The ages of suspicion, diagnosis, amplification, and intervention in deaf children

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KEYWORDS
Suspicion of hearing loss; Diagnosis; Amplification; Intervention; High-risk factors; Consanguinity

Summary

Objectives: The present study sought to determine the average ages of suspicion, diagnosis, and amplification of profound hearing loss and intervention in deaf children and to compare at-risk and not-at-risk children based on the studied ages.

Methods: This study was conducted on 86 children under 6 years of age with profound bilateral hearing loss in Newsha Aural Rehabilitation Center in Tehran from July to December 2005. Data were gathered through the completion of a questionnaire by the children’s parents, and the children’s medical and rehabilitative records were utilized in order to determine the kind and degree of hearing loss.

Results: The mean ages of suspicion, diagnosis, amplification, and intervention were 12.6 ± 8.9, 15.2 ± 9.3, 20.5 ± 11.1, and 22.3 ± 11.6 months, respectively; there being statistically significant differences between them. 47.7% of the children were in the high-risk group, and statistically there were no significant differences between the at-risk and not-at-risk children in the studied ages. Of all the neonatal diseases investigated, hyperbilirubinemia was the most frequent (40.7%), and there were also four cases of meningitis and six cases of measles.

In terms of consanguinity, mating of first cousins was 41.9% and mating of second cousins and farther familial relationships was 14%. After suspecting hearing loss in their children, the parents had visited physicians (57%), audiologists (37.2%), speech therapists (2.3%), or other specialists (3.5%) for the first time. The economic circumstances of the families had a significant bearing on the average ages of suspicion, diagnosis, amplification, and intervention.

Conclusions: Despite the remarkable improvement in the average ages of suspicion, diagnosis, amplification, and intervention in comparison with those reported
1. Introduction

Delay in identification of hearing loss in children not only has severe effects on their speech and language development, social skills, academic progress, psychological condition, and future job-opportunities but also has serious consequences for family members [1,2]. Early diagnosis of hearing loss and adequate aural rehabilitation services can considerably minimize the damage.

According to a new guideline by the Joint Committee on Infant Hearing in 2000 on the early identification of hearing loss and intervention programs, all infants with hearing loss should be identified before 3 months of age, and infants with confirmed hearing loss should receive intervention before 6 months of age [3]. This goal will not be fulfilled unless hearing-screening programs and intervention modalities are conducted in maternity hospitals before mother and neonate are discharged. Sadly, despite all its potential in terms of technical know-how and skilled manpower, Iran has not gone far enough toward achieving this goal.

The earlier a child with hearing loss is identified, the greater the opportunity would be for his or her normal language development [2,4,5]. In a study by Yoshinaga-Itano [2], children identified before they were 6 months old had significantly higher expressive language scores than children identified after that age, regardless of communication modality or degree of hearing loss. The same result was also reported by Yoshinaga-Itano and Apuzzo [6]. Kitteral and Arjmand [7] conducted a retrospective study on 291 students in Illinois and found the overall average age of diagnosis to be 20.2 months. In their study, children with a risk factor for sensory-neural hearing loss were diagnosed no earlier than children without a risk factor. Another study carried out on 37 hearing-impaired children in Mauritius through questionnaire-based interviews revealed that the studied children were identified late (median age 24 months) and that the management process was imperfect [8].

In a national study, Harrison and Roush [9] found that the median age of identification for children with no known risk factors was 13 months for those with severe to profound hearing loss and 22 months for those with mild to moderate hearing loss.

Children with known risk-factors who had mild to moderate or severe to profound hearing loss were identified at a median age of 12 months. In the Prendergast et al. [4] study on the parents of 77 children with severe to profound sensory-neural hearing loss, it was reported that hearing loss had first been suspected at a mean age of 8.16 months and that the mean ages of diagnosis and amplification were 14.58 and 19.05 months, respectively. Mankowitz and Larson [10] reported that children received greater benefits when enrolled in early intervention services at younger ages. This study confirmed the results of a preceding study at Lexington School for the Deaf [11].

