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Factors affecting the quality of postoperative rehabilitation in children with cochlear implants based on the theory of knowledge, attitude and practice

Ken Lin,[1] Yiyun Zhang,[2] Wenyue Chi ,[3] Xia Li,[1] Xiuli Ma,[1] Dong Su,[1] Yuling Du,[3] Jing Ma,[1] Tiesong Zhang[1]

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KL, YZ and WC contributed equally.

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[1]Department of Otolaryngology, Head and Neck Surgery, Kunming Children's Hospital, Kunming, Yunnan, China
[2]School of Ethnology and Sociology, Yunnan University, Kunming, Yunnan, China
[3]Kunming Medical University, Kunming, Yunnan, China

Correspondence to
Dr Tiesong Zhang; zts68420@sina.com and Dr Jing Ma; majing@etyy.cn

ABSTRACT

Objectives This study aimed to examine factors that influence postoperative rehabilitation outcomes in children with cochlear implants, using a knowledge–attitude–practice (KAP) framework.

Design A total of 683 children with cochlear implants participated in this study. Hearing and speech assessments were conducted through face-to-face and/or telephone interviews, while parents' or guardians' KAP were assessed following detailed instructions provided beforehand. Responses were recorded meticulously.

Setting Data were collected through a convenience sampling method at a children's hospital.

Participants Out of 840 questionnaires distributed, 683 completed questionnaires were retained for analysis after excluding responses with missing data.

Results Parents' average KAP score was 8.03 (SD = 3.13). Household income and education levels directly influenced KAP scores, while certain child characteristics were significantly associated with higher scores on the Infant–Toddler Meaningful Auditory Integration Scale (IT-MAIS). Children who were outgoing (32.29 points), had used a cochlear implant for more than 3 years (32.78 points), and had surgery funded by state support (32.14 points) demonstrated higher MAIS scores. Factors such as personality, monthly family income, surgery funding and parents' beliefs significantly affected rehabilitation outcomes among children.

Conclusion Parental knowledge about deafness, trust in cochlear implant procedures and healthcare providers, and parental behaviours during the treatment and rehabilitation process have a direct impact on children's health outcomes. Enhancing parents' KAP levels is critical to improve rehabilitation outcomes for children with cochlear implants.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study examined factors influencing children with cochlear implants based on the theory of parental knowledge, beliefs and behaviours.
⇒ The study used a convenience sampling method, and there was a lack of long-term quality monitoring, which may limit the accuracy of the findings in reflecting the postoperative rehabilitation outcomes for children over extended periods.
⇒ Due to time and geographical constraints, the study included participants from only one region, which limits the generalisability of the results.
⇒ The sample size limitations led to a skewed distribution of the Meaningful Auditory Integration Scale scores. As a result, a dichotomous analysis approach was used, and conclusions should be interpreted with caution.
⇒ While the study focussed on factors related to cochlear implantation, it did not account for environmental factors influencing the child's life. Future research will broaden the analysis to establish a comprehensive causal chain model.

INTRODUCTION

Hearing loss is a physiologically disabling form of deafness that often leads to significant impacts on psychological well-being, quality of life and social integration for both patients and their families.[1 2] In 2021, the WHO reported that approximately 430 million people experience moderate to severe hearing loss, and require rehabilitative services; which is estimated to rise to 700 million by 2050.[3 4] Cochlear implantation is recognised as an effective intervention for individuals with severe to profound hearing loss, particularly within the paediatric population.[5 6] Cochlear implants can restore language abilities and improve the overall quality of life in children with severe to profound hearing loss or complete deafness.[7] Notably, cochlear implants have demonstrated substantial benefits for both speech perception and understanding.[8] However, cochlear implants are not always the preferred treatment option, primarily due to the high surgical costs,

limited availability of medical and rehabilitation facilities and variations in patient and caregiver understanding of the procedure. As of 2018, only approximately 650 000 individuals worldwide had received a cochlear implant. The incidence of cochlear reimplantation due to adverse effects ranges from 4.1% to 18.5% globally.[9] Studies have indicated that children, compared with adults, face greater challenges in achieving rehabilitation outcomes and are more likely to experience limitations during the rehabilitation process.[10 11]

