Educational and Employment Achievements in Prelingually Deaf Children Who Receive Cochlear Implants

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Objective: To investigate the educational and employment achievements of prelingually deaf children who undergo cochlear implantation.

Design: Prospective study. Data were examined within groups defined by current age and additional disabilities. Multivariate analyses were used to identify variables influencing grade failure and communication mode.

Setting: Tertiary referral center.

Participants: One hundred prelingually deaf children who received cochlear implants before 6 years of age and who also had at least 4 years of follow-up.

Intervention: Interview of parents using a standardized questionnaire.

Main Outcome Measures: The type of schooling, form of communication, employment status, age at which the child learned to read and write, number of grade failures, and educational support required.

Results: Mainstream schooling, regardless of educational level, was the standard experience for children without additional disabilities (16 of 24 [67%] in the 12- to 15-year age group to 20 of 24 [83%] in the 8- to 11-year age group). Four of 8 participants older than 18 years (50%) had a university-level education; the remainder had vocational training. Delayed reading and writing skills were experienced by 19 of 74 participants (26%) and, depending on the age group, 42% to 61% of participants (10 of 24 in the 8- to 11-year age group to 11 of 18 in the 16- to 18-year age group) had failed a grade. The number of grade failures was associated with communication mode at the time of the survey. Age at implantation, preoperative communication mode, and educational support influenced the final communication mode. In children with additional disabilities, the level of academic achievement and employment status varied.

Conclusions: Despite significant differences in the grade failure rate between the children with cochlear implants and the general population, the participants in the present study ultimately achieved educational and employment levels similar to those of their normal-hearing peers. To minimize these delays and improve academic success in mainstream education, early oral education and early cochlear implantation are important.


For profoundly deaf children, cochlear implantation with rehabilitation is the recommended treatment to provide auditory function and facilitate proficiency in oral communication. In an ideal situation, cochlear implantation should also allow recipients to integrate into the hearing world and improve their quality of life; however, these outcomes can be difficult to measure. The needs and the concerns of cochlear implant recipients vary with age, making comparison of children difficult. It is even difficult to follow up children longitudinally because most of the tests assessing language development and quality of life cannot be used from infancy to adulthood.

One method to assess quality of life is to compare the educational and employment status of deaf children with those of their normal-hearing counterparts. These 2 outcomes—education and employment—are important components of mental and social well-being and correlate well with dependence levels in adulthood.

We designed this study to examine long-term educational and employment achievements of prelingually deaf children who received cochlear implants, subdividing this group into participants with and without additional disabilities. We report these results and describe the impact of the age at implantation, type of schooling, mode of communication, and level of educational support on the
method of additional disabilities. For participants without additional disabilities (n=74), we divided data into the following 4 age groups: 8 to 11 years (n=24), 12 to 15 years (n=24), 16 to 18 years (n=18), and older than 18 years (n=8). These groupings approximate the 4 main academic stages in France, consisting of elementary school (7-11 years), junior high school (12-15 years), high school (16-18 years), and postsecondary education. A high school diploma is required for access to post-secondary education.

Educational placement was categorized as follows: full-time mainstream school; part-time mainstream school (some OC with normal-hearing peers eventually supplemented with teaching using SL or TC), specialized schools (for those with additional handicaps), and schools for the deaf (SFD). For children with additional disabilities, we used only the following 3 groups: 8 to 11 years (n=10), 12 to 15 years (n=8), and 16 years or older (n=8).

Delay in acquisition of reading and writing skills was assessed at school with the evaluation performed once at the end of the first year of elementary school according to the recommendations of the French National Ministry of Education.

