XI CONGRESO IBEROAMERICANO DE IMPLANTES COCLEARES Y CIENCIAS AFINES
GICCA 2025
5 al 7 de julio del 2025
Alvear Icon Hotel. Buenos Aires, Argentina
Presidente: Prof. Dr. Carlos Boccio

N° 7568

EXPLORING LANGUAGE DEVELOPMENT IN PRELINGUALLY DEAF CHILDREN: INSIGHTS FROM A PUBLIC COCHLEAR IMPLANT PROGRAM

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Introduction

Cochlear implants (CIs) have become the standard intervention for children with severe to profound prelingual deafness, aiming to provide auditory access and foster language development. However, outcomes vary greatly, influenced by individual, familial, and societal factors. Most research on CI outcomes comes from developed countries, but this study focuses on children from lower socioeconomic backgrounds in southern Brazil, a context marked by significant inequalities. The primary goal was to identify characteristics associated with better language outcomes among pediatric CI recipients in a public health program.

Materials and Methods

This retrospective cohort study included all children with prelingual deafness who received a CI between 2010 and 2020 at the only public hospital in our state accredited for such procedures. Inclusion required regular follow-up and at least one recent audiometry. Etiologies were determined via comprehensive clinical and genetic evaluation, and all patients had profound hearing loss pre-surgery.

Language development was assessed using standardized parent-report scales: IT-MAIS for children under 4, MAIS for those 4 and older, and MUSS for all ages. These tools evaluate spontaneous listening behaviors and speech use in daily life, with scores reflecting the frequency of observed behaviors.

Variables potentially influencing language outcomes were collected from medical records and parent interviews, including surgical details, audiological data, perinatal history, and sociodemographic factors (e.g., maternal education, bilingualism, reading habits, screen exposure, and speech therapy engagement). Data were analyzed using Pearson's correlation and multivariable linear regression to identify independent predictors of language development.

Results

Out of 225 eligible children, 129 met the inclusion criteria. The cohort was socioeconomically homogeneous and predominantly from families with low maternal education (Table 1). Key findings included:

- Language Outcomes: A majority showed language development below expected norms: 59.7% scored below -1 SD on MAIS (receptive language), and 62% below -1 SD on MUSS (expressive language).
- Correlates of Better Language Outcomes (Table 3):
- Expressive Language (MUSS): Weak positive correlations with absence of bilingualism, frequent reading, negative NICU history, higher Apgar scores, and frequent speech therapy. Moderate correlations were found for longer speech therapy duration and more programming sessions per year.
- Receptive Language (MAIS): Weak positive correlations with negative NICU history, absence of maternal depression, monolingual environment, and frequent speech therapy. Moderate correlations with frequent reading and longer speech therapy.

Regression Analysis (Table 4): Gestational age and pure-tone average (PTA) emerged as independent predictors. Speech therapy duration and frequency were consistently linked to better outcomes. The number of programming sessions, while correlated in bivariate analysis, was not significant in multivariable models.

Discussion

Language outcomes in this cohort were generally lower than those reported for early-implanted children in higher-income settings. This is likely due to the compounding effects of low socioeconomic status (SES), limited parental education, and potentially reduced access to resources and support.

Contrary to some previous studies, factors such as gender, age at implantation, gestational age, and screen exposure did not reach statistical significance in this sample, possibly due to the uniformly late age of implantation and the study's retrospective design. Nevertheless, several notable associations emerged:

NICU Admission and Apgar Scores: Weak correlations suggest that early neurodevelopmental challenges may impact later language development, underscoring the need for cognitive assessments in CI candidates.

Maternal Depression: Although only weakly correlated, this factor may affect both the quality of parent-child interaction and the family's ability to adhere to demanding rehabilitation schedules.

Reading Habits: Regular exposure to reading, even in low-resource settings, was moderately associated with better language outcomes, highlighting an accessible intervention for language stimulation.

Bilingualism: Children in bilingual homes had poorer language outcomes, possibly due to reduced exposure to the spoken language targeted by rehabilitation. This finding warrants further investigation, especially in culturally diverse regions.

Conclusion

This study highlights the complex interplay of medical, familial, and sociodemographic factors influencing language development in prelingually deaf children with CIs in a public health setting. Key modifiable factors—such as promoting regular speech therapy and reading habits—emerge as actionable targets for intervention, while the findings also emphasize the need for tailored support for families facing socioeconomic and psychological challenges. Further research, particularly in underrepresented populations, is essential to refine prognostic models and optimize outcomes for all children receiving cochlear implants.

