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# Factors Affecting Age of Diagnosis and Rehabilitation Intervention in Children Receiving Cochlear Implant

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## Abstract

**Background and Objective:** Age of cochlear implantation (CI) is an important factor for restoring normal auditory processing and different language skills so that early diagnosis of hearing loss significantly influences the rate of developmental skills in these children. The present study aimed to investigate different factors affecting the age of hearing loss diagnosis and CI in children with hearing loss.

**Methods:** This was a descriptive cross-sectional trial conducted on the children with hearing loss that underwent CI (n=252) in the Khuzestan Cochlear Implant center, Ahvaz, Iran during 2012 to 2015. The demographic data of children and parents, age of diagnosis, application of hearing aid, and rehabilitation therapy were collected through a questionnaire during the regular visits of the patients. The data were analyzed using statistical package SPSS (Windows, version 18).The normality of data and homogeneity of variances were evaluated through Kolmogorov-Smirnov and Leven tests, respectively. Then, T-test was used to evaluate the statistically significance of the difference and Pearson correlation coefficient to determine the relationship between the quantitative variables.

**Results:** The mean age of diagnosis was 10.7 months (range 0.1 to 60 months). Of 252 patients, 131 (52%) were male and 121 (48%) were female ($p=0.98$) and 123 patients (50.2%) had a positive family history of hearing loss or deafness ($p<0.0001$). In addition, 17 patients (6.9%) had a favorable economic status, while 96 (38.9%) had a moderate and 134 (53.2%) a low economic status. Interestingly, 78.8% of the deaf children were from parents of consanguineous marriages, and 12.2% from non-consanguineous unions. Of the six studied variables, only family history and family relationship variables showed significant relationship with age of diagnosis of hearing loss.

**Conclusion:** Providing comprehensive basic information and increased awareness may help all parents, even those with low socioeconomic status and educational level, to detect hearing loss in their newborns as early as possible. This approach could prevent the consequent adverse effects of hearing loss on psychological, social, and social dimensions as well as on educational achievement in childhood.

**Keywords:** cochlear implantation, age of diagnosis, family history, economic status.

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## INTRODUCTION

Congenital sensorineural hearing loss is a significant childhood condition with incidence rate of 1-3 per 1000 live birth[1,2]. It has been reported that hearing loss during the first three years of life induces an acutely inhibitory impact on the development of language acquisition skills of children which in turn leads to adverse effects on their psychological, social, educational dimensions as well as academic achievement[3-5]. Therefore, reducing the harmful effects of hearing loss on language and speech abilities, especially during the first three years of life, is of particular importance[5,6].

Children with severe to profound hearing loss manifest a delay in expressive and receptive language skills compared with the age-matched normal-hearing counterparts. These children receive no significant benefit of auditory access from conventional hearing aids so that they need an alternative approach and CI is an efficient treatment option[7]. However, when they receive a CI device they can begin developing near-normal rates of language growth and educating in regular education school settings alongside their hearing peers[7-10]. Normal auditory processing of signals is a pivotal stage in producing intelligible speech and other language skills. Previous studies showed that age of CI is an important factor for restoring normal auditory processing of speech signals. Considering the close relationship between the auditory processing and different language skills, early diagnosis of hearing loss and thus age of CI is pivotal in improvement of auditory and speech performance.

Recent evidence on the efficacy of CIs in children demonstrated that the improvements occur over time in speech perception, speech production, language, and reading skills. McKinny showed that CI below 12 months of age was safe and effective procedure[8]. Speech rehabilitation therapy showed better speech and language advantages. In addition, children that implanted earlier showed normal auditory skills as early as 3 months post CI activation. Ching et al. found that Children whose amplification started at age two years had poorer language skill than those whose amplification started at 3 months[9]. In addition, children who received CIs at 24 months had poorer language skills than those received the CIs at 6 months. Moreover, Vlastarakos et al. suggested that children receiving CI before the age of 1 experienced a faster rate of growth in language skills compared to those between the ages of 1 and 2, which is comparable to those of children with normal hearing[10].

CI can also dramatically improve communication skills and quality of life in children with congenital deafness and enables them to be educated in regular education school settings alongside their hearing peers[11-14]. There is now a strong tendency to undergo CI at very young ages, because they are the critical periods in childhood learning[15]. Delayed identification of severe/profound childhood hearing loss leads to the loss of critical periods for language learning; this, in turn, restricts educational achievement and reduces the child's occupational and social opportunities as well as causes discomfort and concern for the family with hearing loss children[16].

