The Impact of Ethnicity on Cochlear Implantation in Norwegian Children

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Abstract

Objectives: To explore the impact of parental ethnicity on cochlear implantation in children in Norway with regard to incidence rates of cochlear implants (CIs), comorbidities, age at onset of profound deafness (AOD), age at first implantation, uni- or bilateral CI, and speech recognition. **Method:** This retrospective cohort study included all children ($N = 278$) aged <18 years in Norway who received their first CI during the years 2004-2010. **Results:** 86 children (30.9%) in our study sample had parents of non-Nordic ethnicity, of whom 46 were born in Nordic countries with two non-Nordic parents. Compared with the background population, children with non-Nordic parents were 1.9 times more likely to have received CI than Nordic children (i.e., born in Nordic countries with Nordic parents). When looking at AOD, uni- vs. bilateral CIs, and comorbidities, no significant differences were found between Nordic children and children with a non-Nordic ethnicity. Among children with AOD <1 year ($n = 153$), those born in non-Nordic countries with two non-Nordic parents ($n = 6$) and adopted non-Nordic children ($n = 6$) received their first CI on average 14.9 and 21.1 months later than Nordic children ($n = 104$), respectively ($p = .006$ and $.005$). Among children with AOD <1 year, those born in Nordic countries with two non-Nordic parents ($n = 31$) received their CI at an older age than Nordic children, but this difference was not significant after adjusting for calendar year of implantation and excluding comorbidity as a potential cause of delayed implantation. The mean age at implantation for children with AOD <1 year dropped 2.3 months/year over the study period. The mean monosyllable speech recognition score was 84.7% for Nordic children and 76.3% for children born in Norway with two non-Nordic parents ($p = .002$). **Conclusions:** The incidence of CI was significantly higher in children with a non-Nordic vs. a Nordic ethnicity, reflecting a higher incidence of profound deafness. Children born in Norway have equal access to CIs regardless of their ethnicity, but despite being born and receiving care in Norway, prelingually deaf children with non-Nordic parents

are at risk of receiving CI later than Nordic children. Moreover, prelingually deaf children who arrive in Norway at an older age may be at risk for a worse prognosis after receiving a CI due to lack of auditory stimulation in early childhood, which is critical for language development and late implantation; this is a serious issue with regard to deafness among refugees.

Keywords: cochlear implant; children; deafness; ethnicity; minorities

The Impact of Ethnicity on Cochlear Implantation in Norwegian Children

1. Introduction

The knowledge about hearing-disabled children with a multiethnic background is limited. In Norway, as in many Western countries, the number of refugees immigrating to the country is increasing, and there is growing pressure on authorities to meet the health care needs of these populations. This includes identification of deafness, modes of communication, and adequate rehabilitation. In the absence of a national registry for children with severe to profound deafness, data on pediatric cochlear implants (CIs) may provide useful information about the present situation of deaf children and what to focus on in the future.

All children with a CI in Norway are implanted and followed up at the same center.

Approximately 95% of profoundly deaf children in Norway receive a CI. Others do not due to factors such as severe comorbidity, anatomical reasons, or parents who decline a CI for their child. According to the World Health Organization [1], profound deafness is defined as hearing thresholds >80 dB HL in the better ear. A child with profound sensorineural hearing loss is a candidate for bilateral CIs in Norway, following early detection and a hearing aid trial. Typically, children identified in the newborn screening program for deafness who show no progress in auditory skills or speech/language development with the use of hearing aid receive bilateral CIs in a simultaneous implantation procedure, preferably before 1 year of age.