Table 1. Clinical and sociodemographic/cultural characteristics of the study population

Characteristic	Value
Gestational age (weeks), mean (SD); range	37.4 (3.2); 24-43
Birth weight (g), mean (SD); range	3043 (696); 900-5355
NICU* admission, no. (%)	25 (19.4)
Apgar score at 5 minutes	
< 4, no. (%)	2 (2.2)
5-7, no. (%)	6 (6.5)
8-10, no. (%)	86 (91.5)
Age at first CI, mo, mean (SD); range	
General	40.5 (16.9); 9-100
Bilateral	34.7 (19.4); 9-100
Unilateral	42.1 (15.9); 14-86
IC use, hours daily, mean (SD); range	10.3 (4.4); 0-18
Etiology	
Auditory Neuropathy	4 (3.1)
Congenital infection	4 (3.1)
Inner Ear Malformation	8 (6.2)
Genetic Syndromic	8 (6.2)
Meningitis	10 (7.8)
Neonatal conditions	13 (10.1)
Genetic Nonsyndromic	13 (10.1)
Unknown	69 (53.5)
Family income, no. (%)	
< 1 minimum wage	8 (6.3)
2-4 minimum wages	115 (90.6)
>4 minimun wages	4 (3.1)
Maternal education, no. (%)	
Middle School	35 (27.1)
High School	57 (44.2)
College/University	35 (27.1)
Reading habit, no. (%)	
Never	56 (43.4)
Occasionally	5 (3.9)
Frequently	39 (30.2)
Daily	29 (22.5)
Bilingual family, no. (%)	
Yes	37 (28.7)
No	90 (69.8)
Exposure to screens (hours/daily), no. (%)	

0 to 1	7 (5.4)
1 to 2	18 (14.0)
2 to 3	29 (22.5)
3 to 4	26 (20.2)
> 4	46 (35.7)
Maternal diagnosis of depression	10 (7.8)

Table 2. Postoperative follow-up data.

Characteristic	Value
Pure tone average (PTA), mean (SD)	32.6 (18.6)
PTA <30dB, (%)	54.3
PTA 30-40dB, (%)	31
PTA >40dB, (%)	14.7
Programming sessions, per year, mean (SD)	
Planned	3.4 (1.8)
Performed	2.4 (1.4)
Speech therapy time), no. (%)	
Never	16 (13.2)
Intermittently	16 (13.2)
Since activation	89 (73.6)
Speech therapy frequency, no. (%)	
Never	24 (18.6)
Once a month	10 (7.8)
Once a week	76 (58.9)
Twice a week	16 (12.4)
IC usage, no. (%)	
Not using	8 (6.2)
1-8 hours/day	15 (12.5)
9-14 hours/day	64 (49.6)
15-18 hours/day	5 (2.9)

Table 3. Results of linear correlation between selected variables and language outcomes, MAIS and MUSS Z-scores

	Z-score MUSS			Z-score MAIS		
Variables	n	r	p	n	r	p
Gender	129	-0.15	0.089	129	-0.04	0.639
Age at first cochlear implant	129	-0.06	0.520	129	-0.01	0.895
Gestational age	122	0.17	0.064	122	0.00	0.999

Apgar score at 5 minutes	94	0.25*	0.016	94	0.09	0.399
NICU[a] admission	126	-0.20*	0.023	126	-0.18*	0.039
Maternal depression	126	-0.11	0.221	126	-0.18*	0.044
Maternal education	127	0.12	0.165	127	0.100	0.262
Reading habit	129	0.26*	0.003	127	0.35**	<0.001
Exposure to Bilingualism	127	-0.25*	0.004	127	-0.25*	0.005
Exposure to Screens	126	-0.17	0.061	126	-0.10	0.283
Speech therapy time	121	0.32**	<0.001	121	0.38**	<0.001
Speech therapy frequency	126	0.25*	0.005	126	0.27*	0.002
Pure tone average	129	-0.15	0.078	129	-0.15	0.080
Mean programming sessions performed per year	129	-0.31**	<0.001	129	0.14	0.117

[a] Neonatal intensive care unit; * Weak Pearson's correlation coefficient; ** Moderate Pearson's correlation coefficient

Table 4. Results of Multiple Linear Regression of selected variables to language outcomes (Z-scores for MAIS and MUSS)

	Z-score MUSS			Z-score MAIS		
Variables	B	p	r'	B	p	r'
Gestational age	0.11	0.024	0.22			
Maternal depression				-3.87	0.02	-0.22
Reading habit	0.31	0.016	0.23	1.13	0.002	0.29
Exposure to Bilingualism	-1.05	0.003	-0.29	-2.80	0.005	-0.27
Exposure to Screens	-0.23	0.006	-0.26			
Speech therapy time	0.50	0.032	0.21	2.21	0.001	0.31
Pure tone average	-0.02	0.005	-0.27	-0.04	0.04	-0.19
R^2	0.31			0.33		

B coefficient = represent impact of one unit increase on the Z-scores for each outcome.
p = statistical significance;
r' = partial correlation coefficient from the regression model;
R^2 = proportion of variance indicates the total variance in the outcome measure that is explained by the developed prediction model