

Original articles

Resistance to the use of the FM System by children and adolescents: fact or myth? An analysis of records of patients assisted in a hearing health center

Caroline Spósito¹ Larissa de Almeida Carneiro² Bruna Carolina da Silva Bento¹ Érika Cristina Bucuvic¹ Regina Tangerino de Souza Jacob² 

¹ Universidade de São Paulo - USP, Hospital de Reabilitação de Anomalias Craniofaciais - HRAC, Divisão de Saúde Auditiva, Bauru, São Paulo, Brasil.

² Universidade de São Paulo, Faculdade de Odontologia de Bauru - FOB/USP, Laboratório de Acessibilidade Auditiva e Audiologia Educacional - LAAAE, Departamento de Fonoaudiologia, Bauru, São Paulo, Brasil.

ABSTRACT

Purpose: to compare the use of the Frequency Modulation (FM) System by children and adolescents in a public hearing health center in the state of São Paulo.

Methods: the analysis of medical records based on eligibility criteria. Data were collected from 340 participants born between 1998 and 2011, fitted with FM System, and who attended the follow-up appointment after fitting the device. Data were analyzed descriptively and inferentially.

Results: hard-of-hearing children and adolescents of both genders from all over Brazil, attending elementary, middle or high school in public or private schools, participated. The data showed that 115 children and 155 adolescents effectively used the device, especially at school. The main difficulty for children was the lack of support from teachers; for adolescents, it was the feeling of embarrassment.

Conclusion: some difficulties, especially on children, in adhering to the use of FM Systems were identified. Hence, to ensure the FM System's effective use, the importance of providing guidance and awareness of its benefits to patients, and their family members and teachers, during the fitting appointment and follow-up consultations, is emphasized.

Keywords: Hearing Loss; Speech Perception; Noise; Hearing Aids; Wireless Technology

Study conducted at University of Sao Paulo - USP, Hospital for Rehabilitation of Craniofacial Anomalies, Hearing Health Division, Bauru, Sao Paulo, Brazil.

Financial support: Multidisciplinary Residency Program in Hearing Health at HRAC-USP - Scholarship from Brazil's Ministry of Education and Culture (MEC).

Conflict of interests: Nonexistent.

Corresponding author:

Regina Tangerino de Souza Jacob
Alameda Doutor Octavio Pinheiro Brisola,
9-75, Vila Universitária
CEP: 17012-901 – Bauru, São Paulo,
Brasil
E-mail: reginatangerino@usp.br

Received on: November 2, 2022
Accepted on: January 31, 2023



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INTRODUCTION

Health is critical to habilitate and rehabilitate people with disabilities, preparing them to exercise fundamental rights and freedom to achieve social inclusion and respect to citizenship.

In the auditory rehabilitation process of hard-of-hearing (HH) people, the use of Frequency Modulation (FM) Systems, a complement to the fitting of hearing aids (HA) and/or cochlear implants (CI), aims to improve speech perception in noisy, reverberant environments and in situations when the sound source is distant from the listener^{1,2}. Currently, remote microphones' technology is not restricted to modulated radio frequency waves to transfer information between the transmitter and the receiver, with new models using digital protocols.

In Brazil, the Ministry of Health regulates the granting of FM Systems to children and adolescents through Ordinance 1.274/13³; therefore, for being the technology most used by public health services' patients and the object of this research, the term FM System will be maintained throughout the text.

It should be noted that the abovementioned ordinance represented an advance to equalize conditions for HH students, as established by the Brazilian Law for Inclusion of Persons with Disabilities (*Lei Brasileira de Inclusão da Pessoa com Deficiência*)⁴.

In this scenario, the Bauru School of Dentistry, one of the University of São Paulo (USP) campuses, has been strengthening Ordinance 1.274/13³ through several studies^{2,5-12} that prove the efficiency and effectiveness of FM Systems. However, even though the device was created half a century ago and the vast international scientific production proves the effectiveness and benefits of using this technology, adolescents have significant difficulties adapting and adhering to FM Systems^{13,14}.

