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The use of system of Frequency Modulation by children and adolescents from a hearing health care service

O uso do Sistema de Frequência Modulada por crianças e adolescentes atendidos em serviço de saúde auditiva

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ABSTRACT

Purpose: To analyze de use and reasons for not using of FM systems by children and adolescents with hearing loss and users of hearing aids (HA) and or cochlear implant (CI). **Methods:** A questionnaire applied in the form of an a interview through telephone contact was used. The questions were removed from the questionnaire "*FM Listening Evaluation for children*", translated and adapted for Portuguese language by Jacob et al. (2010) and named "Avaliação do Sistema FM", and three other questions prepared by the researchers. **Results:** 87 parents/guardians were interviewed, and it was verified that less than half of the sample used the FM system. As for the median use of the FM systems daily hours, there was a statistical difference in patients with FM in CI, Who used the device for a greater number of daily hours than hearing AID users. The main reason for non-use also presented statistical difference to the fact that patients have received new hearing aids and/or CI incompatible with previously obtained. Also, respondents would like the guidance provided improved. **Conclusion:** Most patients did not use the FM system, the main reason being the usage of new hearing aids and/or CI. Patients with CI use FM more effectively (daily).

Keywords: Hearing loss; Hearing aids; Cochlear implant; Noise; Child; Learning

RESUMO

Objetivo: Analisar o uso e os motivos para o não uso do Sistema de Frequência Modulada (FM) por crianças e adolescentes com perda auditiva e usuários de aparelhos de amplificação sonora individual (AASI) e/ou com implante coclear (IC). **Métodos:** Foi aplicado um questionário em forma de entrevista, por meio de contato telefônico. As questões foram retiradas do questionário *FM Listening Evaluation for Children*, traduzido e adaptado para a língua portuguesa por Jacob et al. (2010) e denominado Avaliação do Sistema FM, bem como outras três perguntas elaboradas pelos pesquisadores. **Resultados:** Foram entrevistados 87 pais/responsáveis, verificando-se que o sistema FM era utilizadopor menos da metade da amostra. Quanto à mediana de uso de horas diárias do sistema, observou-se diferença nos pacientes com FM no IC, que usavam o dispositivo por maior número de horas diárias, do que os usuários de AASI. Igualmente apresentou diferença estatística o principal motivo para onão uso, relacionado ao fato de os pacientes terem recebido novos AASI e/ou IC incompatíveis com a tecnologia obtida anteriormente. Ainda, os entrevistados gostariam que lhes fossem fornecidas melhores orientações. **Conclusão:** a maior parte dos pacientes não utiliza o sistema FM, sendo o principal motivo o uso de novos AASI e/ou IC. Os pacientes com IC usam o FM de forma mais efetiva (diariamente).

Palavras-chave: Perda auditiva; Auxiliares de audição; Implante coclear; Ruído; Criança; Aprendizagem

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INTRODUCTION

Reducing the negative impact of hearing loss on communication is one of the main objectives of the habilitation or rehabilitation process for people with hearing loss. The process starts with the recommendation, selection, and hearing aid fitting.

Nowadays, we have access to cutting-edge technology, such as the use of algorithms, which partially suppresses environmental noises, and directional microphones, which make it possible to capture sounds from a certain direction. However, we find that hearing aids have limitations, especially when it comes to optimizing the signal/noise relationship for thehearing impaired, particularly when the sound source is distant[1]. Background noise (competitive) hinders communication. It may disrupt comprehension and cause tiredness due to increased listening effort and learning difficulties caused by the loss of information or by the wrongmeaning extracted from the speaker's message[2].

To improve the comprehension of the signal/speech in noisy, reverberant environments and when the sound source is distant, there is the Modulated Frequency System - FM, which is a hearing accessibility device[3]used as a complement to the hearing aid, or cochlear implant (CI). Its use can result in a better perception of speech recognition for adults and children with or without hearing loss[4].

In Brazil, Ordinance nº 1.274 ofJune 25th2013 includes the FM System in the table of procedures, medications, orthoses, prostheses and special materials of Sistema Único de Saúde – SUS (Unified Health System). According to the Ordinance nº 1.274, to be eligible to receive a hearing aid, patients must be at least 5 years of age and not older than 17 years of age, have mild, moderate, severe or profoundsensorineural hearing loss impairment, andbe enrolled in elementaryschool, junior high or high school.The reason for that recommendation relies on the fact that during formal education years, students with hearing loss need to hear their teacher's voices, even in noisy, reverberant environments or from a great distance[3,5]. Some authors consider this system an important educational tool for people with hearing impairment[6].

