz, and 2 kHz, regardless of configuration, with 115 dB used as the calculation for no response thresholds. Audiograms obtained after the child's third birthday were used in all subsequent analyses.

Measures of Nonverbal Intelligence

All children in the study were seen for psychological evaluations during their preschool years. Certified clinical psychologists with expertise in working with deaf children administered nonverbal intellectual measures or developmental assessments to the study participants. The psychologist selected the test instrument deemed to be most appropriate for the child, depending on his/her age at the time of testing. Measurement tools included the Weschler Preschool and Primary Scale of Intelligence,[42] the Weschler Intelligence Scale for Children-III,[43] or the Hiskey-Nebraska Test of Learning Aptitude.[44] Nonverbal IQ scores were derived in 84 of 112 cases. In the remaining 28 cases, the psychologist did not provide a formal test score, because of the child's young age at the time of testing. In these cases, the psychologist used infant developmental measures, such as the Bayley Scales of Infant Development[45] or the Hawaii Early Learning Profile[46] to assess the developmental status of the child. In all of these cases, the psychologist reported that the child had at least average intelligence.

Language Measures

Children in this study were involved in regular, longitudinal monitoring of developmental status as part of their comprehensive early intervention programs. It is beyond the scope of the present study to examine all of the measures that were completed during the child's enrollment in the intervention program. Instead, measures of vocabulary and verbal reasoning skills collected at or near 5 years of age are the focus of the present investigation. Each child was tested individually by a speech language pathologist with additional training and experience in working with children who are deaf/hh. Signing children included in this study used a manual code of English (signing exact English). Adults who tested these children were fluent in the communication mode of the children, as determined through objective evaluation of staff sign language skills. All child language scores were entered into the children's archival records, which were reviewed for the purposes of this retrospective analysis.

Vocabulary Skills

Participants' vocabulary skills were assessed with the Peabody Picture Vocabulary Test (PPVT),[47,48] an instrument commonly used to measure receptive vocabulary for standard American English. This test was standardized on children with normal hearing and was not specifically designed for children who are deaf/hh. However, these materials have been applied to different populations of children including children with hearing loss as a measure of English vocabulary.[9,49–51] It was also relevant to the goals of this study to compare early- and late-identified participants with normal hearing peers, which further motivated the selection of this measure.

The vocabulary scores of children in the oral and TC programs were compared using analysis of variance. This revealed no significant differences for communication mode ($F[1,110] = .326$; $P = .569$), which justified combining the 2 intervention groups for analysis. There are extensive data supporting the concurrent and predictive validity of the PPVT with young children.[47] Concurrent validity of the PPVT for the children in this study was examined by correlating the PPVT scores with a measure of expressive vocabulary (Expressive One-Word Picture Vocabulary Test [EOWPVT]).[52] The 2 vocabulary measures were significantly correlated ($r = .81$; $P < .01$). Correlations between these 2 vocabulary tests were intentionally included to determine whether receptive vocabulary measures were inflated by signed administration (eg, premature and ill-advised. Among their objections was concern for the lack of empirical evidence documenting the effectiveness of early intervention.[23] This statement, and related criticisms of early intervention research, prompted further investigation of intervention outcomes in relation to age of identification. Researchers have worked to address at least 2 primary questions: 1) Does early intervention contribute to lasting differences in language outcomes for children with hearing loss?; and 2) What variables, in addition to early intervention, influence outcomes?

Three recent studies address the first question. Robinshaw[24] described outcomes for 5 early-identified children with severe to profound sensorineural hearing loss in comparison with hearing, age-matched controls and a group of 12 late-identified children with hearing loss. Results showed a clear advantage for the early-identified subjects, who achieved developmental milestones in vocalization and language at similar ages to their hearing peers and in advance of their later-identified hard-of-hearing peers. This study has limited generalizability, however, because of the small number of subjects, variability in the interventions implemented, and lack of use of standardized measures.

Further evidence of the benefits of intervention before 6 months of age was provided by Apuzzo and Yoshinaga-Itano,[2] based on a retrospective analysis of outcomes in 69 children, grouped by ages of identification. Infants identified between birth and 2 months of age performed significantly better at 40 months of age than did later-identified infants on measures of general development and expressive language. Because of concerns about sample distribution, including a limited pool of subjects in the early identification group, the study was replicated on a larger, more representative sample.[1]

Receptive and expressive language skills were examined in 150 deaf and hard-of-hearing children (deaf/hh): 72 identified before 6 months of age; 78 identified after 6 months of age.[1] The majority of children (96%) were enrolled in the Colorado Home Intervention Program.[25] Several child and family background variables were controlled in the analysis. Children were evaluated between the ages of 13 and 36 months. Children enrolled in services before 6 months of age performed significantly better than later-identified peers in receptive and expressive language, with an effect size of nearly 1 standard deviation (SD). The early identification advantage was observed in children with normal cognitive abilities, regardless of communication mode, degree of hearing loss, socioeconomic status, gender, minority status, or presence of additional disabilities. Children identified before 6 months of age performed comparably to hearing peers on language measures administered.