We used multivariate analysis to investigate the association between grade failures (failure or no failure) and current age, at implantation (<3 or ≥3 years), current communication type (OC vs TC or SL), communication type before implantation (OC vs TC or SL), and the need for educational support (<3 or ≥3 years of support). Bivariate analysis was used to identify variables for multivariate analysis. Because most of the variables were qualitative, we used the Wilcoxon rank sum test to select variables for stepwise logistic regression modeling for multivariate analysis (level of significance, P≤.05). Changes in the mode of communication before implantation and at present were assessed by the χ² test (level of significance, P≤.05). Distributions of academic level (elementary school, junior high school, high school, university, vocational training, and worker) in children without additional disabilities against the French general population were studied in the groups of ages 8 to 11, 12 to 15, and 16 to 18 years. Kolmogorov-Smirnov tests and power calculations were performed for each group (level of significance, P≤.05 and P>.80, respectively). Rates of grade failures between the groups aged 8 to 11, 12 to 15, and 16 to 18 years and the French age-matched populations were performed with the z test (level of significance, P≤.05). Statistical analyses were performed using commercially available software (Systat, version 10.0; Systat Software Inc, Chicago, Illinois).

Figure 1. Types of additional disabilities reported by participants in this study. The sum of the percentages is greater than 100% because some children have several additional disabilities.
CHILDREN WITHOUT ADDITIONAL DISABILITIES

Academic and Employment Outcomes

Of the 74 participants, 19 (26%) experienced delays in acquiring reading and writing skills; 39 (53%) experienced grade failures. Irrespective of age at implantation, full-time mainstreaming was the most common type of scholar placement (67%-83%, Table 2). Part-time or SFD-based education was observed in 11% to 33% of participants (2 of 16 in the 16- to 18-year age group to 8 of 24 in the 12- to 15-year age group), with higher use of part-time education noted at the junior high school level. In the 2 oldest groups, 11% and 12% (2 of 18 in the 16- to 18-year age group and 1 of 8 in the >18-year age group, respectively) were employed and were not continuing any studies (Table 2).

Compared with the age-matched general French population,3 cochlear implant recipients without an additional disability had a mild delay in educational placement (Table 3). For example, in the group aged 8 to 11 years, 20 children (83%) went to elementary school, with 4 (17%) going to junior high school, whereas in the age-matched general French population, 79.0% of children attended elementary school (Table 3). This difference was not statistically significant (P = .37, Kolmogorov-Smirnov test). However, this could be explained by the small size of the samples tested in this age group (power ≤80%). This difference is consistent with the large number of grade failures by children with cochlear implants during elementary school (10 of 24 [42%] subjects in the group aged 8-11 years failed a grade). In this group, the rate of grade failures was statistically higher than that in the general age-matched population (P = .03, z test).

Grade failures were also observed in the groups aged 12 to 15 years and 16 to 18 years, with cumulative grade failures of 58% (14 of 24 children) and 61% (11 of 18), respectively (Table 2). A progressively larger number of children in these same age groups also received vocational education: 17% (4 of 24 children) and 44% (8 of 18), respectively, compared with 2.4% and 26.6%, respectively, in the general population (Table 3). A higher percentage of participants aged 16 to 18 years with cochlear implants were in the work force (2 in 11%) vs 6.3% in the general population) (Table 3). We observed a statistically significant difference of distribution between cochlear implant recipients and the general population only for the group aged 12 to 15 years (P = .007, Kolmogorov-Smirnov test). No statistically significant difference was found in the group aged 16 to 18 years, but the sample size was too small to rule out any significant difference (power ≤80%). The specific rate of grade failures in secondary education (19% [high school minus elementary school]; Table 2) was not statistically different from the rate reported in the literature for the general population (P = .22, z test), but the sample size was also too small to rule out any difference (power ≤80%). Moreover, the raw rate of grade failure at the end of secondary school (61%) caught up to the rate of the general population (68.3%; P = .40, z test).

In the group of 8 cochlear implant recipients older than 18 years, 5 (62%) had a high school diploma vs 53% in the general population.3 More than one-third (3 of 8 children [38%]) pursued vocational studies, but more than half had reached university-level education: 4 (50%) attended a university and 1 (12%) was employed with a master’s degree (Table 3). Half of this group had experienced at least 1 grade failure.