In 2020 a new ordinance of Ministério da Saúde– MS (Brazilian Ministry of Health) (Ordinance of November 19th, 2020) was published in order to extend the use of FM System to people with hearing impairment who are attending any school level, regardless of their age[7]. Its aim was to improve students hearing abilities and, consequently, learning opportunities.

The use of the FM System involves the proper trainingfor parents and teachers, given the fact that the family is fundamental during the adjustment period to wearing hearing aids and for language development. Teachersspend a lot of time with children at school, and it is important that they know how to handle the device so that students have a clear reception of the messages being conveyed, which is thefirst step in processing information and learning[8]. A few authors state that instructions should be given to the entire school staff, including support teachers, trained personnel, and classmates of the hearing aid user. The fear of handling hearing devices may cause the user to partially use it or not to use it at school[6].

Considering the benefits of the FM System in the reception of auditory stimuli and, as a result, the development of language and learning, as well as the possibility of its concession by hearing health programs accredited by the Ministério da Saúde (Brazilian Ministry of Health), it is necessary to investigate the use of this device by children and adolescents who, through the public system, receive it with the hearing aid or CI. This study aimed toanalyze the use and reasons forchildren and adolescents with hearing loss not using the FM System.

METHODS

We conducted an observational, analytical, cross-sectional study which was approved by the Research Ethics Committee of the Hospital de Clínicas of Porto Alegre under the number 2.140.611. Since the data collection was carried out by telephone, and in accordance with the authorization of the Research Ethics Committee, the initial part of the telephone call was about the Informed Consent Form. The interviews startonly after the reading of information and details about the research and the acceptance by the parents of the children and adolescents.

The sample consists of children and adolescents with bilateral hearing loss users of hearing aids and/or cochlear implants who received the FM System at the institution, according to the criteria for prescription determined by the Ordinance 1.274. We consulted a protocol book to identify patients. Subsequently, electronic medical records were consulted to verify patients' data, such as gender, age, type and degree of hearing loss, and telephone numbers to contact. As for the degree of patients' hearing loss, we choose the classification following the World Health Organization (WHO)[9].

We excluded from the sample patients over 18 years of age and those whose parents/guardians did not answer the telephone calls after three failed attempts. We excluded patients over 18 years of age because of the objective of this study, which is to investigate the use of the FM System by children and adolescents. According to the Estatuto da Criança e do Adolescente – ECA (Child and Adolescent Statute), individuals under 12 years of age are considered children, and individuals between 12 and 18 years of age are considered adolescents[10].

To assess the use of the FM System in children and adolescents, as well as the reasons for not using it, part of the *FM Listening Evaluation for Children* instrument, which was created by Cheryl Johnson in 2003[11] and translated and adapted by Jacob et al.[11], was used. We used questions addressing the topic "Information on the use of the FM System". To obtain specific information about the use of this resource at school, the challenges of its adaptation and suggestions, we elaborated and included three more questions.

Considering that many patients do not live in the same city as the institution where this study was carried out, we decided to use a questionnaire was administered over the telephone, following a script designed specially for the study. The same researcher made all the calls using the institution's telephones. We decided to ask the questions to parents or guardians due to the age of part of the participants and the possibility that, over the telephone, patients have difficulty in understanding questions.

The researcher followed a script over the phone. At the beginning, parents/guardians answered questions about the daily use of FM System. When they informed that the patient did not use it daily, the classification we gave was occasional use. After that, the question was about the hours of use.

Subsequently, the explanation was:

> I will ask you a few questions about everyday situations without FM (or with FM). You will tell me which answer is closest to

the number of times that it happens to your child in a given situation. For example, if the auditory response happens in a certain normally exposed situation, you can tell me "4" or "5". If your child hardly ever responds audibly to this, you will indicate "1" or "2". Thus, the options are from 1 to 5;the more often they respond in a situation, the higher the score. An example of what we expect from you is: if I ask you "Do you drink milk?" and your answer is 1 (one), it means that you almost never drink milk, or if you answer 5 (five), it means that you always drink milk. Think before answering, take your time. There is no right or wrong answer. I am interested to find out what really happens to your child in these situations. If I ask something that does not happen on a daily basis, let me know, for we can check the answer 'not applicable'. Some situations exemplified may not be relevant to your child at this time, but that does not mean that their development is delayed. As this questionnaire is used to assess children of different age groups, some questions may not apply, but it is important that you report it to me so that I can make a note and verify their development in this situation in assessments that will be carried out in the future[12].