The situation for children with non-Nordic ethnicity may be different, due to cultural factors, late detection of deafness, and different or non-existent rehabilitation strategies in their country of origin. In a review, Belzner and Seal [2] stated that the few studies that exist on deaf children with multiethnic backgrounds tend to include small populations, and they stressed the need for research on the incidence of CIs that includes minorities. Stern et al. [3]

found that in the US, white and Asian children were implanted more often than Hispanic and African-American children. Furthermore, white and Asian children received CIs more often than would be expected based on the prevalence of severe to profound sensorineural hearing loss, and low socioeconomic status was correlated with a lower implantation rate. In a later study from the US, Wiley and Meinzen-Derr [4] could not verify a direct impact of ethnicity on implantation rate, but they found a higher incidence of deafness in ethnic minority groups and in populations with low socioeconomic status. In a US study by Armstrong et al. [5], no differences were found in ethnicity, age at implantation, or time between evaluation and implantation. To the best of our knowledge, no similar studies on ethnicity in children with CI in the Nordic or other European countries have been published.

Worldwide there is variability in the extent to which CIs are provided to children from multiethnic backgrounds. Given the current influx of refugees in Norway [6], the situation of deaf children with a non-Nordic background in the country needs to be better understood.

The aim of the present study was to explore the impact of parental ethnicity on cochlear implantation in children in Norway. The study focused on (1) the incidence rates of CIs in the pediatric population, (2) comorbidities, (3) age at onset of profound deafness (AOD) and age at first implantation, (4) unilateral or bilateral CIs, and (5) speech recognition.

2. Material and methods

2.1. Design and population

All children <18 years who received their first CI during the years 2004–2010 in Norway were included ($N = 278$). Indications for a CI over the period were 1) the combination of little or no response to sounds and delayed or absent progress in spoken language skills with hearing aids, and 2) either a) sensorineural hearing loss with thresholds >75 dB HL in the better ear for children <1 year and >70 dB for older children, or b) rapidly progressive sensorineural hearing loss in the better ear when the worst ear met threshold criteria under a),

or c) auditory neuropathy spectrum disorder (ANSO) with severely delayed language development and no benefit from hearing aids.

2.2. Data collection

Data was retrieved from the CI database of the National Pediatric CI team and from patients' records. We chose to begin the study period on the 1st of January 2004, as simultaneous bilateral implantation in children was introduced as a preferred treatment that year. The study period ended on the 31st of December 2014, with a minimum of 4 years of follow-up after implantation for each child. Background data on the pediatric population during the study period were retrieved from Statistics Norway, which has overall responsibility for official statistics in Norway [7].

2.3. Variables

2.3.1. Ethnicity

Children were categorized according to the ethnic background definition of Statistics Norway, i.e., Nordic children are at least second generation born in a Nordic country (Norway, Sweden, Denmark, Finland, or Iceland). Nordic children in these countries are considered culturally homogenous, and health care systems differ very little with regard to detection and rehabilitation of deafness. For the present analysis, children were grouped as Nordic or non-Nordic. Non-Nordic children were subcategorized into: 1) those with two non-Nordic parents and born in Nordic countries, 2) two non-Nordic parents and born in non-Nordic countries, 3) one non-Nordic parent regardless of birthplace, or 4) adopted.

2.3.2. Comorbidity

Comorbidity was defined as any known medical condition or disorder except for uncomplicated conditions with spontaneous recovery. Cognitive, developmental, or learning (CDL) disabilities that may have compromised either the benefit or the practical use of CI were considered. Comorbidity may delay the diagnosis of deafness and/or implantation

because of other procedures or interventions, e.g. heart surgery. In order to avoid interaction with ethnicity as a cause of delayed implantation, a separate variable was defined, *comorbidity as a potential cause of delay*, which refers to comorbidity that could theoretically have delayed implantation (but did not necessarily do so).

2.3.3 Age at onset of profound deafness

AOD was defined as the age at which severe to profound deafness became obvious based on combined information gained from history, audiological testing (otoacoustic emissions, auditory brain stem response, and, depending on age and cooperation, distraction testing, visual reinforced audiometry, play audiometry, and pure tone audiometry), evaluation of language development, and results from a hearing aid trial. Defining an exact AOD is difficult since testing is usually done repeatedly, and the diagnosis may be set much later than the onset of deafness. Neither is it possible to define the exact date of onset in case of progressing hearing loss or ANSD. It was therefore considered more appropriate to categorize AOD into <1 year, between 1-2 years, between 2-3 years, and ≥ 3 years. A separate group (partial hearing) included children who had partial hearing, ANSD, and/or some language development before receiving a CI, and who may have benefitted from a hearing aid trial prior to receiving CI. This group also included rapidly progressing but not yet profound hearing loss.