Changes in Communication Mode and Educational Support Level

Of participants without additional disabilities, we observed a statistically significant change (P = .007, χ² test) when the communication mode used before implanta-
tion was compared with the communication mode used at the time of our survey. The TC mode was used by almost half of participants (35 of 74 [47%]) before implantation but by only 34% (25 of 74) at the time of this survey (Table 2). The percentage of OC users increased from 24% to 62% (from 18 to 46 participants), and there was only 1 SL user postoperatively (a person who was not using the cochlear implant). Within the different age groups, the communication mode followed the same trends (Table 2).

The educational support used by the children without additional disabilities is summarized in Table 3A.

### Table 2. Characteristics and Outcomes of Children Without Additional Disabilities

<table>
<thead>
<tr>
<th>Age Group, y</th>
<th>8-11 (n=24)</th>
<th>12-15 (n=24)</th>
<th>16-18 (n=18)</th>
<th>&gt;18 (n=8)</th>
<th>All (N=74)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD) age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At present, y</td>
<td>9.9 (0.2)</td>
<td>13.6 (0.3)</td>
<td>17.2 (0.2)</td>
<td>19.4 (0.3)</td>
<td>13.7 (0.3)</td>
</tr>
<tr>
<td>At implantation, mo</td>
<td>42.8 (2.9)</td>
<td>43.5 (3.1)</td>
<td>48.4 (3.6)</td>
<td>48.4 (5.3)</td>
<td>44.1 (1.4)</td>
</tr>
<tr>
<td>Communication mode, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preimplantation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OC</td>
<td>6 (25)</td>
<td>6 (25)</td>
<td>3 (17)</td>
<td>3 (38)</td>
<td>18 (24)</td>
</tr>
<tr>
<td>TC</td>
<td>13 (54)</td>
<td>12 (50)</td>
<td>8 (44)</td>
<td>2 (25)</td>
<td>35 (47)</td>
</tr>
<tr>
<td>SL</td>
<td>5 (21)</td>
<td>6 (25)</td>
<td>7 (39)</td>
<td>2 (25)</td>
<td>20 (27)</td>
</tr>
<tr>
<td>At present</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OC</td>
<td>16 (67)</td>
<td>15 (63)</td>
<td>9 (50)</td>
<td>6 (75)</td>
<td>46 (62)</td>
</tr>
<tr>
<td>TC</td>
<td>8 (33)</td>
<td>8 (33)</td>
<td>7 (39)</td>
<td>2 (25)</td>
<td>25 (34)</td>
</tr>
<tr>
<td>SL</td>
<td>0</td>
<td>1 (4)</td>
<td>0</td>
<td>0</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Educational support, No. (%)</td>
<td>7 (29)/17 (71)</td>
<td>13 (54)/11 (46)</td>
<td>16 (89)/2 (11)</td>
<td>8 (100)/0</td>
<td>44 (59)/30 (41)</td>
</tr>
<tr>
<td>Placement, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-time mainstream school</td>
<td>21 (88)</td>
<td>16 (67)</td>
<td>14 (78)</td>
<td>6 (75)</td>
<td>57 (77)</td>
</tr>
<tr>
<td>Part-time mainstream school</td>
<td>2 (8)</td>
<td>7 (29)</td>
<td>2 (11)</td>
<td>1 (12)</td>
<td>16 (12)</td>
</tr>
<tr>
<td>Specialized school or school for the deaf</td>
<td>2 (8)</td>
<td>1 (4.2)</td>
<td>0</td>
<td>0</td>
<td>3 (4)</td>
</tr>
<tr>
<td>Work</td>
<td>0</td>
<td>0</td>
<td>2 (11)</td>
<td>1 (12)</td>
<td>3 (4)</td>
</tr>
<tr>
<td>Grade failures, No. (%)</td>
<td>10 (42)/18.0</td>
<td>14 (58)/38.5</td>
<td>11 (61)/68.3</td>
<td>4 (50)</td>
<td>39 (53)</td>
</tr>
</tbody>
</table>

**Abbreviations:** OC, oral communication; SL, sign language; TC, total communication.

Data are expressed as number (percentage) of participants receiving less than 3 support services/3 or more support services.