Childhood deafness significantly impacts family dynamics, as a child's quality of life is closely linked to their personal development and the healthy functioning of the family unit.[12] However, due to children's physical, psychological and social vulnerabilities, as well as their limited ability to understand and evaluate complex information, parental involvement remains a crucial factor in clinical interventions aimed at enhancing the quality of life for deaf children. Prior research has identified various factors that influence cochlear implantation outcomes, including neurological conditions, age at implantation, prior use of hearing aids and cochlear morphology.[13–16] Additionally, factors such as technological advancements, device malfunctions, skin necrosis or infection around the implant site and cochlear migration have been identified as high-risk factors for reimplantation procedures.[17] For children, postoperative infections and inconsistent rehabilitation are major contributors to cochlear implant failure, both of which are closely associated with parental knowledge, beliefs and practices concerning cochlear implantation.[18] Given the physiological sensitivity of children, successful postoperative care and rehabilitation can be challenging, making parental knowledge, attitudes and practices (KAP) essential for maximising cochlear implant outcomes. Despite the importance of these factors, few studies have directly examined the association between parental KAP as a dependent variable and rehabilitation outcomes, and even fewer have conducted a comprehensive analysis of this relationship. Therefore, this study aims to investigate the effects and influencing factors of cochlear implantation from the perspective of KAP theory, with the goal of improving postoperative rehabilitation quality, enhancing intervention effectiveness and ultimately raising the quality of life in children with cochlear implants.

This study introduces two key innovations: (1) it will analyse the influence of parents' KAP as a factor affecting the quality of postoperative rehabilitation, providing a foundational literature base for refining and optimising future cochlear implantation interventions; and (2) it employs a multidimensional approach in selecting indices. Building on previous analyses focussed on individual and family-level factors, this study incorporates a macro-level perspective to develop a theoretical analysis model. This model comprises micro-level individual factors, meso-level family dynamics and macro-level policy influences, allowing for a comprehensive analysis of the mechanisms that impact rehabilitation outcomes following cochlear implantation.

MATERIALS AND METHODS

Data collection

The questionnaire was developed and revised in October 2022, and data collection was conducted in November and December 2022. This survey included follow-up telephone interviews with parents whose children had undergone cochlear implantation at Kunming Children's Hospital. All parents of children recorded in the hospital's medical system and the information system of the Disabled Persons' Federation were contacted. At the outset, informed consent was obtained, ensuring parents that their information would be securely protected.

Both in-person and/or telephone interviews were used to collect baseline data on hearing and speech assessments for the children, as well as to evaluate the parents' or guardians' KAP. Detailed instructions were provided to parents/guardians before assessments, and responses were carefully documented. A total of 840 responses were collected; after data cleaning, 683 responses were included in the final analysis to ensure data quality.

Measures

Dependent variables

Postoperative hearing and speech outcomes were assessed using the Infant–Toddler Meaningful Auditory Integration Scale (IT-MAIS)–MAIS as dependent variables.[19–21] The MAIS is applied to children older than 3 years, while the IT-MAIS is used for children or infants under 3 years. Questions 1 and 2 assess hearing aid use and spontaneous vocalisation in infants and young children. Questions 3 through 6 evaluate the child's ability to detect sounds and Questions 7 through 10 assess sound comprehension abilities. Each item is rated on a 5-point scale, from 0 (never, 0%) to 4 (always, 100%), with a maximum score of 40 points. For ease of multiple regression analysis, we categorised the MAIS scores: children scoring above the median (31) were classified as having a favourable rehabilitation outcome and assigned a value of 0, while those with lower scores were classified as having an unfavourable rehabilitation outcome and assigned a value of 1.

