

## DEGREES OF HEARING LOSS: OUTCOMES

REFERENCE	DESIGN	RECRUIT- MENT	CASE DEFINITION	SUBJECTS	ASSESSMENT TOOLS	RESULTS	AUTHOR'S CONCLUSIONS
Davis JM, Shepard NT, Stelmachowicz PG, Gorga MP. Characteristics of hearing-impaired children in the public schools: part II—psycho-educational data. J Speech Hear Disord. 1981;46(2):130-7.	Cohort, survey	Audiologists in 13 of 15 Area Education Agencies completed questionnaires in an attempt to describe characteristics of children with hearing loss in public school settings.	<p><i>Group A:</i> Bilateral or unilateral conductive loss = normal air conduction, air-bone gaps of &gt;10 dB* (3 subgroups).</p> <p><i>Group B:</i> Bilateral or unilateral high frequency hearing loss &gt;25 dB at 4 kHz,* 6 kHz, or both (4 subgroups).</p> <p><i>Group C:</i> Sensorineural or mixed hearing loss at more than one frequency (6 subgroups).</p> <p>See appendix in full article for subgroups.</p>	<p>Total: N = 1,250</p> <p>With hearing loss: N = 1,250</p> <p>Controls: N = 0</p> <p>1,250 children with hearing loss that had files for the 1976-77 academic year.</p> <p>Number of subjects in different comparison groups varied because not all children had the same battery of tests.</p>	Survey questionnaires about degree and type of hearing loss, educational placement, use of amplification, and other demographic data using information available in children's personal school files.	<p>Children with UHL* demonstrated a slight decrement in verbal IQ relative to performance IQ, but this was not related to degree of loss.</p> <p>Similar trends for children with bilateral conductive loss at high frequencies and mild sensorineural or mixed loss.</p> <p>Children with mild-moderate bilateral hearing loss did not show lower test scores in reading, math, or spelling. Only when hearing loss was &gt;50 dB were scores depressed.</p> <p>UHL: Children's test scores were independent of type, degree, and configuration of loss.</p> <p>Language skills below normal for all hearing loss categories.</p> <p>Difference between language age equivalency and chronological age increased sharply with age.</p> <p>The greater the hearing loss, the more likely the child received special support and classroom placement.</p>	<p>Taken at face value, data suggested that children with mild-moderate hearing loss (<math>\leq 50</math> dB) did not exhibit significant academic problems, while children with losses &gt;50 dB showed educational deficits that increased in severity over time.</p> <p>Intellectual and language test data indicated steadily increasing verbal deficit across hearing loss categories, beginning with mild hearing loss.</p>

\*dB = decibel; kHz = kilohertz; UHL = unilateral hearing loss.

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Huttunen KH, Sorri MJ. Long-term outcome of early childhood hearing impairments in northern Finland. Scand Audiol Suppl. 2001;52:106- 8.	Retrospective and longitudinal observational (15-year follow-up) with semi- structured questionnaire when subjects in mid-20's.  Information collected retrospectively about hearing, rehabilitation, primary educational setting, main communication mode, and language development at the time the subjects were, on average, 9 years of age.	Oulu University Hospital, Finland.	Not provided for degrees of hearing loss.	Total: N = 51  With hearing loss: N = 51  Controls: NA: Subjects compared with population norms  51 children with hearing loss born 1965-1979 who were in their mid-20's at the time of the study.  7 mild  17 moderate  13 severe  14 profound  Non-syndromal, sensorineural  No associated disabilities.	Semi-structured questionnaire on education and employment history and current employment status administered to subjects who were in their mid-20's at the time of the study.	29% of subjects had received only compulsory basic education* (mainly those with moderate or profound hearing loss) versus 18% of all 25-29 year-olds in Finland.  29% of subjects with hearing loss dropped out of school versus 10% of young adults with no hearing loss.  48% of respondents were currently unemployed versus 15% of all 25-29 year- olds in Finland.  Employment status was not associated with degree of hearing loss.  Subjects with severe and profound hearing loss often needed special support from the employment authorities.	Subjects with hearing loss were at a great disadvantage compared with their hearing age peers.  More emphasis on education and communication skills along with special support can help improve employment outlook for individuals with hearing loss in the future.

\*Compulsory basic schooling normally lasts from the age of 7 years until 16 years.