Data are expressed as number (percentage) of participants/percentage of the general population. Data for grade failure of students older than 18 years are not available from the French Ministry of Education.

### Table 3. Educational Stages of Cochlear Implant Recipients Based on Chronological Age

<table>
<thead>
<tr>
<th>Educational Stage</th>
<th>Elementary</th>
<th>Junior High</th>
<th>High</th>
<th>University</th>
<th>Vocational</th>
<th>Worker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children without additional disabilities by age, y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-11 (n=24)</td>
<td>20 (83)/79.0</td>
<td>4 (17)/21.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12-15 (n=24)</td>
<td>2 (8)/0.4</td>
<td>17 (71)/83.9</td>
<td>1 (4)/13.3</td>
<td>4 (17)/2.4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16-18 (n=18)</td>
<td>0</td>
<td>0</td>
<td>7 (39)/49.6</td>
<td>1 (6)/15.6</td>
<td>8 (44)/26.6</td>
<td>2 (11)/6.3</td>
</tr>
<tr>
<td>&gt;18 (n=8)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4 (50)</td>
<td>3 (38)</td>
<td>1 (12)</td>
</tr>
<tr>
<td>Children with additional disabilities by age, y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-11 (n=10)</td>
<td>9 (90)</td>
<td>1 (10)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12-15 (n=8)</td>
<td>3 (38)</td>
<td>4 (50)</td>
<td>1 (12)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>≥16 (n=8)</td>
<td>0</td>
<td>0</td>
<td>3 (38)</td>
<td>0</td>
<td>5 (62)</td>
<td>0</td>
</tr>
</tbody>
</table>

Data are given as number (percentage) of cochlear implant recipients/percentage of general age-matched French population.

Last degree for all was a high school diploma.

Data are given as number (percentage) of cochlear implant recipients.

Last degree for all was a master’s degree.

For children without other disabilities, we found significant relationships between the number of grade failures and chronological age and current communication mode ($P<.05$, stepwise logistic regression). In detail, the risk of grade failure increased with the chronological age at the time of the survey and decreased with the use of OC.
There was no association between grade failure and preoperative communication mode, age at implantation, or the use of educational support \((P \geq .13)\) (Table 4). We also assessed the association between current communication mode and current age, age at implantation, communication mode before implantation, and educational support requirements. All variables were associated with current communication mode at \(P = .04\) (Table 4). The OC mode was likely associated with a higher age at the time of the survey, cochlear implantation at an early age, use of an OC mode before implantation, and a higher degree of educational support after implantation.

### OUTCOMES IN CHILDREN WITH ADDITIONAL DISABILITIES

Of the 26 children with additional disabilities, 15 (58%) had delayed reading and writing milestones and 19 (73%) failed at least 1 grade. Full-time mainstream schooling was more difficult to achieve for those with additional disabilities, with 5 of 10 (50%) attending mainstream school in the group aged 8 to 11 years but only 2 (25%) attending mainstream school in the group aged 12 to 15 years. In the group 16 years and older, mainstream schooling increased (5 of 8 children [62%]). However, this increase may reflect the fact that no SFD or specialized school provides a high school or university-level education.