2.3.4. Speech recognition

Open speech recognition of Norwegian monosyllables (phonetically balanced word lists according to Haskins 1949 and Øygarden 2009) was registered as scores (%) of correctly repeated words out of a list of 25 or 50 words. Test results closest to 4 years, within a period 40-80 months after the first CI were analyzed. Only results from children able to perform recognition of open speech were included in the analysis.

2.4. Analysis

Data were analyzed using SPSS[®] version 21. Depending on distributions, parametric (t test) or nonparametric tests (Welch test, Mann-Whitney U test) were used for continuous data. Categorical and ordinal data were analyzed by Pearson's chi square test (χ^2), likelihood ratio, or Fischer's exact test, depending on group sizes. P-values $>.05$ were considered non-significant (n.s.). Confidence interval is shortened to CI when within brackets, not to be confused with CI (cochlear implants) in the text.

2.5 Privacy protection statement

The CI registry has been approved by the local Ethical Committee (2011/20654), which stated that the present analysis did not require their further approval. Data collection and publication were approved by the hospital's Privacy and Data Protection Officer (2011/7381).

3. Results

3.1. Ethnicity and incidence of CI

Table 1 shows the characteristics of all 278 children in our study sample. The five most common countries of parental origin for non-Nordic children were Pakistan (20), Russia (7), Somalia (5), Iraq (4), and Afghanistan (4). There was a significant association between ethnicity (Nordic or non-Nordic) and incidence of CI ($\chi^2 (1) = 24.46, p < .001$). The odds ratio for having a CI were 1.9 (95% CI 1.5-2.4) times higher among non-Nordic children compared with Nordic children, i.e., ethnicity explained 46.8% of the total incidence of CI in the non-Nordic children. In particular, children with Pakistani background were significantly overrepresented, comprising 7.2% of our study sample, but only .09% of the pediatric Norwegian pediatric population.

3.2. Comorbidity

One hundred seventeen children (42.1%) had some comorbidity. CDL was diagnosed or suspected in 21.9% of the study sample (Table 1), but it was more abundant in children with

AOD <1 year than ≥ 1 year (30.7% and 11.2%, respectively ($p < .01$)). Comorbidity as a potential cause of delayed CI was recorded in 27.3% of the study sample. All three investigated categories of comorbidity were as common in Nordic as in non-Nordic children, regardless of their place of birth.

3.3. Age of onset of profound deafness and at age at implantation

The majority of children had an AOD <1 year ($n = 153$). Their characteristics are shown in Table 2. Among these children, the main subgroups included Nordic children ($n = 104$) and children born in Nordic countries with two non-Nordic parents ($n = 31$). Age at implantation varied widely in all AOD groups, especially among those with AOD >3 years and the partial deafness group ($n = 56$) (Fig. 1). Among children with AOD <1 year, 26 received a CI before 12 months of age; three of whom (12%) were of non-Nordic and 23 (88%) of whom were of Nordic ethnicity. The difference in proportions was not significant. Age at implantation was higher in children with non-Nordic parents compared with Nordic children, with great variation observed within and between non-Nordic subgroups (Table 3). A linear regression analysis indicated a decrease of 2.3 months per year in the age at implantation during 2004-2010 ($R^2 = .108$, 95% CI 0.8-3.8, $p = .003$) among children with AOD <1 year and without comorbidity as a potential cause of delayed implantation. The variation in age at implantation in this subset was more pronounced in 2004-2006 compared with 2006-2010 (Figure 2). When further explored in a multivariate regression model adjusted for year of implantation, a mean difference of 7.0 months was found between children with Nordic and non-Nordic parents, but the results were of borderline significance (95% CI 0.2-14.1, $p = .056$). The t test showed a delay of 4.8 months among non-Nordic children when compared with Nordic children, and this value decreased to 1.9 months when children with comorbidity as a potential cause of delay were included, although both results were n.s. The longest delay

between AOD and implantation was found in children born in non-Nordic countries with non-Nordic parents.