It is not yet known if the advantages observed through the latest tested age (36 months) in the study by Yoshinaga-Itano et al[1] will be maintained at later ages. Some have suggested that children may simply catch up once intervention has begun. It is important to examine outcomes beyond the third year of life and to control for developmental differences of children tested at varying ages by evaluating all subjects at the same chronological age point (eg, 5 years of age).

Early intervention researchers have also examined the influence of background variables, such as family factors, on outcomes. Previous research documents that families vary widely in their adjustment to the child's hearing loss,[26,27] motivation,[28] affective state,[29] responsiveness to the child,[30,31] and social support,[29,32–34] all of which can influence long-term outcomes. Parents who become involved in intervention have been found to communicate better with their children and to contribute more to the child's progress than parents who do not participate in such programs.[35,36] Calderon et al[37] retrospectively analyzed characteristics of 28 families who participated in the same early intervention program. Among their findings was the conclusion that late identification results in families spending limited time in early intervention programs. As a consequence, parents of later-identified children did not demonstrate high levels of confidence or independent knowledge related to their children's language needs.[37] Multiple variables may influence intervention outcomes. Better understanding of these relationships is needed.

The primary purpose of the present study was to explore the relationship between age of enrollment in early intervention services and specific language development outcomes measured at 5 years of age in a group of children with sensorineural hearing loss. Because vocabulary and verbal reasoning skills are known to contribute to reading comprehension,[38] the status of these specific language behaviors in children enrolled in intervention at various ages was of interest. It is hypothesized that age of enrollment will be correlated with language performance at 5 years of age, and that the earliest-identified children will attain standard scores that approximate those of hearing peers. A secondary goal of this investigation was to examine the relationship between family involvement in intervention and child language outcomes.

METHODS

Participants

Participants in this study were 112 children (58 males; 54 females) with prelingual-onset hearing losses ranging from mild to profound (mean better ear pure tone average [PTA] = 77.8; range = 25–120 dB; SD = 24.2). All children were graduates of the Diagnostic Early Intervention Program (DEIP), a parent/infant program operated in a metropolitan community. Children were included in this retrospective study if they had: 1) confirmed bilateral, sensorineural hearing loss; 2) participated in the DEIP program between 1981 and 1994; 3) received formal language evaluations through 5 years of age; 4) lived in a home where English was spoken; 5) hearing parent(s); and 6) no evidence of major secondary disabilities, including nonverbal intelligence scores <70. Table 1 summarizes the demographic characteristics of the sample.

Age of Identification/Enrollment

The children in this study represent a group whose hearing losses were identified before the implementation of universal screening of hearing in newborns in the local community. They were identified through such procedures as high-risk registries, neonatal intensive care unit screening, child find programs, and

Early Intervention and Language Development in Children Who Are Deaf and Hard of Hearing

Mary Pat Moeller, MS

ABSTRACT. *Objective.* The primary purpose of this study was to examine the relationship between age of enrollment in intervention and language outcomes at 5 years of age in a group of deaf and hard-of-hearing children.

Method. Vocabulary skills at 5 years of age were examined in a group of 112 children with hearing loss who were enrolled at various ages in a comprehensive intervention program. Verbal reasoning skills were explored in a subgroup of 80 of these children. Participants were evaluated using the Peabody Picture Vocabulary Test and a criterion-referenced measure, the Preschool Language Assessment Instrument, administered individually by professionals skilled in assessing children with hearing loss. A rating scale was developed to characterize the level of family involvement in the intervention program for children in the study.

Results. A statistically significant negative correlation was found between age of enrollment and language outcomes at 5 years of age. Children who were enrolled earliest (eg, by 11 months of age) demonstrated significantly better vocabulary and verbal reasoning skills at 5 years of age than did later-enrolled children. Regardless of degree of hearing loss, early-enrolled children achieved scores on these measures that approximated those of their hearing peers. In an attempt to understand the relationships among performance and factors, such as age of enrollment, family involvement, degree of hearing loss, and nonverbal intelligence, multiple regression models were applied to the data. The analyses revealed that only 2 of these factors explained a significant amount of the variance in language scores obtained at 5 years of age: family involvement and age of enrollment. Surprisingly, family involvement explained the most variance after controlling for the influence of the other factors ($r = .615$; F change = 58.70), underscoring the importance of this variable. Age of enrollment also contributed significantly to explained variance after accounting for the other variables in the regression ($r = -.452$; F change = 19.24). Importantly, there were interactions between the factors of family involvement and age of enrollment that influenced outcomes. Early enrollment was of benefit to children across all levels of family involvement. However, the most successful children in this study were those with high levels of family involvement who were enrolled early in intervention services. Late-identified children whose families were described as limited or average in involvement scored >2 standard deviations below their hearing peers at 5 years of age. Even in the best of circumstances (eg, early enrollment paired with high levels of family involvement), the children in this study scored within the low average range in abstract verbal reasoning compared with hearing peers, reflecting qualitative language differences in these groups of children.