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Jarvelin MR, Maki-Torkko E, Sorri MJ, Rantakallio PT. Effect of hearing impairment on educational outcomes and employment up to the age of 25 years in northern Finland. Br J Audiol. 1997;31(3):165- 75.	Prospective, longitudinal case-control.  Subjects followed prospectively since birth in 1966.  Multiple logistic regression stratified by IQ, adjusting for demographic and medical variables.	All subjects identified by questionnaire about hearing and school achievement sent to families of 11,780 members of cohort alive at age 14 years and by audiometric screening.  977 controls randomly selected from cohort of infants born in Finland in 1966.	3 hearing loss categories:  <i>Clinically significant</i> = if PTA* (.5, 1, 2 kHz*) >25 dB* in better ear  <i>4 kHz loss</i> = ≥30 dB at 4 kHz and PTA ≥25 dB  <i>Slightly abnormal</i> = >20 dB at any frequency and didn't fit above criteria.	Total: N = 1,372  With hearing loss: N = 395  Controls: N = 977  Average age 15 years.  395 with hearing loss.  977 controls.	Information on school performance to age 14 years obtained from parent questionnaire and school offices.  IQ obtained from institutions for children with disabilities, child guidance centers, and hospitals.  Applications for intermediate level schooling obtained from Ministry of Education and employment status from Statistics of Finland.	<i>Social background and perinatal outcomes:</i> Even modest decrease in birth weight denoted risk of hearing loss. Low level of maternal education had strongest association with hearing loss.  <i>Elementary school performance (Basic):</i> The more severe hearing loss, the poorer the child's performance in elementary school.  <i>Application and entrance to intermediate level education:</i> Those with clinically significant loss had lowest acceptance (64%); a high proportion (32.7%) did not apply at all.  <i>Outcome of education by the age of 25 years:</i> Vocational schools** more often final achievement by children with hearing loss. More severe hearing loss associated with worse educational outcome.  <i>Main occupational activity and employment at 25 years:</i> 7% of controls were unemployed compared with 9% with a 4 kHz loss and 14% of those with clinically significant hearing loss.	After adjusting for social and medical factors hearing loss had an independent effect on the final outcome of education.  The more severe the degree of hearing loss, the poorer the elementary school performance.  Young people with hearing loss were much less likely to complete a higher education degree compared with their normal hearing peers

\*PTA = pure tone average; kHz = kilohertz; dB = decibel.

\*\* Upon completing their basic (i.e. elementary) education, adolescents in Finland normally take part in the national application system for intermediate level education, including the upper secondary schools and the vocational schools. Higher education includes the universities and the upper levels of vocational school.

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Kiese-Himmel C, Schroff J KE. Identification and diagnostic evaluation of hearing impairments in early childhood German-speaking infants. <i>Eur Arch Otorhinolaryngol.</i> 1997;254(3):133-9.	Observational, cohort	All infants and preschool children identified in the Department of Phoniatics and Pediatric Audiology (outpatient clinic) in Göttingen, Germany, during 1-year period (Oct. 1994-Oct. 1995).	<p>Average threshold 1-4 kHz* using ABR* and 0.5-6 kHz using pure tone thresholds.</p> <p>UHL* = lateral difference <math>\geq 10</math> dB.*</p> <p>Causes unknown in 17 (39%) children.</p> <p>Mild: &lt;35 dB</p> <p>Moderate: 40-65 dB</p> <p>Severe: &gt;65 &lt;85 dB (N = 8)</p> <p>Profound: <math>\geq 85</math> dB</p>	<p>Total: N = 44</p> <p>With hearing loss: N = 44</p> <p>Controls: NA (Compared with hearing norms)</p> <p>41 (93%) sensorineural loss and 3 (7%) pure conductive loss.</p> <p>32 (73%) bilateral loss and 9 (21%) unilateral loss.</p> <p>Median age of identification 32 months.</p> <p>Median age 35.5 months when fitted with hearing aids.</p> <p>25 males, 19 females.</p> <p>Children with recurrent episodes of conductive hearing loss excluded.</p>	<p><i>Clinical exam:</i> Clinical history, family history of hearing loss, pregnancy, obstetric/perinatal care/otological investigation.</p> <p><i>Hearing aids:</i> Fitted and child re-tested after 4 weeks.</p> <p><i>Cognition:</i> Evaluated using developmental scale based on perceptual, non-verbal knowledge (CMMS*).</p> <p><i>Language:</i> Tested using FBIT*-picture vocabulary, AWST 3-6* for infants 3 years and older. Children with hearing loss compared to standardized hearing norms. Percentages and distribution of frequencies calculated.</p>	<p><i>Age of Identification:</i> Ranged from 1-77 months (median 32 months). Maximum 2-3 years. UHL identified at median age of 31.5 months (range 1-71 months). Bilateral losses identified at median 33.5 months (range 2-77 months). Conductive losses identified earlier (2-27 months). Children with profound and severe losses identified earlier compared with those with mild and moderate losses.</p> <p>Children with early diagnosis had slightly better language development. All children had larger receptive than expressive vocabulary. There was only a small difference in receptive vocabulary between children with bilateral hearing loss and UHL.</p> <p>There was a significant negative correlation between degree of hearing loss and productive vocabulary, but no correlation between degree of hearing loss and receptive vocabulary.</p>	<p>This study showed 27% of children with UHL as opposed to lower estimates in previous studies.</p> <p>Children with severe-profound losses identified earlier than children with mild-moderate losses.</p> <p>Authors suggested several reasons for late identification.</p> <p>Effects of hearing loss on language development can be severe and pervasive; prelingually deafened children showed lowest scores.</p> <p>Authors made recommendations for management.</p>

\*kHz = kilohertz; ABR = auditory brainstem response audiometry; UHL = unilateral hearing loss; CMMS = Columbia Mental Maturity Scale; FBIT = French-Bilder-Intelligentztest; AWST = Aktiver Wortschatztest für dreibis sechsjährige Kinder.