Children with AOD between 1-2 years ($n = 24$) showed a similar pattern of age at implantation as those with AOD <1 year. Children born in non-Nordic countries with non-Nordic parents were implanted significantly later (Table 4). For children with a higher AOD, age at implantation showed great variation for children of both Nordic and non-Nordic ethnicities (Fig. 1).

The partial deafness group ($n = 56$) was heterogeneous with regard to AOD as well as type of deafness. Progressive deafness, partial high frequency deafness, and ANSD were represented. The mean age at implantation for non-Nordic ($n = 16$) and Nordic ($n = 40$) children was 96.5 months and 79.0 months, respectively. The mean age at implantation for adopted non-Nordic children ($n = 6$) was 56.7 months.

3.4. Speech recognition

Monosyllable speech recognition scores were available for 189 children (Table 5). Table 6 shows reasons for missing results. Children with two non-Nordic parents scored significantly lower than Nordic children, particularly if they were born in non-Nordic countries. The median score for AOD <1 year was 84% (mean 80.1%, SD 16.1%), and no significant difference related to ethnicity was found.

3.5. Unilateral or bilateral CIs

Two hundred and thirteen children (76.6%) had bilateral CIs. Children with two non-Nordic parents had bilateral CIs in 89%. The rate of bilateral CIs was stable throughout the study period. There were no significant differences with regard to ethnicity, AOD group, CDL disabilities, or comorbidity as a potential cause of delay. Children with AOD <1 year with unilateral CI were on average 24.9 months older at implantation than those with bilateral CIs

($p = .001$). Late implantation with little benefit was the most common reason for a second CI not being offered.

3.6. *Non-users of the CI*

Sixteen children did not use their CIs at all. Seven were of non-Nordic and 9 were of Nordic ethnicity. Nine had CDL disabilities. The average age at implantation for non-users with AOD <1 year was 43.6 months (SD 33.7 months), and age at implantation did not correlate with ethnicity or comorbidity.

4. Discussion

The primary aim of this study was to assess whether children in Norway have equal access to CI regardless of parental ethnicity (non-Nordic vs. Nordic), and whether age at implantation is different in the two groups. This was achieved by summarizing data on all children living in Norway and who received a CI between 2004 and 2010. The two main categories we explored were prelingually deaf children, here used synonymously with AOD <1 year, and those with later AOD or partial deafness. Definitions of prelingual deafness vary, but over the past decade the threshold has been dropping from 4 years [8], to 3 years [9, 10], to 1 year. Perilingual deafness defines an intermediate group [11]. Therefore our categorization into AOD groups allows for comparisons with studies where prelingual deafness is defined differently. Prelingually deaf children constituted the largest and most homogenous group with regard to ethnicity and AOD. Our older AOD groups had a more heterogeneous history of deafness, exposure to spoken or sign language, and ethnicity.

Prelingual profound deafness was mainly focused on because early implantation is crucial for optimal development of spoken language [12-15]. With regard to delayed implantation, postlingually deaf children are less vulnerable when it comes to maintaining a functional spoken language.