Independent variables

The independent variables included: (1) micro-level individual factors, such as gender, personality, age at evaluation, age at cochlear implantation, time elapsed between initial evaluation and implantation, presurgical use of hearing aids and daily duration of cochlear implant use; (2) meso-level household factors, including monthly household income, number of children in the household, family history of deafness, postoperative rehabilitation model, cochlear implant brand and parents' knowledge and beliefs regarding cochlear implantation and postoperative rehabilitation outcomes; and (3) macro-level policy factors, such as the payment method for the surgery. Details for each variable are presented in table 1. The KAP questionnaire for assessing the parents' perceptions of cochlear implantation and postoperative rehabilitation was developed through a combination of subjective

Table 1 Variable selection and descriptions

Variable	Description
Dependent variable	
Rehabilitation effect	0=Good rehabilitation effect, 1=Poor rehabilitation effect
Independent variables	
Micro-level individual factors	
Gender	1=Male, 2=Female
Personality	1=Active, 2=Impulsive, 3=Calm and introverted, 4=Sentimental
Age at evaluation	1 = <3 years old , 2=3–6 years old , 3= >6 years old
Age at cochlear implantation	1= <3 years old , 2=3–6 years old , 3= >6 years old
Duration between initial evaluation and implantation	1= <1 year, 2=1–3 years, 3= >3 years
Preoperative hearing aids	1=Yes, 2=No
Daily cochlear implant use (hours)	1= <8 hours, 2=8–16 hours, 3= >16 hours
Medium family factors	
Family monthly income	1= <5 thousands, 2=5–10 thousands, 3= >10 thousands
Number of children at home	1=One, 2=Two, 3=Three or more
Family history of deaf–mute	1=Yes, 2=No
Postoperative rehabilitation model	1=Family rehabilitation education, 2=Institution rehabilitation education, 3=Family and institution rehabilitation education
Cochlear origin	1=China, 2=Austria, 3=America , 4=Australia, 5=Other
Macro-level policy factors	
Payment method for surgery	1=National project reimbursement , 2=Partial fund subsidy, 3=Self-paying

and objective measures based on a literature review and expert consultation (see online supplemental appendix 1 for details). The first section assessed Knowledge (K-score) through 10 items covering topics such as understanding the principles and procedure of the surgery, awareness of preoperative and postoperative precautions and knowledge of factors influencing cochlear implantation outcomes. This section demonstrated high reliability and validity, with a Cronbach's alpha of 0.934 and a structural validity of 0.93. The second section assessed Attitude (A-score) with 4 items, including confidence in the child's recovery, accurate understanding of the procedure and realistic expectations. This section showed a Cronbach's alpha of 0.624 and a construct validity of 0.697. The third section evaluated Practice (P-score) with 5 items, such as adherence to the doctor's plan and ensuring adequate time for the child's training. The overall Cronbach's alpha for the KAP questionnaire was 0.921. An overview of both dependent and independent variables is provided in table 1.

Statistical analysis

Statistical tests were conducted using SPSS software (IBM SPSS Statistics, V. 26.0). Continuous data are presented as mean±SD (x±SD), while categorical data are expressed as frequency ratios. Logistic regression was employed to analyse the risk factors associated with postoperative rehabilitation outcomes in children with cochlear implants. A p value of less than 0.05 was considered statistically significant.

RESULTS

Sample characteristics

Table 2 presents the distribution of the demographic characteristics of the participants. In this survey, 840 questionnaires were collected, with 683 retained after excluding those with missing essential information. The sample consisted predominantly of male children (58.9%) and a large proportion were classified as having active personalities (74.0%). A majority of participants were over 6 years old, had been using cochlear implants for more than 3 years, had not used hearing aids prior to surgery and reported using their cochlear implant devices for 8–16 hours per day. Regarding cochlear implant brand preference, 78.8% of families selected the MED-EL cochlear implant. In terms of family structure, families with two children and no family history of deafness represented the highest proportions at 58.3% and 98.5%, respectively. From a policy perspective, 50.8% of families used the national programme to cover surgery costs, 31% paid out-of-pocket and the smallest group, 18.2%, received partial subsidies from other funding sources.