Then, parents/guardians answered the 12 questions. The initial 5 questions were about the handling, operating conditions and the comfort in using the device. The answers received scores from 1 (hardly ever) to 5 (usually) or NA 'not applicable'.The questions were the following:

1. Are they easy to handle?
2. Have they been in good functional order?
3. Are they comfortable for your child to use it?
4. Does your child try to turn it off?
5. Do they have audio feedback (whistling)?

Questions 6 and 7 were about activities in which FM System was used (break time at school, games, reading stories, playground, walking, speech therapy, shopping mall, car). Considering all the activities, they should inform in which of them the patient used the technology in question number 6, whereas in question number 7 they should indicate in which activity FM System had helped the most. Question number 8 was about the interviewee's knowledge about the benefits of FM System. Question number 9 was about the parents'/guardians'perception on the greatest changes due to the use of the technology.

With questions 10, 11, and 12, created by the authors, we aimed to investigate the use of FM System at school, the adaptation challenges, and suggestions about the process of adaptation to the use of a hearing aid.

The sample size calculation was performed using WinPEPI ("*Programs for Epidemiologists*"), 11.43version, and based on the study by Alves et al.[13]. For a confidence level of 95%, maximum estimated prevalence of 50% (questions about the activity in which the FM System is used, ease of use, good operating conditions, comfort, child who tried to turn it off, greater benefit of the FM System, changes perceived because of the FM System), population that received the FM System (155 children and adolescents), error rate of 7%, the minimum total number obtained was 87 children and adolescents.

The numerical variables were described considering their mean and standard deviation, or median and interquartile range. The categorical variables were described by absolute and relative frequencies.To compare the medians, Mann-Whitney test or Kruskal-Wallis test, and Dunn tests, were used. To the comparison of the proportions, Fisher's Exact test or Chi-squared test, and analysis of adjusted residuals were used. The significance level we used was 5% ($p<0.05$) and the analysis were carried out using the program SPSS 21.0 version.

RESULTS

Throughout the study, we could identify that 176 patients had received FM System at the institution. 21 of them were excluded for being over 18 years of age on the day of the telephone call and 68 did not answer the phone calls after three attempts, or the telephone number was out of date. Therefore, the sample had 87 patients. The mean age was 11.9±2.4 years and 56.3% were female.

The hearing categorization of patients included in the study indicates that 95.4% of them had sensorineural hearing loss and the predominant degree was profound (Table 1).

It was found that, of 87 patients, 39 (44.8%) children/adolescents were using FM System. The total sample of patients who received the FM System was distributed regarding the use (or not using) of the device considering the indication hearing aid or Cochlear Implant or hearing aid and Cochlear implant, no significance was found (p=1.0) (Table 2). The main reasons that caused patients not to use their devices were due to imcompatibility with the hearing aids or technical problems (Figure 1).

As for data regarding daily use (or not), there was a similarity in the number of patients with hearing aids or CI who reported having used the device daily. As for the median for the daily use of the system, there was a statistical difference in patients with FM in their CI who used the device for longer hours daily than hearing aid users(p=0.002) (Table 3).

Table 1. Auditory caracterizazion of patients included in the study

Variables	n=87
Type of hearing loss – RE – n(%)	
Condutive	2 (2.3)
Mixed	2 (2.3)
Sensorineural	83 (95.4)
Type of hearing loss- LE – n(%)	
Condutive	2 (2.3)
Mixed	2 (2.3)
Sensorineural	83 (95.4)
Grade of hearing loss – RE – n(%)	
Milid	1 (1.1)
Moderate	7 (8.0)
Severe	10 (11.5)
Profound	69 (79.3)
Grade of hearing loss – LE – n(%)	
Mild	2 (2.3)
Moderade	9 (10.3)
Severe	6 (6.9)
Profound	70 (80.5)
Hearing loss – n(%)	
Simetric	75 (86.2)
Assimetric	12 (13.8)

Subtitle: n = absolute value; RE = right ear; LE = left ear; % = percentage

Among patients who used the FM System daily and occasionally, data on handling, operating conditions, feedback, comfort and attempts to turn off the device were collected. Except for the questions about disconnection attempts and feedback, the answers were similar between daily and occasional users (Figure 2).

With regard to the main uses of the FM System, it was found that patients used the devices to read stories and for speech therapy (Figure 3).