4.1. Incidence rate of cochlear implant versus ethnicity

Children with a non-Nordic ethnicity and CIs were overrepresented compared with Nordic children, with an odds ratio of 1.9 for having a CI compared with Nordic children. This indicates a higher incidence of profound prelingual deafness in children with non-Nordic ethnicity in Norway. There was a significant dominance of children with parents of Asian origin, particularly Pakistani (23.3% of the non-Nordic children and 7.2% of the study population). The dominating and most homogenous non-Nordic subgroup was children born in Nordic countries with two non-Nordic parents. They were followed up in the Norwegian health care system in the same manner as all other Norwegian children. This allowed for comparisons without confounding factors related to previous and/or unknown circumstances in the country of origin before arriving in Norway. The most plausible explanation of the high representation of deafness is consanguinity of parents with reinforced recessive heredity. Other studies have shown differences in genes coding for deafness in certain ethnic minorities [16-20]. Alternative explanations could be infections, prematurity, and neonatal complications [21], but this is less likely in view of the evenly distributed comorbidity in the present study. The high representation of non-Nordic children with CI in Norway differs from previous findings that ethnic minorities such as African-American children in the US were less likely to receive CI than white children [3]. Our findings are similar to those reported in more recent studies from the US, in which no direct impact of ethnicity was found on implantation rate, but socioeconomic status was an important factor for access to CI [4, 5]. We did not find any studies on the ethnicity of deaf children with CI in Europe. The Norwegian health care system includes free screening of all newborns for deafness, which should guarantee access to CI irrespective of socioeconomic status. We conclude that for deaf children in Norway, access to CI does not depend on ethnicity. This is supported by the finding of similar rates of bilateral CIs, on average 77%, which are even higher than the average in children with two parents of

non-Nordic background (89%). Notably, CDL disabilities did not affect the rate of bilateral CIs.

4.2. Age at implantation versus ethnicity

Children with non-Nordic ethnicity were implanted later than Nordic children. Among children born in Norway with AOD and age at implantation <1 year, very few had non-Nordic ethnicity, although they were born and followed in the Norwegian health care system. Several analyses also indicated a possible >2-month delay in implantation in prelingually deaf non-Nordic children. A regression analysis revealed a close to significant delay of 7 months in children with non-Nordic ethnicity when comorbidity as a potential cause of delay was excluded. Interestingly, this delay was shorter when children with comorbidities were included, suggesting that comorbidity believed to cause delay may in fact have contributed to earlier diagnosis and implantation.

The design of our study does not allow us to elucidate the reasons for delayed implantation in the prelingually deaf group. However, the experience of the CI team is that evaluation and implantation are delayed in several cases due to long visits to the country of origin, sometimes combined with a second opinion there. Other explanations may be cultural differences in accepting or treating disabilities [5, 22], different compliance to health care follow-up, and suboptimal communication modalities in hospitals and health care centers. There is clearly a need for further investigation of this finding, including a delay between conclusive auditory brain stem response, decision of CI, and implantation.

Children born in non-Nordic countries were considerably older than Nordic children at implantation in AOD categories <1 year and 1-2 years (Tables 3 and 4). These children were older when they arrived in Norway, and the diagnosis and habilitation of deafness was late or absent, resulting in a reduced or uncertain prognosis for the benefit of CI. Another worrying factor was that implantation was delayed in some cases because families waited a long time to

1 obtain permanent residency status. This is a critical issue that demands special attention, as
2 there are deaf children among the currently increasing population of refugees with urgent
3 needs, and who often have no experience with hearing aids and no early access to spoken
4 language.
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7 The group with partial deafness was heterogeneous, and conclusions about ethnicity and
8 delayed implantation could not be drawn for different reasons. First, profound deafness may
9 have been present much earlier than it was diagnosed in some of these children, while in
10 others hearing decreased gradually. If not closely followed up, both situations may have
11 resulted in late implantation [23]. Furthermore, a delay may be desirable in cases where
12 prolonged observation time is required before a decision about implantation is made, e.g. in
13 ANSD.
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15 The mean age at implantation decreased by 2.3 months per year over the study period for
16 children born in Norway with AOD <1 year. This may partly be attributed to the introduction
17 of the screening of newborns for deafness in 2008, and to indications for CI gradually
18 becoming more liberal regarding degree of hearing loss and age. The further development of
19 age at implantation after 2010 will be explored in a separate study.
20

21 *4.3. Speech recognition*

22 Speech recognition tests were standardized and mainly performed in Norwegian.
23 Nevertheless, children born in Nordic countries with non-Nordic parents, who may use
24 another language at home, still scored 76.3% in monosyllable tests. Compared with 84.7% in
25 children with Nordic background, this is considered a good result, and test scores might not
26 have differed had tests been performed in the non-Nordic children's native language. Children
27 born in non-Nordic countries had the lowest scores, 66.9%. The plausible explanations are
28 that they were older at implantation, and they had been less exposed to spoken language early
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in life because of late or absent diagnosis and rehabilitation. Furthermore, socioeconomic conditions may play a critical role in speech development [5].