Studies indicate the main factors that can impact on the adolescents' acceptance or rejection of the FM System: 1) acceptance of their hearing status and personal self-esteem; 2) adolescents' motivation to perform well at school and actively participate in classroom activities; 3) adolescents' priority of being treated in the same way as their peers and being equal to them; 4) their age when they started to use FM systems; 5) their teacher's or other school staff member's motivation to use the device and whether these professionals believe it is necessary for students' access to communication (e.g., teachers who disbelieve FM systems because they think their voice is loud

enough for the student to hear); 6) adolescents not wanting to impose extra work on teachers; 7) how well the technology is working and how consistently device functionality is monitored; 8) support given to classroom teachers regarding the purpose and intended benefits of the technology, how to use it and how to solve potential problems; 9) students' knowledge of the technology, intended purpose and benefits, what the technology can and cannot do, and recommended uses; 10) the information that was provided to parents and guardians to gather their support^{14,15}.

This research aims to collaborate in elaborating and implementing new strategies for using and disseminating FM Systems, thus, guaranteeing the expansion of access for children and adolescents to this resource, through public policies.

Hence, the present study aimed at comparing the use of FM Systems by children and adolescents in a public hearing health center, in the state of São Paulo.

METHODS

We conducted a retrospective analysis of medical records of children and adolescents, aged between 6 and 18 years old, undergoing rehabilitation at the Hearing Health Division (*Divisão de Saúde Auditiva - DAS*) of the Hospital for Rehabilitation of Craniofacial Anomalies (*Hospital de Reabilitação de Anomalias Craniofaciais - HRAC*). Free and informed consent forms were unnecessary since this research consisted of analyses of the medical records.

Data collection began after approval by the Research Ethics Committee of the Hospital for Rehabilitation of Craniofacial Anomalies, Brazil, with CAAE number 81825518.7.0000.544, evaluation number 5.072.505 and CAAE number 62585716.7.0000.5441, evaluation number 2.573.583.

Eligibility criteria

Were included in the study individuals who:

- received the FM System kit from HRAC's Hearing Health Division from September 2013 to June 2017,
- were born between 1998 and 2011, i.e., aged between 6 years old and 18 years old,
- resided in Brazilian territory,
- met the eligibility criteria of Ordinance 1.274/13³ of the Ministry of Health, i.e., to be HH and user of HAs and/or CIs; master oral language or being in the process of mastering it; be enrolled in Elementary, Middle or High School; and present

certain performance level in the assessment of speech recognition skills in silence. Whenever possible, a Speech Recognition Percentage Index (*Índice Percentual de Reconhecimento de Fala - IPRF*) better than 30% in silence was suggested. In the case of children who were still developing oral language, when it was not possible to perform the evaluation or use of other tests with words due to their age, a voice detection threshold (*limiar de detecção de voz*) equal to or lower than 40 was considered (with HAs or CIs) for the concession of FM Systems³,

- Individuals who returned for other appointments after having their FM System fitted - as this is the only way possible to investigate and compare the use of the device before and after the fitting, the main interest of this research.

The data extracted from the medical records of children and adolescents who were selected for the research were:

- Demographic characterization of participants (age, gender, level of education, type of school they were, city of origin, parents' education level and socio-economic classification),
- Type and degree of hearing loss¹⁶,
- Year FM system was fitted, its model and brand,
- Verification measures used when fitting the device,
- Frequency and environments FM Systems were used, with effective use being considered a minimum of two hours at school.

The collect of all the information was possible because the public hearing health center where this

study was conducted has a «Personal Frequency Modulation System Selection and Fitting Form» based on the American Academy of Audiology (AAA) guide for fitting remote microphone systems^{17,18}, from which all speech-language information was taken.

Statistical analysis

The collected data were tabulated in Excel and analyzed using the Minitab Software with the support of a statistician.