Relationships between parents' KAP and different variables

The study examined differences in parents' KAP scores in relation to various factors, both determinable and indeterminable. The mean knowledge score was 8.03 (SD=3.13). Parents of children under 3 years of age had a higher average knowledge score (9.47, SD=1.48) compared with parents of children over 6 years (7.26, SD=3.49). Additionally, parents whose children had undergone surgery within the past year had higher knowledge scores than those whose children completed surgery 1–3 years ago, or more than 3 years ago, with a general downward trend in scores observed over time since surgery. Furthermore, parents whose children used a cochlear implant for more than 16 hours daily scored an average of 1.8 points higher

Table 2 Demographic characteristics of the participants

Variable	N	(%)
Gender		
Male	402	58.9
Female	281	41.1
Personality		
Active	506	74.0
Impulsive	17	2.5
Calm and introverted	150	22.0
Sentimental	10	1.5
Age at evaluation		
<3 years old	55	8.0
3–6 years old	223	32.7
>6 years old	405	59.3
Age at cochlear implantation		
<3 years old	317	46.4
3–6 years old	271	39.7
>6 years old	95	13.9
Duration between initial evaluation and implantation		
<1 year	71	10.4
1–3 years	260	38.1
>3 years	352	51.5
Cochlear origin		
China	97	14.2
Austria	538	78.8
America	20	2.9
Australia	20	2.9
Other	8	1.2
Family monthly income		
<5 k	313	45.8
5–10 k	351	51.4
>10 k	19	2.8
Number of children at home		
One	193	28.3
Two	398	58.3
Three or more	92	13.4
Family history of deaf–mute		
Yes	65	9.5
No	618	90.5
Payment method for surgery		
National project reimbursement	347	50.8
Partial fund subsidy	124	18.2
Self-paying	212	31.0
Preoperative hearing aids		
Yes	171	25.0
No	512	75.0
Postoperative rehabilitation model		
Family rehabilitation education	316	46.3
Institution rehabilitation education	144	21.1
Family and institution rehabilitation education	223	32.6
Daily cochlear implant use (hours)		
<8 hours	12	1.8
8–16 hours	630	92.2
>16 hours	41	6.0

than those whose children used their cochlear implant for less than 8 hours per day.

Significant differences in parental knowledge scores were also found across factors such as household monthly income, number of children and type of postoperative rehabilitation model. Parents with a monthly income exceeding 10 000 yuan had the highest knowledge scores (9.58, SD=1.22), averaging 1.3 points more than parents with a monthly income below 5000 yuan (7.19, SD=3.69). Moreover, parents with two children scored 0.38 points higher on average than those with only one child. Among postoperative rehabilitation models, parents whose children received rehabilitation at home had the highest knowledge scores, averaging 2.16 points higher than those whose children received rehabilitation at an institution. Additionally, the method of cochlear implant surgery payment appeared to influence parental knowledge scores. Parents whose children's surgery was partially funded achieved the highest knowledge score, with an average of 9.23 (SD=1.82).

Variations in home environments and postoperative rehabilitation models contribute to differences in parents' KAP levels. At present, Chinese children with cochlear implants typically follow one of three main postoperative rehabilitation models, differentiated by the educators and settings involved: (1) family-based rehabilitation: rehabilitation training is conducted by parents at home, focussing on listening and language exercises, integrating cochlear implants into daily life. This model leverages natural family interactions to support rehabilitation. (2) Institution-based rehabilitation: rehabilitation is provided within specialised institutions, led by professional therapists who deliver systematic listening and language training using specialised equipment and resources. (3) Combined family and institution rehabilitation: this mixed model includes both cochlear implant exercises at home and regular sessions at a rehabilitation institution, integrating the benefits of both settings for comprehensive support. In this study, we performed stratified comparisons of parents' KAP scores, focussing on variables such as rehabilitation model and household income. The results indicated no significant differences in parents' attitudes (A-scores) towards surgery and rehabilitation across the different factors. All A-scores were above