In a study by Watkin et al. [12] on the role of parental suspicion, while the parents had suspected the presence of hearing loss in 44% of children with severe to profound hearing loss, this contribution was much lower when the children suffered from mild or moderate permanent hearing loss. In another similar study by Parving [13], at-risk children were identified no earlier than not-at-risk children. Furthermore, in 50–60% of the cases, parents were the first to suspect their children’ hearing loss [13,14].

In a study on German children in 1998, the mean age of diagnosis was 2.5 years for severe hearing loss and 1.9 years for profound hearing loss [15]. A study on Malaysian children reported that hearing aids were fitted late with a mean age of 5.32 years [16]. Recently, Ozcebe et al. [17] in a retrospective study on 199 children with severe to profound hearing loss reported that hearing loss had been suspected at a mean age of 12.5 months and that the average ages of identification, amplification, and intervention were 19.4, 26.5, and 33.0 months, respectively.

In the Lotfi and Jafari [18] study on 1352 bilateral symmetrical sensory-neural hearing-impaired children under 6 years of age, the average ages of suspicion, diagnosis, hearing-aid fitting, and intervention were 19.4 ± 15.1, 25.9 ± 16.8, 34.8 ± 21.3, and 43.6 ± 24.5 months, respectively. In addition, there was no statistically significant difference between these figures. 35.5% of the children were in the high-risk group, and in terms of the average ages, there was no statistically significant difference between the high-risk-group children and not-at-risk children.
The family history of permanent childhood sensory-neural hearing loss is one of the high-risk factors [3]. In the Das [19] study, children with positive family history of deafness in parents or siblings, or both, constituted 23.3% of the cases.

In Iran, there being no other study on the average ages of suspicion and diagnosis of hearing loss except the one conducted by Lotfi and Jafari [18], we sought to determine the average ages of suspicion, diagnosis, amplification of hearing loss and intervention in children with profound hearing loss at Newsha Aural Rehabilitation Center in Tehran and to compare these results with similar results in other studies.

2. Methods

2.1. Subjects

This cross-sectional descriptive-analytic study was performed on 86 children under 6 years of age suffering from bilateral profound hearing loss (girls: 50% and boys: 50%; average age: 33.7 ± 11.1 months; range: 4–70 months) in Newsha Aural Rehabilitation Center, affiliated to The A.G.Bell Organization in USA and The Welfare Organization in Tehran.

2.2. Data gathering

Data were gathered through questionnaire-based interviews. A three-part questionnaire (24 items), composed of personal history (6 items), hearing-loss history (6 items), and medical history (12 items), was designed (see Appendix A). The children’s medical and rehabilitative records were relied upon in order to determine the kind and range of hearing loss.

2.3. Definitions

Age of suspicion (months): the first time the child’s hearing loss is suspected. Age of diagnosis (months): the first time the child’s hearing loss is formally confirmed through hearing test(s). Age of hearing-aid fitting (months): the first time the child receives a hearing aid and begins to use it. Age of intervention (months): the age at which the child begins to receive aural rehabilitation and educational programs. Profound hearing loss/deafness (dB HL): hearing loss equal to or more than 91 dB HL, according to Audiologic criteria [20]. In our study, all the children had profound hearing loss. High-risk children: children with one or more high-risk factors based on the guidelines of the Joint Committee on Infant Hearing Year 2000.

2.4. Ethical considerations

The inclusion criterion for parents was their willingness for participation and submission of informed consent.

2.5. Statistical methods

Significant difference between the studied ages was defined by dependent $t$-test. The studied ages in at-risk and not-at-risk children were compared by means of independent $t$-test. One-way ANOVA test (Post Hoc Multiple Comparisons) helped examine the effect of the families’ economic circumstances on the studied ages. And finally, statistical analysis was performed by SPSS 12.00, and $p < 0.05$ was considered as significant.