Data analysis was performed using qualitative descriptive statistics and presented through tables and figures of absolute and relative frequency. Pearson's Chi-Square (X^2) association test and a significance level of 5% ($p = < 0.05$) were used to compare qualitative variables.

RESULTS

After analyzing the medical records and applying the eligibility criteria, data were collected from 155 children and 185 adolescents, calculating 340 individuals (Table 1).

Children and adolescents of both genders who resided throughout the country participated in the research. Regarding gender, the data show that the granting of FM Systems was conducted equally. Regarding education, most individuals attended elementary or middle school (complete or incomplete); that is, they were enrolled in one of the grades from the first to the ninth year of regular school in a public school.

Table 1. Characterization of participants in absolute frequency and percentages concerning age group, gender, educational level and type of school

		Children (n=155)	%	Adolescents (n=185)	%
Aged	5 to 11 years old	155	45.6%		
	12 to 18 years old			185	54.40%
Gender	Males	75	48.0%	98	53.0%
	Females	80	52.0%	87	47.0%
	Total	155	100%	185	100%
School level	Elementary School	103	66.9%	6	3.2%
	Middle School	51	33.1%	112	60.5%
	High School	0	0	67	36.2%
	Total	154	100%	185	100%
	Not specified	1			
Type of School	Total	155			
	Public school	46	65.7%	73	83.9%
	Private school	24	34.3%	14	16.1%
	Total	70	100%	87	100%
	Not specified	85		98	
	Grand total	155		185	

Captions: n = absolute frequency, % = percentages

Some individuals attended by the hearing health center had an FM System. From 2013 and 2017, the concession of FM Systems was more frequent in 2014.

The model usually fitted was the T31 Amigo, from Oticon, with an incidence of binaural use, for both children and adolescents (Table 2).

Table 2. Characterization of participants in absolute frequency and percentages concerning the year they were fitted with an Frequency Modulation System and the model of their device

		Children	%	Adolescents	%
They have an FM System	Yes	154	99.4%	166	89.7%
	No (it was returned)	1	0.6%	19	10.3%
	Total	155	100%	185	100%
Year it was fitted	2013	14	9.0%	47	25.4%
	2014	34	21.9%	104	56.2%
	2015	41	26.5%	32	17.3%
	2016	42	27.1%	2	1.1%
	2017	24	15.5%	0	0%
	Total	155	100%	185	100%
Type of fitting	Monaural	23	21.90%	12	9.6%
	Binaural	78	74.3%	88	70.4%
	Vibrating arc	2	1.9%	6	4.8%
	Neckloop	1	1.0%	29	23.2%
	Total	105	100%	125	100%
	Not specified	51		60	
Model/Brand of the transmitter	Grand total	155		185	
	T31 Amigo/Oticon	125	80.6%	75	40.5%
	Inspiro/Phonak	30	19.4%	32	17.3%
	Dm10/ConfortDigisystem	0	0%	8	4.3%
	Smartlink/Phonak	0	0%	70	37.8%
	Total	155	100%	185	100%

Captions: n = absolute frequency, % = percentages, FM System = Frequency Modulation System

Regarding the association between the effective use of FM Systems and the parents' education level, there was a statistically significant connection between

its use by children and adolescents and the mothers' education level (Table 3).

Table 3. Association between effective and non-effective use of Frequency Modulation Systems and parents' level of education in absolute frequency and percentages

Level of education	Effective use		Non-effective use		
	Child	Adolescent	Child	Adolescent	
p-value	0.054		0.142		
Mother	Elementary School	6 5.50%	14 9.70%	3 7.90%	3 10.70%
	Middle School	12 10.90%	30 20.70%	7 18.40%	12 42.90%
	High School	50 45.50%	62 42.80%	16 42.10%	7 25.00%
	Higher education	42 38.20%	39 26.90%	12 31.60%	6 21.40%
	Total	110 100%	145 100%	38 100.00%	28 100.00%
p-value	0.002*		0.332		
Father	Elementary School	7 7.60%	15 12.00%	3 9.10%	10 41.70%
	Middle School	20 21.70%	34 27.20%	4 12.10%	7 29.20%
	High School	34 37.00%	46 36.80%	13 39.40%	5 20.80%
	Higher education	31 33.70%	30 24.00%	13 39.40%	2 8.30%
	Total	92 100.00%	125 100.00%	33 100.00%	24 100.00%