Table 3 Analysis of factors influencing knowledge, attitudes and practices (KAP)

Variable	N	Knowledge	Attitude	Practice
Age of cochlear implantation				
<3 years old	55	9.47±1.48	3.95±0.30	4.78±0.81
3–6 years old	223	9.06±2.18	3.87±0.54	4.75±0.83
>6 years old	405	7.26±3.49	3.86±0.46	4.30±1.45
Duration between initial evaluation and implantation				
<1 year	71	9.59±1.51	3.99±0.12	4.92±0.28
1–3 years	260	9.32±1.77	3.92±0.52	4.82±0.68
>3 years	352	6.76±3.59	3.82±0.48	4.15±1.57
Average monthly household income				
<5 k	313	7.19±3.69	3.79±0.64	4.21±1.56
5–10 k	351	8.69±2.38	3.95±0.24	4.71±0.88
>10 k	19	9.58±1.22	3.84±0.37	4.79±0.54
Number of children at home				
One	193	7.80±3.29	3.89±0.41	4.47±1.30
Two	398	8.18±3.01	3.88±0.48	4.52±1.20
Three or more	92	7.86±3.27	3.83±0.59	4.37±1.40
Payment method for surgery				
National project reimbursement	347	8.77±2.39	3.86±0.53	4.61±0.99
Partial fund subsidy	124	9.23±1.82	3.91±0.36	4.62±1.18
Self-paying	212	6.11±3.87	3.87±0.44	4.20±1.61
Postoperative rehabilitation model				
Family rehabilitation education	316	8.81±2.54	3.94±0.27	4.76±0.80
Institution rehabilitation education	144	6.65±3.78	3.72±0.77	3.60±1.98
Family and institution rehabilitation education	223	7.81±3.09	3.88±0.43	4.66±0.89
Daily cochlear implant use (hours)				
<8 hours	12	5.00±4.57	3.75±0.87	3.83±1.90
8–16 hours	630	8.00±3.11	3.87±0.48	4.47±1.26
>16 hours	41	9.39±2.15	3.98±0.16	4.85±0.79
Total	683	8.03±3.13	3.87±0.48	4.48±1.26

3.7, indicating an overall positive attitude among parents. However, both the type of postoperative rehabilitation model and the duration of daily cochlear implant usage significantly affected parental practice scores. Specifically, the A-score for parents engaged in family-based rehabilitation was 1.16 points higher than those whose children attended institution-based rehabilitation. Additionally, parents whose children used a cochlear implant for more than 16 hours per day scored 1.26 points higher than those with children using the device for over 8 hours per day. The detailed data analysis results are presented in table 3.

MAIS score analysis of children with different variable characteristics

The MAIS scores of children, analysed across various characteristics, are presented in table 4. Children with active personalities scored higher on the auditory speech component (32.29, SD=7.03) compared with children with impulsive (27.47, SD=8.91), calm and introverted (28.95, SD=8.15) or sentimental personalities (28.10, SD=6.1). Children who had undergone surgery more than 3 years prior scored an average of 3.06 points higher than those who had surgery less than 1 year prior. In terms of family income, children from households earning between 5000 and 10 000 yuan per month scored 1.12 points higher than those from families with incomes over 10 000 yuan and 1.76 points higher than those from families earning less than 5000 yuan per month. When considering the method of surgical expense payment, children whose families received reimbursements from national programmes achieved the highest MAIS scores (32.14, SD=7.73), while children from partially funded families had the lowest scores (29.62, SD=6.85). In relation to the postoperative rehabilitation model, children participating in institution-based rehabilitation education had the highest scores (33.38, SD=7.31), outperforming

Table 4 Meaningful Auditory Integration Scale (MAIS) score statistics for each influencing factor