4.4. Strengths and limitations

The fact that all children in Norway have been implanted in one center since the beginning of the CI era ensures large study populations and allows for longitudinal studies focusing on trends over time. The present study involves all Norwegian children who received their first CI during the period studied, including non-users. This should minimize biases such as the exclusion of children with comorbidities, CDL, or non-Nordic native languages, which could lead to better results. Ethnicity was the main focus in this study, and there is no risk of selection bias in speech perception test results. However, we are aware that the lack of language-appropriate testing may have resulted in lower scores in children with non-Nordic ethnicity, as concluded by other authors [22]. Therefore, speech recognition results should be interpreted with caution as a rough indicator of potential major differences – which were not found in this study sample.

This study is retrospective and based on data from the CI registry and patient's records, and it has the innate disadvantages of such a design. In the absence of a national registry on deaf children, the number of deaf children who, for different reasons, do not have CI is not exactly known, but is estimated at ~5% based on the number of pupils in schools for deaf, and the number of deaf children to whom CI was not offered, or not accepted by the parents.

5. CONCLUSIONS

In Norway, children with non-Nordic ethnicity are nearly twice as likely to receive a CI compared with Norwegian children, indicating a higher incidence of profound deafness. The mean age at implantation decreased over the study period both for non-Nordic and Nordic children. Given the same age at onset of profound deafness, children with non-Nordic

background were implanted later compared with their Nordic peers. The difference was most pronounced for children born in non-Nordic countries, a finding which underlines the current challenge with regard to the rehabilitation of deaf refugee children. In spite of being born and followed up in Norway, prelingually deaf children with two non-Nordic parents are at risk of being implanted later than Nordic children. Few non-Nordic children were implanted before 1 year of age. Our findings urge further investigation in order to eliminate parents' and doctor's delay.

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Table 1. Subject characteristics, all children ($N = 278$)

Ethnic background	Nordic parents	Non-Nordic (NN) parental ethnicity				Total
		Born in Nordic countries	Born in NN countries	One NN parent	Adopted	
Total count	192	46	16	10	14	278
Sex						
Girls	83	16	4	4	11	118
Boys	109	30	12	6	3	160
Geographic origin						
Nordic countries	192	—	—	—	—	192
Asia and Turkey	—	34	7	2	5	48
Other European country	—	3	3	4	3	13
Africa	—	3	6	2	2	13
South America	—	1	—	—	3	4
Unknown	—	3	—	2	1	6
Comorbidity						
Any comorbidity	84	21	4	2	6	117
CDL	45	14	1	—	1	61
Comorbidity as potential cause of delayed CI	55	17	1	1	2	76
None	108	25	12	8	8	161
Age of onset of deafness*						
<1 yr	104	31	6	6	6	153
1–2 yrs	13	6	4	1	—	24
2–3 yrs	7	1	1	—	—	9
> 3 yrs	28	1	4	1	2	36
Partial deafness**	40	7	1	2	6	56

CDL=cognitive, developmental or learning disabilities. * Severe to profound bilateral deafness. **Partial deafness on one or both sides.