Question number 8 was about the interviewee's knowledge about the FM System benefits: 56.4% answered that they noticed overall improvement in understanding and 20.5% evidenced noise reduction and amplification of important sounds.

With question 9, we wanted to verify the parents'/guardians' opinionsabout the greatest change they noticed about their child due to the use of technology: 38.5% reported that 'attention improved' and 28.2% informed 'learning improvement'.

After answering the questions, the parents/guardians were asked about a few specific situations. With regard to the school, from the total of respondents (87), 66.7% reported that there was acceptance by children and adolescents' peers at school. However, when asked about difficulties in the adaptation process, only 30.2% answered that the process happened without any difficulty. Among the challenges during the process, 29.1% of interviewees mentioned 'school'; 15.1%, the 'embarrassment presented by the patients because of the use'; 15.1%, the 'difficulty in handling the technology'. When asked about suggestions for improving the FM System adaptation process, most parents whose children used the FM System had no suggestions. Among parents whose children did not use the device, 56% reported having no suggestions; 25% would like to be given instructionsand believe that teachers should be given as well, and, in this item, there was a significant difference between the parents of patients who used (or not used) the device (p=0.041) (Table 4).

DISCUSSION

This study analyzed the use and the reasons that cause patients not to use the technology FM System, provided by SUS, which complements the adaptation of hearing aids and/or CI, aiming to provide patients with a better reception and understanding of people's speech in different types of environment.

The results indicate that nearly half of the patients included in the study who had received the FM System did not use it, which confirms previous studies[14,15]. The main reason mentioned by the interviewees was related to the fact that they had received

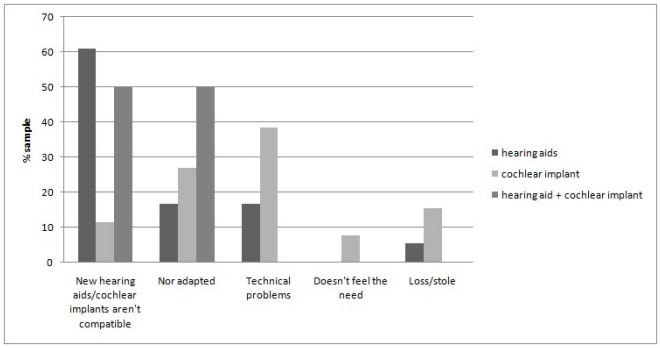

Figure 1. Reasons for not using the FM system
Subtitle: p = significant association by the residual test adjusted to 5% significance; % = percentage

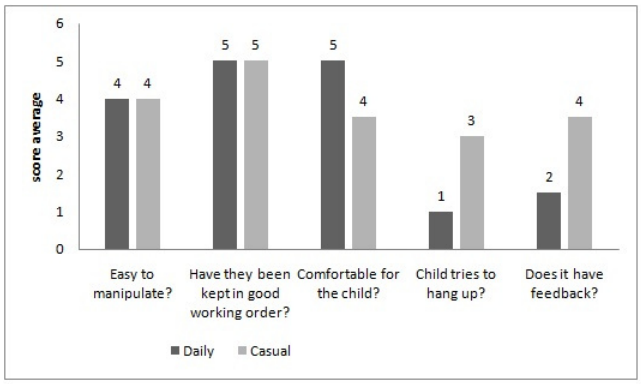

Figure 2. Comparison of patients who use daily versus occasional use
Subtitle: 1- 2 = rarely; 3 = sometimes; 4-5 = normally

Table 2. Association of use/non use I the total sample in relation to the device to witch it was adopted (hearing aids, cochlear implant or both)

Variables	FM on hearing aid (n=42)	FM in CI (n=45)	p value
Use of FM system – n(%)			1.00
Yes	19 (45.2)	20 (44.4)	
No	23 (54.8)	25 (55.6)	

Subtitle: FM = frequency modulated system; CI = cochlear implant; n = number; % = percentage

Table 3. Report of use of the Frequency Modulated System in relation to the adaptation of the device (hearing aids, cochlear implant or both)

Variables	FM on hearing aids (n=19)	FM on IC (n=20)	p value
Frequency use FM – n(%)			1.00
Daily	11 (57.9)	12 (60.0)	
Occasionally	8 (42.1)	8 (40.0)	
Hours/day – md (P25-P75)			
Daily	4 (4-4)	5 (5-6)	0.002*
Occasionally	6 (3-10)	6 (2-12)	0.95

*Significant difference between groups
Subtitle: FM = Frequency modulated system; IC – cochlear implant; md – median; n = number; % percentage; P25 = percentile 25; P75 = percentile 75