Variable	N	MAIS
Personality		
Active	506	32.29±7.03
Impulsive	17	27.47±8.91
Calm and introverted	150	28.95±8.15
Sentimental	10	28.10±6.10
Duration between initial evaluation and implantation		
<1 year	71	29.72±7.57
1–3 years	260	29.93±7.18
>3 years	352	32.78±7.42
Average monthly household income		
<5 k	313	30.52±8.05
5–10 k	351	32.28±6.91
>10 k	19	28.84±5.77
Payment method for surgery		
National project reimbursement	347	32.14±7.73
Partial fund subsidy	124	29.62±6.85
Self-paying	212	31.16±7.25
Postoperative rehabilitation model		
Family rehabilitation education	316	30.93±8.12
Institution rehabilitation education	144	33.38±7.31
Family and institution rehabilitation education	223	30.72±6.35

those in family-based and combined family–institution rehabilitation. Specifically, institution-based rehabilitation scores were 2.45 and 2.66 points higher than those in family-based and family–institution joint rehabilitation models, respectively.

Regression analysis

The logistic regression analysis results for MAIS scores are presented in table 5. Children with predominantly calm and introverted personalities had lower auditory and speech abilities compared with more active children. Specifically, the odds of achieving lower MAIS scores were 2.40 times higher for calm and introverted children compared with active children (95% CI: 1.548 to 3.734). Significant differences in MAIS scores were observed based on the payment method for cochlear implant surgery. Compared with families who received reimbursement from national projects, children from partially subsidised and self-funded families were 2.85 times (95% CI: 1.654 to 4.892) and 2.74 times (95% CI: 1.659 to 4.539) more likely, respectively, to have lower auditory and speech scores. This finding suggests that partial subsidies and self-funding are risk factors for lower MAIS scores in children.

The analysis also showed that children who underwent cochlear surgery more than 3 years prior were less likely to have low MAIS scores compared with those who underwent surgery less than a year ago, indicating that a longer duration since surgery is associated with improved MAIS scores and potentially better quality of postoperative rehabilitation. Additionally, children receiving institution-based rehabilitation education were 73% less likely to have low MAIS scores than those receiving family-based education (OR=0.27, 95% CI: 0.159 to 0.454). Furthermore, children with parents exhibiting low belief in the rehabilitation process were 2.07 times more likely (95% CI: 1.055 to 4.071) to have lower auditory and speech scores than those with parents showing high belief, suggesting that high parental belief serves as a protective factor for successful rehabilitation outcomes.

DISCUSSION

In this study, we aimed to collect data from both the children who underwent cochlear implant surgery and their parents' levels of KAP regarding cochlear implants. Our findings indicate that parents' KAP directly impacts the children's postoperative rehabilitation. Although parental KAP scores varied according to child and family characteristics, parents generally demonstrated a solid understanding and positive attitude toward cochlear implants and appropriate practices. High levels of parental belief and engagement were associated with more favourable rehabilitation outcomes in children, suggesting that strengthening parental KAP could improve children's health outcomes, rehabilitation success and overall quality of life following cochlear surgery.

Personality emerged as a significant factor influencing rehabilitation quality postimplantation, with children displaying active personalities showing a more positive response to postoperative interventions. This highlights the role of a child's temperament in their rehabilitation progress. Clinically, some children with cochlear implants experience psychological or behavioural challenges, such as introversion, timidity or social withdrawal, and may face peer biases. These traits, such as limited verbal communication, delayed cognitive development and slower auditory and speech progress,[22–24] can hinder both their recovery and broader developmental growth. These findings suggest that, in addition to implantation timing and rehabilitation methods, intrinsic factors such as the child's personality warrant attention. The family environment and parenting style are crucial in shaping a child's character and can influence rehabilitation outcomes. Therefore, early identification of family education challenges based on children's behavioural characteristics is essential in clinical practice. Tailored guidance for families can foster a supportive, balanced and nurturing environment that promotes healthy growth and enhances rehabilitation success in children with cochlear implants.