Hearing aid technology has improved tremendously in recent years. This provided appropriate conditions for identifying, referring and early diagnosis of hearing loss through the implementation of neonatal hearing screening programs throughout the world. This, in turn, can provide the best opportunities for implementing early hearing detection and intervention and reduce the age of CI for children with severe to profound hearing loss. The gap between chronological age (CA) and developmental age (DA) minimizes with decreasing CI age. Studies have shown that children with early CI have the chance to develop the language skills similarly to their normal hearing (NH) peers. Therefore, the age of CI plays an effective role in hearing performance and development of speech perception and production in children with loss hearing.

Given the importance of early diagnosis of hearing loss in the rate of development skills in children with loss hearing, the present study aimed to investigate various factors affecting the age of diagnosis and CI among the children with severe to profound hearing loss in a CI center in southwest of Iran.

## METHODOLOGY

### Participants

Between March 2012 and July 2016, of 438 patients who underwent CI in the Department of Otorhinolaryngology, 252 children were enrolled in the study. They were identified during newborn hearing screening program in Southwestern of Iran[17]. The inclusion criteria for the studied children were as follow:

- Prelingual severe to profound sensorineural hearing loss
- Normal imaging of temporal bone
- Complete insertion of electrode into the cochlea
- No postoperative adverse events
- Regular attendance at pre- and post-operative rehabilitation sessions

For this study, necessary information including demographic data of children and parents, age of diagnosis, application of hearing aid and rehabilitation were collected through a questionnaire. All files with missing or incomplete data were excluded.

The experimental procedures of the present study including interventions, data collections, and clinical assessments were performed in the Khuzestan Cochlear Implant Center, which is affiliated to Ahvaz Jundishapur

University of Medical Sciences (AJUMS), Ahvaz, Iran. The protocols and all experimental procedures of the study were approved by the local ethics committee of AJUMS, Ahvaz, Iran (registration code: IR.AJUMS.REC.1395.652), which were in complete agreement with the ethical regulations of human studies.

### Data analysis

The collected data were analyzed with the statistical package of SPSS (Windows, version 21). Numerical data were presented as means ± standard deviations (SD) and categorical data were reported as number (percentage). The "normality" and "homogeneity of variances" of quantitative variables were analyzed using Kolmogorov-Smirnov and Leven tests, respectively. To compare the results between groups, we used Independent sample t-test for parametric results and Mann-Whitney-test for non-parametric variables. Results were considered significant at $p \leq 0.05$ level.

## RESULTS

The mean age of diagnosis was 10.7 months (range, 0.1 ± 60 months). Of these patients, 131 (52%) were male and 121 (48%) were female (p=0.98). In addition, 204 patients (81.3%) lived in the city and 47 (18.7%) in the village. 123 patients (50.2%) had a positive family history of hearing loss or deafness (p<0.0001). Seventeen patients (6.9%) had a favorable economic status, while 96 (38.9%) had a moderate and 134 (53.2%) had a low economic status (p=0.355). Twenty-six (10.4%) of mothers had academic education and 224 (89.6%) had no academic education (p=0.781) (Table 1).

Thirty-seven (15.2%) of fathers did not have academic education and 207 (84.8%) had academic education (p=0.3). Further, 197 (78.8%) of children were from parents of consanguineous marriages, and 53 (12.2%) from non-consanguineous unions. Of the six studied variables, only two variables, namely family history and family relationship, were statistically significant (Table 2).

## DISCUSSION

Surprisingly the results of our study showed that the age of diagnosis of congenital hearing loss was not significant compared to the economic status and educational level of parents. This finding is not consistent with the findings of the study by Ozcebe et al. suggesting that the poor economic status of the families and low educational level of parents are among the factors affecting the late detection and intervention of children with hearing loss[18]. In addition, in another study, Jeddi et al. investigated the impact of families' educational level and economic status