Captions:

n = absolute frequency

% = percentages

FM System = Frequency Modulation System

Elementary School = Brazilian Ensino Fundamental I (complete or incomplete)

Middle School = Brazilian Ensino Fundamental II (complete or incomplete)

High School = Brazilian Ensino Médio (complete or incomplete)

Higher education = Brazilian Ensino Superior (complete or incomplete)

Pearson's Chi-Square (χ^2) Association Test

* $p < 0.05$ statistically significant

Regarding the children and adolescents' most cited difficulties with the use of FM Systems in their daily lives, the following stand out:

- Embarrassment of using the device was significantly higher among adolescents (15.5% of them mentioned it, but no children did),

- The lack of support from teachers to help the individual during classes was significantly higher among children,
- HAs or FM System breaking was a determinant for children not to use the device (Table 4).

Table 4. Association between the use of Frequency Modulation Systems and the children and adolescents' most cited difficulties in absolute frequency and percentages

	Effective use			Non-effective use		
	Yes	No	Total	Yes	No	Total
Difficulties		p=0.091			p=0.557	
Children	27 23.50%	88 76.50%	115 100.00%	28 70.00%	12 30.00%	40 100.00%
Adolescents	51 32.90%	104 67.10%	155 100.00%	19 63.30%	11 36.70%	30 100.00%
Embarrassment		p=0.000*			p=0.015*	
Children	0 0.00%	115 100.00%	115 100.00%	3 10.00%	37 90.00%	40 100.00%
Adolescents	24 15.50%	131 84.50%	155 100.00%	11 36.70%	19 63.30%	30 100.00%
Lack of support from teachers		p=0.664			p=0.008*	
Children	8 7.00%	107 93.00%	115 100.00%	11 27.50%	29 72.50%	40 100.00%
Adolescents	13 0.40%	142 91.60%	155 100.00%	1 3.30%	29 96.70%	30 100.00%
When HA or FM System breaks		p=0.090			p=0.016*	
Children	20 17.40%	95 82.60%	115 100.00%	14 35.00%	26 65.00%	40 100.00%
Adolescents	11 7.19%	144 92.90%	155 100.00%	3 10.00%	27 90.00%	30 100.00%

Captions:

n = absolute frequency

% = percentages

HA = hearing aid

FM system = Frequency Modulation System

Pearson's Chi-Square (χ^2) Association Test

*p<0.05 statistically significant

When comparing the effective and non-effective use of FM Systems, we verified that adolescents use FM Systems more often since a quarter of children

stated they do not use them regularly in their daily lives (Figure 1).