3. Results

In our study, the mean age of suspicion of hearing loss was $12.6 ± 8.9$ months (range: 1–36); hearing-loss diagnosis $15.2 ± 9.3$ months (range: 1–36); fitting the hearing amplification device(s) $20.5 ± 11.1$ months (range: 3–56); intervention (commencement of aural rehabilitation programs) $22.3 ± 11.6$ months (range: 3–56) (Graph 1). Based on these results, the average delays between the ages of suspicion and diagnosis: $2.7 (p = .00029)$; diagnosis and amplification: $5.2 (p = .00047)$; amplification and intervention: $1.8$ months ($p = .001$) were yielded. These differences were statistically significant.

Certain factors in the familial or medical history of the child can result in the child’s being at-risk of hearing loss. In our study, 41 (47.7%) children were in the at-risk group. In Table 1, the means of four studied ages are presented for at-risk and not-at-risk children. The statistical test revealed that there were no significant differences between the two groups in the average ages.

Graph 1 Ages of suspicion, diagnosis, amplification, and intervention.
Our questionnaire included diseases that predispose a child to hearing loss; of all these diseases, the percentage of hyperbilirubinemia (Jaundice) was the highest (40.7%: slight, 25.6%; severe, 15.1%). While the treatment of choice in the case of severe hyperbilirubinemia in our children had been fluorescent light (6.0%) and blood exchange (7.2%), 1.9% of our subjects had not received any treatment. There were also four cases (4.7%) of meningitis, six cases (7%) of measles, and one case (1.2%) of mumps. Two (2.3%) mothers reported suffering from rubella during pregnancy; two other (2.3%) mothers had used ototoxic drugs during pregnancy, one of them in the first trimester (Gentamycin) and the other in the last trimester (Kanamycin). The consumption of ototoxic drugs (Gentamycin, range: 8 days to 2 months) during neonatal period was reported in seven cases (8.8%).

Receiving blows to the abdominal region during pregnancy were reported by three (3.5%) mothers. The frequency of pre-term and post-term births was 2.3% (two children) and 9.3% (eight children), respectively. The frequency of delay in breathing or other respiratory difficulties was 17.40% (15 children). The confinement of the child to the NICU or in the incubator (for 2—75 days) was reported in 13 (15.1%) cases. Ten (11.6%) children had been born with a sensory and/or motor disorder, and 9 (10.5%) children had a familial history of congenital sensory-neural hearing loss among their parents (8.1%) or sisters (2.3%). Moreover, four (4.7%) children had been born with weights lower than 1500 g.

Consanguinity was reported among 48 (55.9%) families, including 36 (41.9%) cases of mating of first cousins and 12 (14%) cases of mating of second cousins and farther familial relationships. Parents (74.4%) were the first to suspect their children’s hearing loss, followed by physicians (10.5%), relatives and friends (8.1%), nursery nurse(s) (2.3%), and others (4.7%). After having suspected their children’s hearing loss, the parents in our study had visited physicians (57%), audiologists (37.2%), speech therapists (2.3%), or other specialists (3.5%) for the first time. 74.4% of hearing aids had been provided by private audiology clinics and 25.60% by state-run centers.

Five (5.8%) families lived in favorable economic circumstances, while 59 (68.6%) and 22 (25.6%) families lived in moderate and difficult economic circumstances, respectively. There were significant differences between families in favorable economic circumstances, and those in difficult economic circumstances, respectively. There were significant differences between families in favorable economic circumstances and those in difficult economic circumstances in terms of the mean ages of diagnosis (p = 0.048), amplification (p = 0.007), and intervention (p = 0.006).