In France, the other types of schooling in addition to full-time mainstream education included specialized (non-SFD) schools, part-time school, and SFD. Enrollment rates for these 3 types of education were 10%, 10%, and 30% (1, 1, and 3 of 10 children), respectively, in the group aged 8 to 11 years and 12%, 12%, and 50% (1, 1, and 4 children), respectively, in the group aged 12 to 15 years. In the entire group of 26 children with disabilities, 12 (46%) attended a full-time mainstream school, 2 (8%) attended an SFD, and 3 (12%) attended a specialized school. A significant delay in educational placement was noticed from the age of 12 years, and a larger number of

Table 4. Results of Multivariate Analysis in Children Without Additional Disabilities

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Grade Failures</th>
<th>Communication Mode at Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.01</td>
<td>.04</td>
</tr>
<tr>
<td>Age at implantation(^a)</td>
<td>.58</td>
<td>.01</td>
</tr>
<tr>
<td>Preoperative communication mode(^b)</td>
<td>.77</td>
<td>.001</td>
</tr>
<tr>
<td>Communication mode at survey(^b)</td>
<td>.03</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Educational support(^c)</td>
<td>.13</td>
<td>.03</td>
</tr>
</tbody>
</table>

\(^a\) Indicates younger than 3 years vs 3 years or older.

\(^b\) Indicates oral vs sign language or total communication.

\(^c\) Indicates less than 3 vs 3 or more services.
participants 16 years and older (5 of 8 [62%]) received vocational education (Table 3) than did those without additional disabilities.

Changes of communication mode were less dramatic in the 26 children with additional disabilities, with 5 (19%) still using SL after implantation (compared with 10 [38%] before implantation) and only 10 (38%) using OC (compared with 5 [19%] before implantation). No change was observed with TC (11 children [42%] before implantation and at the time of the survey). The use of speech therapy and other educational support (except personal tutors) remained important beyond 16 years of age despite some changes over time (Figure 3B).

**COMMENT**

Widespread cochlear implant use has improved auditory function and oral language development in profoundly deaf children. Although several studies have detailed the cost-effectiveness of this procedure, relatively few have examined its social and educational consequences. Previous studies on quality of life have shown that social integration improves after implantation, however, educational and employment outcomes are also important issues, not only for the well-being of the child but also for economic reasons. The costs associated with rehabilitation mainly relate to support (i.e., speech therapy, special needs assistants, and personal tutors) and education, with mainstream schooling being less expensive than specialized schooling.

This study describes the educational and employment outcomes in children with cochlear implants who also had at least 4 years of follow-up. Similar to the findings reported by Francis et al, most children without additional disabilities attend mainstream schools. Some studies claim that these students attain academic results close to but slightly below those of their normal-hearing peers. We also observed no major differences between the implant recipients in our survey and the general population, with more than 60% of those older than 18 years holding a university degree and some already working. These figures are similar to those in the general population of France, where 53% have at least a high school diploma.

Our study found that the academic success of cochlear implant recipients is often accompanied by a delay in educational placement. In addition, the children in our study demonstrated a higher rate of grade failures compared with children with normal hearing.

More implant recipients learn a vocation compared with the general population: in the groups aged 12 to 15 and 16 to 18 years, 17% and 44%, respectively, attended vocational education vs 2.4% and 26.6% of age-matched peers in the general population. Grade failures remain common, especially during elementary school, perhaps reflecting the language impairment remaining during the first years after cochlear implantation. Indeed, the rate of grade failures observed in the implant recipients attending elementary school (42%) is significantly higher than the rate observed in the age-matched French population (18.0%). Approximately 23% of our patients also experienced delays in acquiring reading and writing skills, a proportion similar to that observed by others. In secondary education, the specific rate of grade failure of 19% (61% minus 42%) is similar to the specific rate of 20.5% observed in the general population, and the raw rates at the end of the secondary level are not significantly different (61% vs 68.3%, respectively).

To identify factors influencing grade failure, we examined age at implantation, communication mode (before implantation and at the time of the survey), and educational support levels and found that age is a confounding factor that correlates with grade failures and communication mode. We used multivariate analysis to adjust for this relationship and found that the only predictive factor against the risk of grade failure was an OC mode at time of the survey. Indeed, children who used OC experienced significantly fewer grade failures than did those in TC and SL programs. Moreover, Stacey et al demonstrated an association between OC and a higher academic achievement. We noticed that the rate of grade failure in the elementary education was higher than the rate of delay in writing and reading skills. This can be explained by variable individual skills but also more specifically by reduced access to the implicit content of the language as suggested elsewhere.