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Moeller M. Early intervention and language development in children who are deaf and hard of hearing. <i>Pediatrics</i> . 2000;106(3):1-9.	<p>Observational, retrospective, cohort</p> <p>Multiple regression models used to examine collective and separate effects of different factors on language outcomes at age 5 years.</p> <p>Results compared with averages for children with no hearing loss.</p>	All subjects were graduates of the same metropolitan area early intervention program for newly identified children	<p>Hearing loss mild-profound:</p> <p>Mean PTA* (.25-8 kHz*) in better ear: 77.8 dB*</p> <p><i>Range:</i> 25-120 dB, SD* = 24.2</p> <p><i>Mild:</i> (21-40 dB): N = 9</p> <p><i>Mild-moderate:</i> (41-55 dB): N = 17</p> <p><i>Moderate:</i> (56-70 dB): N = 19</p> <p><i>Severe:</i> (71-90 dB): N = 20</p> <p><i>Profound:</i> (&gt;91 dB) N = 47</p>	<p>Total: N = 112</p> <p>With hearing loss: N = 112</p> <p>Controls: NA (Compared to hearing norms)</p> <p>112 children aged 5 years with prelingual onset sensorineural, bilateral hearing loss.</p> <p>58 male, 54 female</p> <p>Enrolled in early intervention at various ages.</p> <p>Mean age of identification 18 months</p> <p>Participated in early intervention program 1981-1994.</p> <p>Hearing, English-speaking parents.</p> <p>No evidence of secondary disabilities.</p>	<p>Verbal reasoning assessed in sub-set of 80 children with:</p> <p>PPVT*</p> <p>PLAI* (criterion-referenced)</p> <p>Rating scale developed to characterize level of family involvement in intervention program</p>	<p>Negative correlation between age of enrollment and language outcomes at 5 years.</p> <p>Children enrolled in intervention before 11 months of age had better language outcomes compared with later-enrolled children</p> <p>Regardless of degree of hearing loss, early-enrolled children achieved language scores that approximated hearing peers.</p> <p>Multiple regression models revealed that a significant amount of the variance in language scores explained by family involvement and age of enrollment.</p>	<p>Findings that early enrollment in intervention services contributed to positive language outcome similar to the Yoshinago-Itano et al. study</p> <p>Mean vocabulary scores of those enrolled early in intervention within the average range compared with those without hearing loss.</p> <p>Those enrolled later had scores 1.0-1.5 SDs below hearing peers.</p> <p>Those enrolled early in intervention also had better verbal reasoning skills compared to those enrolled later.</p> <p>The scores of those enrolled early were within the low average range of scores compared with those of hearing peers when asked to respond to abstract questions (e.g., why, what).</p> <p>Most successful children in this study were those with high levels of family involvement and who were enrolled early in intervention services.</p>

\*PTA = pure tone average; kHz = kilohertz; dB = decibel; SD = standard deviation; PPVT = Peabody Picture Vocabulary Test; PLAI = Preschool Language Assessment Instrument.