Table 4. Parents/guardians suggestions for maintaining/expanding the use of the Frequency Modulated System

Variables	Use FM Sistem	Non use Sistem FM	p value
Suggestions – n(%)			0.04*
No suggestions	29 (74.4)	27 (56.3)	
Improve guidance (parents and teachers)	3 (7.7)	12 (25.0)*	
Improve the device (technical and aesthetical questions)	6 (15.4)	3 (6.3)	
HIgh maintenance cost	1 (2.6)	2 (4.2)	
Technology follow the hearing aids exchange	0 (0.0)	4 (8.3)	

*Statistically significant association by the residual test adjusted to 5% significance
Subtitle: FM = frequency modulated system

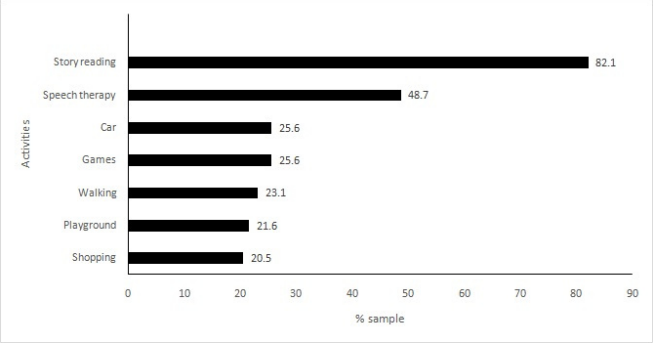

Figure 3. Activities where the FM system is used
Subtitle: % = percentage

new hearing aids and/or new CI that were incompatible with the FM System receptordeliveredpreviously. The SUS hearing health program provides the replacement of hearing aids, but not the FM System. Considering that many children do not know how to handle their devices or take proper care of them, devices' lifespan is reduced. In addition, among other problems that can damage the devices, children participate in activities that put their devices at risk, such as games, which exposes their hearing aids to falls, impacts, and humidity. Thus, it is clear that instruction on the proper handling of the devices is as important as the fitting. Investing in changes in this area is one of the ways to minimize public spending on devices replacement. A study carried out at the same hospital wherethis study was conducted shows that the replacement of hearing aids in children took longer on average than in adults and the elderly. As a result, we state that SUS should consider the possibility of maintainance the FM System[16].

With the new ordinance by the Ministério da Saúde, the age range for granting the FM System was expanded, including individuals attending any academic level[7]. The maintenance or replacement of the FM System due to technical problems is, however, not mentioned in the official documents. Thus, the concession is expanded, but the user is still at risk of discontinue the use if any technical problem occurs, which can be extremely harmful, especially in the age group of this study. Children need to have their hearing aidsreplaced, especially due to technical problems, which often happens more than once[16]. Amplification systems are replaced. In the same way, we strongly believe that FM Systems should be replaced as well.

Some countries that have embraced the use of the FM System, such as Canada, Lithuania and Jordan, provide replacement of this type of technology. In Canada, the government subsidizes 75% of the system value every three years. In Lithuania and Jordan, after five years of use, it is possible for the patient to buy new equipment. However, there are countries such as Brazil, Austria, Denmark, France, Germany, Sweden, Norway and the United States that have adhered to the use of the system, but have not discussed its replacement[17].

Since 6/25/2013 when Ordinance nº 1.274 was published, which included the personal FM device as a hearing aid, it is up to hearing health programs to prescribe the use of this technology, subject to compliance with certain criteria[18]. Respecting, through a thorough evaluation, the indication criteria recommended by the aforementioned ordinance is crucial for the successful adaptation of the FM System, which is individualized for each patient.

In addition to the criteria in the ordinance, a audiologist can check the condition of the FM System using a tool to assess its transparency, that is, to verify its electroacoustic characteristics, which is a crucial procedure for effective adaption. The *American Academy of Audiology* (AAA) defines 'Transparency' as the ability to ensure that the FM System connection does not change the hearing aid gain settings and that both the signals, FM and the hearing aid microphone, are audible. Transparency is achieved when the 65 dB SPL input for the FM microphone produces a result equal to the 65 dB SPL input for the hearing aid microphone[19]. The findings of this study underline the need of verifying the system's transparency, which was not done with the participants. That associated with the auditory profile of the patients who had a high prevalence of profound hearing loss in both ears shows a scenario with the predominance of patients who, with the adoption of hearing aids, have little chance of success, in terms of auditory perception.