We observed that children who had used cochlear implants for more than 3 years achieved higher MAIS scores. Cochlear implant benefits accumulate gradually over several years postimplantation,[25] with longer implant

Table 5 Logistic regression analysis of Meaningful Auditory Integration Scale (MAIS)

	β	SE	P	OR (95% CI)
Gender				
Female vs male	−0.140	0.177	0.430	0.869 (0.614 to 1.23)
Personality				
Impulsive vs active	0.526	0.607	0.386	1.692 (0.515 to 5.559)
Calm and introverted vs active	0.877	0.225	<0.0001	2.404 (1.548 to 3.734)
Sentimental vs active	1.445	0.835	0.084	4.242 (0.826 to 21.791)
Age at evaluation				
3–6 years old vs <3 years old	0.391	0.363	0.281	1.478 (0.726 to 3.009)
>6 years old vs <3 years old	0.328	0.409	0.423	1.388 (0.622 to 3.096)
Age at cochlear implantation				
3–6 years old vs <3 years old	0.134	0.212	0.528	1.143 (0.754 to 1.733)
>6 years old vs <3 years old	0.043	0.301	0.886	1.044 (0.579 to 1.883)
Duration between initial evaluation and implantation				
1–3 years vs <1 year	0.084	0.331	0.800	1.088 (0.568 to 2.082)
>3 years vs <1 year	−1.087	0.384	0.005	0.337 (0.159 to 0.717)
Cochlear origin				
Austria vs China	0.507	0.295	0.086	1.661 (0.931 to 2.963)
America vs China	−0.524	0.664	0.430	0.592 (0.161 to 2.715)
Australian vs China	−0.402	0.623	0.519	0.669 (0.197 to 2.269)
Other vs China	0.615	0.822	0.454	1.850 (0.37 to 9.265)
Average monthly household income				
5–10 k vs <5 k	−0.469	0.198	0.018	0.626 (0.424 to 0.923)
>10 k vs <5 k	0.388	0.576	0.501	1.474 (0.477 to 4.559)
Number of children at home				
Two vs one	0.332	0.202	0.100	1.394 (0.939 to 2.07)
Three or more vs one	0.566	0.291	0.052	1.762 (0.996 to 3.115)
Family history of deaf–mute				
No vs yes	−0.105	0.302	0.729	0.901 (0.499 to 1.627)
Payment method for surgery				
Partial fund subsidy vs national project reimbursement	1.046	0.277	<0.0001	2.845 (1.654 to 4.892)
Self-paying vs national project reimbursement	1.009	0.257	<0.0001	2.744 (1.659 to 4.539)
Preoperative hearing aids				
No vs yes	0.087	0.211	0.679	1.091 (0.721 to 1.651)
Postoperative rehabilitation model				
Institution rehabilitation education vs family rehabilitation education	−1.314	0.268	<0.0001	0.269 (0.159 to 0.454)
Family and institution rehabilitation education vs family rehabilitation education	0.043	0.217	0.844	1.044 (0.682 to 1.598)
Knowledge (low vs high)	−0.745	0.238	0.002	0.475 (0.298 to 0.757)
Attitude (low vs high)	0.729	0.344	0.034	2.072 (1.055 to 4.071)
Practice (low vs high)	0.081	0.265	0.759	1.085 (0.646 to 1.823)

durations showing a more pronounced effect on hearing and speech development. This improvement is likely due to factors such as stabilisation of electrode impedance, optimisation of device settings, auditory adaptation and progressive enhancement of auditory and speech skills.[26 27] Thus, as children's hearing and speech abilities develop, their communication with others improves, promoting further progress in auditory and language skills. Additionally, parents' KAP regarding the rehabilitation process significantly impacts children's postoperative

outcomes and evolves over time as children adapt to the cochlear implant. The greater the interval between initial implantation and subsequent assessments, the more favourable the rehabilitation outcomes tend to be. Therefore, supporting children's long-term stable development by establishing comprehensive health records, conducting regular follow-ups and making timely adjustments is essential to help them progress optimally.