### 4. Discussion

Determining the mean of the four studied ages being the objective of the present study, our results, with the exception of the average age of suspicion (Table 2), are close to those of the Prendergast et al. study [4]. The similarity of the population samples of both studies is also deserving of note. Our results, however, show noticeable differences with those reported by Ozcebe et al. [17]. There are also differences between our results and those in a previous study carried out in some major provincial towns in Iran by Lotfi and Jafari [18]. These differences can be explained by the fact that our study, focusing only on children with profound hearing loss, was conducted in Tehran, a metropolis with considerably better educational and socio-economic

### Table 1  The mean ages of suspicion, diagnosis, amplification, and intervention for at-risk and not-at-risk children

<table>
<thead>
<tr>
<th></th>
<th>Suspicion (months)</th>
<th>Diagnosis (months)</th>
<th>Hearing-aid fitting (months)</th>
<th>Intervention (months)</th>
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<tbody>
<tr>
<td>HR children (present study) (n = 41)</td>
<td>12.4 ± 8.1</td>
<td>15 ± 9</td>
<td>20.3 ± 10.1</td>
<td>22.1 ± 11.7</td>
</tr>
<tr>
<td>Not HR children (present study) (n = 45)</td>
<td>12.8 ± 9.9</td>
<td>15.5 ± 9.8</td>
<td>22.9 ± 11.7</td>
<td>23.7 ± 11.2</td>
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<tr>
<td>HR children (18)</td>
<td>19.1 ± 16.2</td>
<td>26.3 ± 17.9</td>
<td>34.8 ± 20.2</td>
<td>44.0 ± 25.1</td>
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<tr>
<td>Not HR children (18)</td>
<td>19.7 ± 14.5</td>
<td>25.5 ± 16.2</td>
<td>34.8 ± 19.8</td>
<td>43.0 ± 24.2</td>
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### Table 2  The mean ages of suspicion, diagnosis, amplification, and intervention in present study and other studies

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<tr>
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<th>Suspicion (months)</th>
<th>Diagnosis (months)</th>
<th>Hearing-aid fitting (months)</th>
<th>Intervention (months)</th>
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<tr>
<td>Present study (2005)</td>
<td>12.6 ± 8.9</td>
<td>15.2 ± 9.3</td>
<td>20.5 ± 11.1</td>
<td>22.3 ± 11.6</td>
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<tr>
<td>Lotfi and Jafari [18]</td>
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<td>Prendergast et al. [4]</td>
<td>8.16</td>
<td>14.58</td>
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<td>Kitteral and Arjmand [7]</td>
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opportunities in comparison with other provincial towns, where the Lotfi and Jafari study was carried out on children with hearing loss ranging from mild to profound. The center where our research was conducted lays particular emphasis upon aural rehabilitation methods. Those referring to this center for the first time receive basic information on hearing loss, its adverse effects on communication skills and other aspects of life, the importance of hearing aid(s), and the importance of prompt initiation of aural rehabilitation programs. This center, as well as providing usual rehabilitation programs, offers weekly educational programs for families with hearing-impaired children.

Our findings revealed that there were no noticeable differences between at-risk and not-at-risk children in terms of ages of suspicion, diagnosis, amplification, and intervention. We should bear in mind that in the Kitteral and Arjmand [7] and Parving [13] studies, at-risk children were identified no earlier than not-at-risk children. Furthermore, in the Harrison and Roush [9] study, children with known risk factors who had severe to profound hearing loss were also identified no earlier than children with the same range of hearing loss and with no known risk factors.

In our study, the familial history of permanent childhood sensory-neural hearing loss was 10.46%, which is close to the result of the Lotfi and Jafari study [18] (11.1%) but is lower than that of the Das study [19] (23%). If familial history of permanent childhood sensory-neural hearing loss is considered as a cause of genetic hearing loss, then genetic factors can be said to have played a major role in the etiology of 10.5% of the hearing losses in our study. Nonetheless, medical staff’s inattentiveness to high-risk factors at childbirth and during postnatal period and the parents’ inadequate information are also to blame for profound hearing loss in our subjects.