Table 2. Characteristics of children aged <1 year at onset of severe to profound bilateral deafness ($n = 153$)

Ethnic background	Nordic parents	Non-Nordic (NN) parental ethnicity				Total
		Born in Nordic countries	Born in NN countries	One NN parent	Adopted	
Total count	104	31	6	6	6	153
Sex						
Girls	38	10	1	4	6	59
Boys	66	21	5	2	—	94
Comorbidity						
Any comorbidity	54	12	2	1	1	70
CDL	38	9	—	—	—	47
Comorbidity as potential cause of delayed CI	44	11	—	—	—	55
None	50	19	4	5	5	83

Table 3. Age (months) at implantation and ethnicity for children with severe to profound bilateral deafness before age 1year ($n = 153$).

	n	Median	Mean	SD	Range
Nordic parents	104	19.8	23.8	16.8	5.5-116.2
Non-Nordic parents, born in Nordic countries	31	23.2	25.7	15.3	8.3-94.9
Non-Nordic parents, born in non-Nordic countries	6	33.3	38.6*	11.6	27.3-55.2
One non-Nordic parent	6	41.5	52.1**	38.3	12.7-112.3
Adopted, born in non-Nordic countries	6	37.2	44.8***	21.7	22.8-80.7
Total	153	23.0	26.7	18.8	5.5-116.2

* Significantly older than Nordic children ($p = .006$, Mann-Whitney U). ** Significantly older than Nordic children ($p = .005$, Mann-Whitney U). *** Significantly older than Nordic children ($p = .005$, Mann-Whitney U). Due to extreme values, means are higher than median values.

Table 4. Age (months) at implantation and ethnicity for children with onset of severe to profound bilateral deafness between age 1 and 2 years ($n = 24$).

	n	Median	Mean	SD	Range
Nordic parents	13	31.5	34.0	13.4	19.3-70.6
Non-Nordic parents, born in Nordic countries	6	44.1	42.9	13.2	25.9-61.4
Non-Nordic parents, born in Non-Nordic countries	4	71.5	77.1*	19.1	61.4-104.0
One Non-Nordic parent	1	55.9	55.9	–	55.9
Adopted, born in non-Nordic countries	–	–	–	–	
Total	24	40.2	44.3	20.8	19.3-104.0

* Significantly older than Nordic children ($p = .003$, Mann-Whitney U). Due to extreme values, means are higher than median values.

Table 5. Monosyllable scores (%) for children with open speech perception ($n = 189$)

	n	Median	Mean	SD	Range
Nordic parents	133	88.0	84.7	12.4	24-100
Non-Nordic parents, born in Nordic countries	33	82.0	76.3*	15.8	40-94
Non-Nordic parents, born in Non-Nordic countries	9	72.0	66.9*	19.3	24-84
One NN parent	4	75.0	70.5	19.6	44-88
Adopted, born in non-Nordic countries	10	84.0	80.6	16.5	56-100
Total	189	86.0	81.9	14.5	24-100

Test results closest to 4 years, in average 4y;9mo (SD 8.3mo) after the first implantation. The mean age at testing was 8y;9mo (SD 40.9mo). *Children with two NN parents born in Nordic countries and children born outside the Nordic countries scored significantly less compared with Nordic children ($p = .002$ and $.001$, respectively, Mann-Whitney U).

Table 6. Reasons for missing results of open speech perception test 4 years after the first CI

	Frequency
Closed speech perception test	20
Tested outside the interval	19
Nonuser	17
Not testable*	15
Lost to follow-up	8
Followed-up elsewhere	6
Deceased	4
Total	89
*Uncooperative during testing situation or otherwise not able to perform open speech perception test	

Figure(s)

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Figure(s)

Figure 1. The box plot shows age at CI surgery for categories of age at onset of severe to profound bilateral deafness, and for partial deafness. $N = 278$. The youngest group with onset of profound deafness before age 1 year ($n = 153$) showed less variation of age at surgery than the older groups.

Figure 2. Regression analysis of age at the first CI surgery for children deaf before 1 year, born in Norway and without comorbidity as a potential cause of delayed implantation ($n = 98$). Regression lines indicate a gradual decrease of the mean age at implantation for both groups during 2004-2010. $R^2 = .12$ and $.14$ for non-Nordic and Nordic ethnicity, respectively.