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Pressman L, Pipp-Siegel S, Yoshinaga-Itano C, Deas A. Maternal sensitivity predicts language gain in preschool children who are deaf and hard of hearing. <i>J Deaf Stud Deaf Educ.</i> 1999;4(4):294-304.	Prospective, follow-up.  Correlational and hierarchical regression analyses performed.	Colorado Home Intervention Research Project (CHIRP).	PTA* (.5, 1, 2 KHz*) in better ear  <i>Mild:</i> 26-40 dB* hearing loss (N = 3)  <i>Moderate:</i> 41-55 dB hearing loss (N = 4)  <i>Moderate-Severe:</i> 56-70 dB* hearing loss (N = 8)  <i>Severe:</i> 71-90 dB* hearing loss (N = 3)  <i>Severe-Profound:</i> no response on ABR* and no available frequency specific threshold information (N = 1)  <i>Profound:</i> >90 dB hearing loss (N = 5)	Total: N = 24 deaf and hard-of-hearing toddlers and their hearing mothers (83% Caucasian)  With hearing loss: N = 24 children Controls: N = 0  3 children had mild hearing loss.  Aged 21-30 months at initial assessment and 33-41 months at follow-up assessment.  Age of identification 0-26 months.  Selected participants met following criteria: (a) Children had been videotaped interacting with mother 1 on 1 at ~25 months of age. (b) Mothers completed MCDI* at time of videotape session. (c) Mothers completed 2nd MCDI when children ~37 months. (d) Children had no other known medical conditions or handicaps. (e) Both parents hearing.	Sensitivity subscale of EA* Scales-infancy to early childhood version: Mother-child interactions rated on scale from 1-9, where highly insensitive = 1 and highly sensitive = 9.  MCDI, Expressive Language Subscale (standardized parent-report questionnaire) used to assess linguistic development at initial and follow-up assessments.	<i>MCDI, initial assessment:</i> 41.7% no indication of language delay, 16.7% "borderline delays," 41.7% clear delays.  <i>MCDI, follow-up assessment:</i> 25% no language delay, 25% "borderline delays", 50% clear delays.  Initial expressive language positively correlated with follow-up assessment.  No significant correlations between child and family variables and expressive language at initial or follow-up assessment, but maternal sensitivity related to child and family characteristics and expressive language.  Oral-only children had significantly lower degrees of hearing loss.  Maternal sensitivity was not correlated with initial MCDI, but was positively and significantly related to follow-up MCDI.  <i>Hierarchical regression:</i> Revealed mothers' sensitivity predicted follow-up expressive language scores, accounting for 10% of variance (child and family characteristics controlled).	Degree of hearing loss not significantly correlated with expressive language at either assessment.  Expressive language rather than speech was assessed, which could be done in either sign, speech, or both.  Continued sensitivity by a mother might be an important support of language learning when the receptive capabilities of the parents and children differ.  Sensitivity in hearing mothers significantly predicted language gain in deaf and hard-of-hearing children.

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Wake M, Hughes EK, Poulakis Z, Collins C, Rickards FW. Outcomes of children with mild-profound congenital hearing loss at 7 to 8 years: a population study. <i>Ear Hear</i> 2004;25(1):1-8.	Population-based cohort survey.	7-8 year olds drawn from comprehensive database for Australian state; born prior to UNHS* (born between Jan. 1991 and July 1993); fitted with hearing aids by 4.5 years.	PTA* = .5, 1, 2, 4 kHz* in better ear.  <i>Mild:</i> ≤40 dB* hearing loss (N = 19)  <i>Moderate:</i> 41-60 dB hearing loss (N = 27)  <i>Severe:</i> 61-80 dB hearing loss (N = 15)  <i>Profound:</i> >80 dB hearing loss (N = 25)	Total: N = 86  With hearing loss: N = 86  Controls: NA (Compared with norms on standardized tests)  86 7-8-year-olds with mild-profound hearing loss.  Children with known intellectual disability or serious medical condition excluded.	CELF,* PPVT,* WISC-III,* HRQoL,* and CHQ PF-28*  Parents rated intelligibility on scale of 1-5, teachers rated intelligibility on scale of 1-7.  SFQ,* PEDS,* and Revised Rutter Parent and Teacher Scales for School-Aged Children.	<i>CELF and PPVT:</i> Children with hearing loss scored lower than norm. <i>School functioning:</i> Children with hearing loss scored lowest on language-related items, but much better on enthusiasm, remembering routines, and motivation. <i>Reading Progress Test:</i> Children with hearing loss delayed by mean of 9.9 months. <i>HRQoL:</i> For psychosocial summary, children with hearing loss scored lower than norm. <i>Adaptive Skills:</i> Children with hearing loss scored significantly lower than norm. <i>PEDS:</i> Parents of children with hearing loss had more concerns than parents of hearing children. Common areas of concern were expressive and receptive language and social-emotional development. <i>Behavior Problems:</i> Parents and teachers of children with hearing loss reported more behavior problems than those of hearing children. <i>Results by degree of loss:</i> Language scores decreased as function of degree of loss, but children with mild aided losses had total language scores below norm. Although not significant, children with mild losses had lowest psychosocial, HRQoL, and behavior scores compared with children with more severe losses.	Children with hearing loss scored far below the hearing children, especially on language and language-related items and they showed more behavior, academic, and psychosocial problems than hearing children.  Study showed impact congenital hearing loss continues to exert on children of normal intelligence in the early school years.  Children continue to show major delays despite ongoing intervention, amplification, support.

\*UNHS = universal newborn hearing screening; PTA = pure tone average; kHz = kilohertz; dB = decibel; CELF = Clinical Evaluation of Language Fundamentals; PPVT = Peabody Picture Vocabulary Test; WISC-III = Weschler Intelligence Scale for Children-III; HRQoL = Health-related quality of life; CHQ PF-28 = Child Health Questionnaire; SFQ = School Functioning Questionnaire; PEDS = Parents' Evaluation of Developmental Status.