**Table 1.** Patient's characteristics.

| Characteristics | |
|---|---|
| **Age (months)** | 10.70 ± 8.87 |
| **Sex No. (%)** | |
| Male | 131 (52.0%) |
| Female | 121 (48.0%) |
| **Residential status number (%)** | |
| Rural | 47 (18.7%) |
| Urban | 204 (81.3%) |
| **Family history number (%)** | |
| Negative | 122 (49.8%) |
| Positive | 123 (50.2%) |
| **Economic status number (%)** | |
| Weak | 134 (54.3%) |
| Intermediate | 96 (38.9%) |
| Good | 17 (6.9%) |
| **Father's education number (%)** | |
| Illiterate | 14 (5.6%) |
| Primary School | 66 (26.4%) |
| Guidance School | 49 (19.6%) |
| High School | 95 (38.0%) |
| Academic degree | 26 (10.4%) |
| **Mother's education number (%)** | |
| Illiterate | 12 (4.9%) |
| Primary School | 39 (16.0%) |
| Guidance School | 79 (32.4%) |
| High School | 77 (31.6%) |
| Academic degree | 37 (15.2%) |
| **Consanguineous marriage number (%)** | |
| Negative | 53 (21.2%) |
| Positive | 197 (78.8%) |

*The values are expressed as Mean ± SD.

**Table 2.** Effective factors in age of diagnosis.

| Variables | Age Month* | P-value |
|---|---|---|
| **Sex** | | |
| Male | 10.80 ± 10.82 | 0.987* |
| Female | 10.60 ± 10.97 | |
| **Residential Status** | | |
| Rural | 10.70 ± 8.69 | 0.503* |
| Urban | 10.70 ± 11.37 | |
| **Family History** | | |
| Negative | 13.29 ± 10.93 | <0.0001* |
| Positive | 8.31 ± 10.38 | |
| **Economic Status** | | |
| Weak | 12.15 ± 12.84 | |
| Intermediate | 8.93 ± 7.35 | 0.355** |
| Good | 9.89 ± 10.05 | |
| **Father's Education** | | |
| Illiterate | 18.04 ± 19.35 | |
| Primary School | 9.95 ± 9.07 | |
| Guidance School | 11.03 ± 12.79 | 0.781** |
| High School | 10.02 ± 9.26 | |
| Academic degree | 10.76 ± 9.76 | |
| **Mother's Education** | | |
| Illiterate | 18.37 ± 21.44 | |
| Primary School | 12.36 ± 11.07 | |
| Guidance School | 9.82 ± 8.26 | 0.300** |
| High School | 10.18 ± 8.26 | |
| Academic degree | 8.13 ± 8.94 | |
| **Consanguineous marriage** | | |
| Negative | 13.76 ± 12.00 | 0.006* |
| Positive | 9.84 ± 10.43 | |

*The P-values are based on the Mann-Whitney test. **The P-values are based on the Kruskal Wallis test.

on the age of CI in children[19,20]. They analyzed the data of the hearing impaired children (n=96) who underwent CI operation at Amir Alam Cochlear Implant Center in Tehran during 2008 to 2010. Their findings showed that, the age of CI significantly decreased with increasing the educational level of the parents, and a statistically significant difference was observed between the family's economic status and the age of CI. Furthermore, Jafari et al. found that household economic status had a significant effect on the mean age of diagnosis, prescription, adjustment of hearing aid and intervention[21].

Our findings showed that parents with a low educational level did not have a significant effect on the late detection of hearing loss by their parents. That is, parents with low educational level were able to detect hearing loss in their newborns as early as possible, like those with high educational levels. Moreover, no statistically significant difference was observed between the parents with low socioeconomic status and those with high socioeconomic status regarding the early diagnosis of newborn's hearing loss. A possible explanation for these results may be the adequate and comprehensive information as well as increased awareness of people, even with low educational level and socioeconomic status, towards the early diagnosis of newborns' hearing loss in our study population.

Another important finding was that the age variable had a significant positive effect on early detection of infants' hearing loss compared with family history. In this regard, the results of the study by Das on children with hearing loss in Manchester during 10-year period showed that of a total of 339 cases studied, 23% had a positive family history of deafness in parents or siblings or both[22]. Therefore, sensorineural hearing loss associated with family history was identified as one of the main risk factors for permanent hearing impairment in children[23]. These results are congruent with our finding suggesting that due to adequate knowledge and increased awareness level regarding deafness in the infant, parents with a history of positive deafness were able to identify deafness in their children as early as possible. We also found that the positive family history of deafness has a major role in the early identification of hearing loss suggesting the inherited factors that contribute to deafness and hearing loss in children. The latter finding can partly explain the high prevalence of hearing loss in Khuzestan province due to consanguineous marriage.

## CONCLUSION

The findings of this study showed that providing comprehensive basic information and increased awareness may help all parents, even those with low socioeconomic status and educational level, to detect hearing loss in their newborns as early as possible and prevent its adverse effects on psychological, social, and social dimensions as well as educational achievement.


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