Regarding postoperative rehabilitation methods, our study found that early institution-based education yielded the most favourable outcomes, likely due to the structured and professional nature of institutional training.[12] However, given children's strong emotional attachment to their parents, a combined institutional and family-based rehabilitation approach has its advantages. Previous research has demonstrated that combining family and institutional rehabilitation results in higher speech assessment scores than either family-based or institution-based approaches alone.[28] This finding suggests a need for further research into optimising rehabilitation models, including offering additional training to parents to enhance family-based rehabilitation effectiveness.

With regard to payment methods for surgical expenses, children whose surgeries were funded by national projects demonstrated better postoperative rehabilitation outcomes. In Yunnan province, various support measures, including financial subsidies for cochlear implant surgeries, cochlear implant products, hearing aids and rehabilitation training, have been implemented at both provincial and city levels to assist children with hearing disabilities.[29] These subsidies significantly alleviate the financial burden on families, reducing the risk of poverty due to high medical costs and protecting families from catastrophic health expenses. According to Maslow's hierarchy of needs, reducing financial stress allows families to allocate more time and resources to focus on their child's rehabilitation and care, thereby supporting more successful rehabilitation outcomes.

Parental KAP levels directly influence children's postoperative rehabilitation success. Higher parental attitude scores, in particular, suggest a more positive approach to postoperative care, including providing essential emotional support. This positive attitude may also reflect the benefits of a strong social support network, which can contribute to improved health outcomes. Although the regression analysis did not indicate a significant impact of parental attitudes on children's rehabilitation outcomes, it did show a positive effect on parents' postoperative care behaviour. Beliefs strongly drive behaviour change, and establishing positive beliefs and attitudes in parents can encourage children to adopt healthier behaviours themselves.[30] As advocates for their children, parents play a critical role in selecting appropriate treatments and supporting their children's rehabilitation journey. Their understanding of hearing loss, confidence in cochlear surgery and medical providers, and proactive behaviour throughout the treatment and rehabilitation process directly affect their child's health outcomes. Similar findings have been reported in other studies.[31 32] Finally, lower KAP levels were observed among parents with a monthly household income below 10 000 yuan and those using family-based or combined family-institution training models.

To enhance children's postoperative rehabilitation, it is essential to further strengthen parents' KAP levels. First, additional support measures (both financial and otherwise) should be developed, and mechanisms for identifying and monitoring children with hearing impairments should be improved. Subsidies should be scaled according to family income levels, with particular emphasis on supporting parents' KAP, especially in areas of rehabilitation training assistance. Second, we should raise awareness among parents and communities, expanding outreach through multiple channels. This can include distributing informational brochures, setting up notice boards in public spaces, organising educational sessions in hospitals and communities and using social media and other platforms for broader reach. Targeted guidance should also be offered based on the needs of different groups, such as telephone counselling, accessible professional consultations and on-site guidance for those with mobility limitations. Lastly, the government should enhance the role of community groups in supporting parental KAP, encouraging volunteer initiatives to help families access rehabilitation resources and establishing communication platforms to facilitate peer support among parents. Such efforts would expand parents' access to high-quality resources and foster mutual assistance within the community.

Conclusion

The quality of cochlear implant rehabilitation is critical for children's development of hearing and speech abilities. However, most previous studies have focussed on individual child-related factors affecting rehabilitation outcomes, with few examining the influence of parental factors. Building on prior research, this study empirically verified the impact of parental KAP on rehabilitation outcomes and identified key influencing factors. We believe that this study can serve as a valuable resource for guiding parents in enhancing care and rehabilitation practices following cochlear implantation, ultimately contributing to improved health outcomes and quality of life for these children.

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ORCID iD

Wenyue Chi http://orcid.org/0009-0006-7487-3228

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