We found evidence that indicate that the CI users use the FM System more effectively (5-6 hours/day). Previous studies show the same, FM associated with CI as essential for children with hearing impairment, especially at school[4,14,20-22].

The results can be explained by several reasons: careful selection before surgical indication; pre-implant assessment; multifactorial indication, which includes the type and the degree of hearing loss, age, time of auditory sensory deprivation; access to speech therapy; global development; the presence of other impairments related to hearing loss; instruction to parents/guardians about the importance of hearing to their child's development; motivation and participation of parents/guardians in the child's rehabilitation process[21].When the family of the user is more engaged, we promote a favorable attitude toward the process.

The interviewees who said their child used technology on a regular basis also said it happened at school. The classroom setting is an example of how factors, such as reverberation, the

distance between speaker and listener, acoustics, and excessive noise can hinder listening comprehension and cause educational problems. The use of the FM System downplays these obstacles and, consequently, creates opportunities for better learning[1].

When asked about challenges to adapting to the FM System, parents/guardians mentioned the school, the embarrassment of their child in using the technology, and difficulties in handling the device. For the dispensation of the FM System, it is necessary not only a hearing assessment but also follow-ups, through reviews, to verify the use of the system and the benefits related to it. The monitoring of patients who received FM kits by SUS allows the evaluation of their use, benefits, and any problems related to the functioning of the device.

Difficulties at school are the main challenge, which evidences the need for more integration between the audiologist, family, and school. The difficulties may exist due to teachers' lack of knowledge regarding the FM System technology. Other researchers have confirmed similar findings[8,23-26].

We highlight that instruction materials should be distributed to help teachers in the use of this technology, and the implementation of measures that enable parents/guardians to collaborate in theprocess and, consequently, contribute to the adaptation[13,15,32].

The 'embarrassment' in using the devices and the 'handling difficulty' have also been addressed in previous studies[13,15], in which a few children reported not using the FM System in the classroom because they would feel embarrassed in front of their peers.

The integration of patients with hearing impairment in environment where they can, through contact with listeners, have auditory experiences has been proved to be beneficial to hearing, speech, language, and learning development. However, the integration of the family, school and audiologist is crucial.

As for suggestions, parents/guardians of patients who did not use the device made a statement about the possibility of better instruction to family members and teachers, which has been stated by other authors previously[26,27]. It is increasingly common for students using hearing aids or CI to attend regular schools. Therefore, it is necessary to prepare teachers. Specific training for problem-solving and instruction about the benefits of using the devices in the classroom would assist users. However, a single appointment is not enough to address the technology thoroughly. It is essential to promote meetings that enable the clarification of questions with families and teachers on a regular basis. A significant group of parents/guardians identified benefits aboutthe device's use. As for the activity in which the FM System helped the most, the reading of stories was mentioned, findings that agree with other authors[8,12].

The interviewee's understanding about the main benefits of the FM System was identified by other authors[8,13,14] in studies that showed 'improved understanding' as a result of the use of technology.Studies evidence that the use of the FM System favors a positive signal/noise ratio of more than 20 dB HL, due to the proximity of the microphone – 6 to 8 cm from the teacher's mouth –, which influences the improvement of speech perception[28-30]. Improvement of speech perception was one of the aspects that parents/guardians reported in this study. They also reported that the use of technology 'decreases noise'.

We emphasize that attention is a precondition for learning to happen. With the decreasing of noise, attention is favored and the outcome will be an improvement in comprehension, which reflects in better learning. Findings from other authors show that the greatest change perceived was the 'improvement in attention'[8,10,12,13,27,31], which is line with our finding.

To promote inclusive education, it is necessary to instruct teachers considering the principles of diversity in education. In order to do so, it is essential to promote respect in the classroom so that students with special needs have good school performance and feel pleasure in learning[24].

The positive results are not only about students' performance at school, overall improvement can be noticed outside the classroom as well. The system provides better amplification, it helps listening skills and gives hearing aids more impetus, keeping the user focused on the speaker, allowing them to be move around and continue listening.

Among the limitations of the study, the impossibility of obtaining information about the use of the FM System from part of the patientsdue to the difficulty of contacting patients. Although the hospital where the study was carried out requested patients or relatives to keep their telephone numbers updated, some of them did not, which made impossible for the team to contact them.

CONCLUSION

Only 44.8% of patients use the FM System. CI users are the ones who use the system on a daily basis

The main reasons for patients not to use the technology is related to thefact that patients had not received new hearing aids or had received CI that were incompatiblewith the technology.

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