Hyperbilirubinemia, which occurs when there is an excess amount of bilirubin in the blood, manifests itself in a high percentage of normal, full-term babies. In the present study, a high percentage of cases (40.7%) had neonatal hyperbilirubinemia, 15.1% of them being severe. In the Lotfi and Jafari [18] study, 29.2% of the children had severe hyperbilirubinemia at birth. It can only be concluded that this factor, like other high-risk factors, requires constant vigilance on the part of medical staff and parents during the first days of a child’s life.

Consanguinity, responsible for various handicaps in offspring, was reported in more than half of the parents (55.9%) in our study. It seems that there is still much to be done in order to raise public awareness of the risks involved in familial marriage.

The parents (74.4%) in our study were the first to suspect their children’s hearing loss, and then there were first-time visits to the physician (57%). Similarly, in the Lotfi and Jafari [18] study, it was mainly the parents who visited a physician for the first time (83.3%) after suspecting their children’s hearing loss (80.2%). This result shows the importance of early identification of hearing loss and intervention in children. In our study, the percentage of parental suspicion was rather higher than that reported in the Watkin et al. [12] and Parving [13,14] studies. Another important point of which parents and physicians must be aware is the consumption of ototoxic drugs in the neonatal period (present study: 8.8%; Lotfi and Jafari study: 6.0%) and pregnancy period (present study: 3.6%; Lotfi and Jafari study: 2.4%).

The fact that most of the families in our study lived in moderate economic circumstances (68.6%) had a direct bearing on the studied ages; there were considerable differences between families in favorable and difficult economic circumstances in terms of the ages of diagnosis, amplification, and intervention.

5. Conclusion

Although the findings of our study in terms of the average ages of suspicion, diagnosis, amplification, and intervention were more promising than the results of a prior study in Iran [18] for reasons having been discussed earlier, there is still a remarkable gap with the average ages announced by the Joint Committee on Infant Hearing. Studies conducted thus far emphasize the fact that the early detection of hearing loss and intervention (EDHI) and heightening public awareness of high-risk factors are the most efficient ways to decrease these mean ages.

Appendix A

Questionnaire

Hearing-loss history
1. Who suspected the child’s hearing loss for the first time? (parent, physician, nursery nurses, relatives and friends, others)
2. How many months old was the child at the time? (age of suspicion)
3. After suspecting hearing loss, to which kind of specialist did parents refer for the first time? (audiologist, physician, speech therapist, others)
4. How many months old was the child when undergoing the first hearing test? (age of diagnosis)
5. How many months old was the child when having the hearing aid fitted? (age of hearing-aid fitting)
6. How many months old was the child when aural rehabilitation services commenced? (age of intervention)

Medical history
7. Which disease(s) did the child contract when below 2 years of age? (Rubella, Measles, Mumps, Jaundice, Meningitis, others)
8. Is there a history of the child’s being treated with ototoxic drugs for a long time? (please mention drug type, its amount, and duration of consumption)
9. Which disease(s) did the mother contract during pregnancy? (Toxoplasmosis, Rubella, Cytomegalovirus, Herpes, Syphilis, others)
10. Did the mother take ototoxic drugs during pregnancy? (please mention drug type, its amount, and duration of consumption)
11. Did the mother receive a blow to her abdomen during pregnancy? (Please describe it and mention the time of occurrence)
12. Type of childbirth: normal, pre-term, post-term.
13. Did the child experience delays in breathing or other breathing difficulties during childbirth?
14. Was the child confined to the NICU or in the incubator? (please mention its duration)
15. Child’s weight at childbirth: ...
16. Did the child experience hyperbilirubinemia after birth? (please mention its severity and recommended and/or conducted efforts)
17. Is/are there any person(s) with hearing loss among family members?
18. Apart from hearing loss, does the child have other diseases or disorders?

References