Conclusions. Consistent with the findings of Yoshinaga-Itano et al,[1] significantly better language scores were associated with early enrollment in intervention. High levels of family involvement correlated with positive language outcomes, and, conversely, limited family involvement was associated with significant child language delays at 5 years of age, especially when enrollment in intervention was late. The results suggest that success is achieved when early identification is paired with early interventions that actively involve families. *Pediatrics* 2000;106(3). URL: http://www.pediatrics.org/cgi/content/full/106/3/e43; *hearing loss, deaf, hard-of-hearing, early identification, early intervention, language, newborn hearing screening.*

ABBREVIATIONS. deaf/hh, deaf and hard-of-hearing; SD, standard deviation; PTA, pure tone average; DEIP, Diagnostic Early Intervention Program; FM, frequency modulated; TC, total communication; PPVT, Peabody Picture Vocabulary Test; EOWPVT, Expressive One-Word Picture Vocabulary Test; SE, standard error; PLAI, Preschool Language Assessment Instrument.

Recent evidence indicates that many children with sensorineural hearing loss achieve language abilities similar to hearing peers if comprehensive intervention services are provided by 6 months of age.[1,2] Advocates of early intervention emphasize the importance of maximizing sensitive periods of development to prevent the communication, language, and literacy delays frequently observed in children with mild to moderate/severe losses[3–7] and those with severe to profound losses.[8–13] Early detection and intervention are believed to be critical steps toward proactive management of these children. Recent technological advances allow for identification of hearing loss soon after birth,[14–17] and the concept of universal newborn hearing screening has been endorsed by the National Institutes of Health,[18] the Joint Committee on Infant Hearing,[19] and the American Academy of Pediatrics.[20]

Despite widespread theoretical and practical support for universal hearing screening, concerns about the costs versus the potential benefit to society continue to be raised.[21] Recently, Bess and Paradise[22] characterized the advocacy for universal screening as

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Received for publication Feb 18, 2000; accepted May 10, 2000.

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Early Intervention and Language Development in Children Who Are Deaf and Hard of Hearing

Mary Pat Moeller

Pediatrics 2000;106;e43

DOI: 10.1542/peds.106.3.e43

The message I want to leave you with is that UNHS and Early Intervention works. Children with significant hearing losses who have access to the auditory signal at an early age have a far better prognosis for developing oral communication skills, social-emotional skills, cognitive and academic skills like their hearing peers, than those who do not. 54% of children with a diagnosis of hearing loss do not have insurance that will cover the cost of hearing aids or cochlear implants. This is a huge financial burden for them. In terms of therapy services, insurance companies cover anywhere from 4 visits of speech therapy to 20 to 50 visits. A child's access to services that will support his/her acquisition of communication should be covered by insurance. I urge your support of Senate Bill 27 and Assembly Bill 16. I would be happy to address any questions you have about access to the auditory signal or early intervention with young children who are deaf or hard of hearing.

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Testimony in favor of Senate Bill 27 and Assembly Bill 16
March 18, 2009

My name is Anne Heintzelman. I am a speech language pathologist who has specialized in developing intervention programs and working with families of young children who are deaf or hard of hearing for over 20 years. I am also an Associate Clinical Professor in the Department of Communicative Disorders at the University of Wisconsin-Madison.

I'd like to speak to the impact passage of this bill would have on the life of a child with a hearing loss and his/her family.

I'd like to start by briefly reviewing the impact of hearing loss on a child's communication development. The information I am reporting has been clearly documented in research. Prior to universal newborn hearing screening I didn't meet children and families until the child was between 1 and 2 years of age. Parents very likely suspected that their child wasn't hearing, but it often took months and a variety of reasons before the child's hearing loss was identified. At that point we were behind the 8-ball. The child's ability to communicate using words was significantly delayed. His/her responsiveness to the parents voices and sounds and the environment was often limited or simply non-existent. The children were not safe because they could not hear, the bond between the parent and child was not normal, parents felt inadequate to parent their children. In short, children with hearing loss are delayed in their acquisition of oral language, delayed in their social development, and often had emotional/behavioral issues that required more attention from parents, professionals and school programs.

We have been doing hearing screening on newborns in Wisconsin for a number of years now, and the impact has been huge. I now typically see families within 3 to 6 months of their getting a diagnosis. My personal experience is that the children I have seen, diagnosed through UNHS are far more advanced in their oral and sign communication skills by the age of 3 years than children I saw prior to UNHS. By age 3 years, the majority of children I see have age-level or near age-level oral communication skills. They are confident assertive communicators in preschool and daycare settings and with family members. They are "typical". Many enter school at kindergarten needing support services from speech clinicians, teachers of the deaf and hard of hearing, and audiologists to access the curriculum in the classrooms in which they are fully included.

So what does it take to bring a child to this level of communicative competence? In my practice, I typically see families once or twice a month initially. In the early stages of fitting hearing aids and determining cochlear implant candidacy, I may see a child and family once a week in order to determine what the child's functional auditory skills are, and how the child's ability to access the speech signal through the auditory channel affect his/her speech production. Typically I see toddlers once or twice a week with their parents or in a day care setting. We work on speech perception skills, speech production skills, and receptive and expressive language skills.