Age at implantation did not influence grade failure but was associated with the current communication mode, with implantation before 3 years of age being associated with a greater likelihood of OC, as has been demonstrated by others. Early implantation could allow children to reach a higher level of oral language and avoid the loss of school time that occurs with surgery at a later age.

Other factors influencing the type of communication at the time of this survey included the preoperative communication mode and the level of educational support. The use of OC was associated with the use of OC preoperatively and with intensive educative support. We believe that this relationship reinforces the hypothesis that early oral education in children improves their chances of academic success.

Effective OC seems related to the intensity of educational support, although the precise relationship between skill development and skill maintenance is unclear. Because both factors are strongly linked, further analyses may clarify this point. Our survey showed that, after implantation, two-thirds of patients without additional disabilities used OC, almost one-third used TC, and only 1 participant relied on SL. With age, cochlear implant recipients required less educational support, with more than one-third of adults living support free.

Achievement levels for children with other disabilities are known to be lower and our data concur. We found that 58% of our participants showed delays in reading and writing, whereas 19% still used SL and the use of OC and TC was approximately equal. Only 46% attended full-time mainstream schools, with others enrolled in a part-time SFD or specialized school. Grade failure was common (73.1%). Within age groups, educational achievement varied widely, with only 38% of those older than 16 years accessing high school. Vocational education prevented several children from leaving school altogether. However, although these students may under-
achieve as measured in academic terms, most do reach some degree of social and communicative autonomy, an improvement that demonstrates the benefit of cochlear implantation in this population.22

CONCLUSIONS

Prelingually deaf children without additional disabilities achieve satisfactory educational and employment successes after cochlear implantation, especially if the cochlear implant allows the use of OC. Outcomes for children with additional disabilities are less satisfactory and more variable. Mainstreaming is not always possible, and specialized schools are often used. For these cochlear implant recipients, vocational education may provide a valuable alternative, and most still benefit from cochlear implants.

If delays in writing and reading skills and grade failures are commonly observed, perhaps as a consequence of the auditory deprivation before cochlear implantation, early cochlear implantation should reduce these delays, and further studies are required to address this point.

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Author Contributions: Dr Venail and Ms Vieu had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Venail, Mondain, and Uziel. Acquisition of data: Venail, Vieu, Artieres, and Mondain. Analysis and interpretation of data: Venail and Uziel. Drafting of the manuscript: Venail, Mondain, and Uziel. Critical revision of the manuscript for important intellectual content: Vieu and Artieres. Statistical analysis: Venail, Artieres, and Mondain. Administrative, technical, and material support: Venail, Vieu, Mondain, and Uziel. Study supervision: Mondain and Uziel. Financial Disclosure: None reported.

Additional Contributions: Richard Smith, MD, of The University of Iowa, Iowa City, carefully edited this work and provided helpful comments.

REFERENCES


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**Correction**

**Error in Figure.** In the Original Article titled “Educational and Employment Achievements in Prelingually Deaf Children Who Receive Cochlear Implants” by Venail et al, published in the April issue of the *Archives* (2010;136[4]:366-372), an error occurred in Figure 3 on page 370. In the figure’s key for part A, the bar color for children 16 to 18 years old should have been dark blue instead of light gray, and the bar color for children older than 18 years should have been medium blue instead of dark blue. The corrected figure is printed here with its legend.

![Corrected Figure 3](image-url)

*Figure 3.* Types of educational support, in addition to the cochlear implant, used by children without (n=74) (A) and with (n=26) (B) additional disabilities in this study. Data are presented according to the age of the children at the time of the survey. FM indicates frequency-modulated.

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