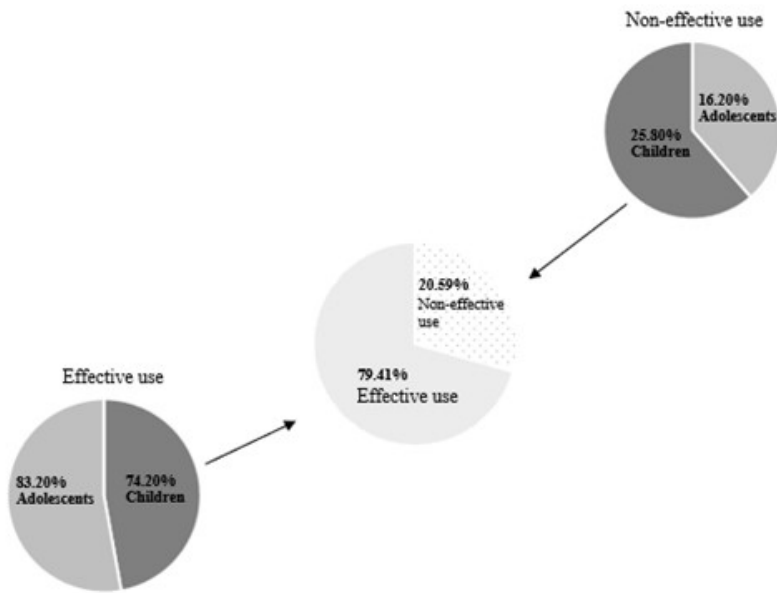
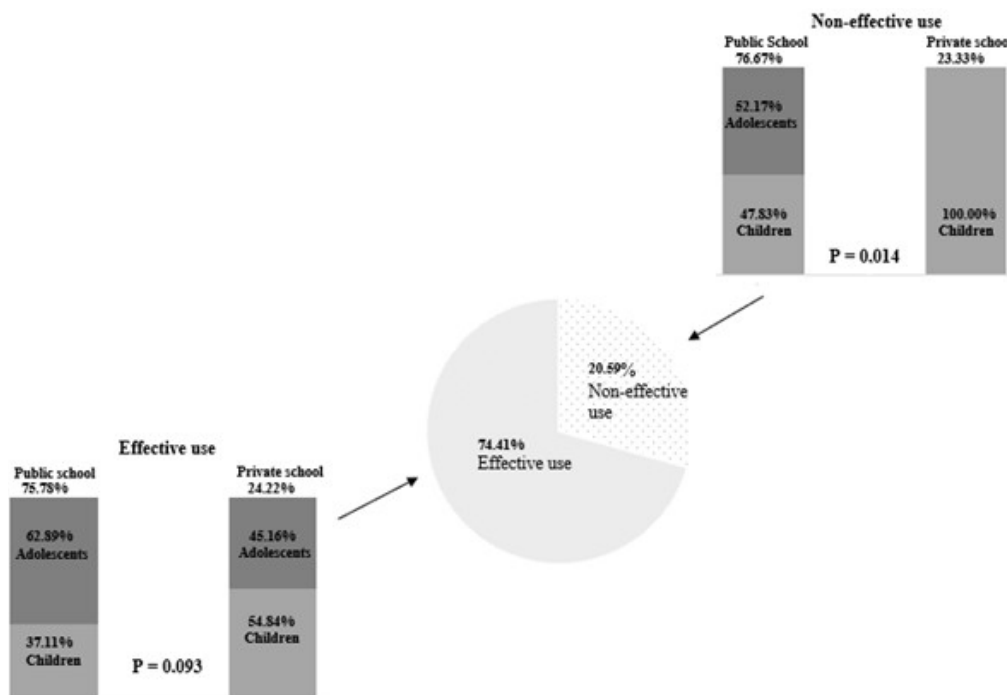


Figure 1. Percentage of children and adolescents who use Frequency Modulation System effectively and ineffectively (n = 340)

Regarding the association between the effective use of FM Systems and types of school, it is important to emphasize that, of the 340 medical records, 70 participants stated they did not use their FM Systems, and of the 270 participants who did, 112 did not declare in which type of school they were enrolled. The crossing of data related to effective use and the type of school

(totaling 158 declarants) demonstrates that all adolescents who did not use FM Systems were from public schools (Figure 2). However, there is no statistical connection between the place of enrollment and diligence to FM System’s use, as children from private schools also stated that they did not use the device.



Pearson’s Chi-Square (X^2) Association Test
 * $p < 0.05$ statistically significant

Figure 2. Percentage of children and adolescents who use Frequency Modulation System effectively and ineffectively and their place of school enrollment (n = 158)

Regarding the connection between FM System's effective use and the places where it was used, we

observed that both groups predominantly used it in the school environment (Table 5).

Table 5. Association between the effective use of Frequency Modulation Systems and the places of use in absolute frequency and percentages

	Child	Adolescent	Total
Home	4 3.5%	26 16.8%	30 100%
School	94 81.7%	98 63.2%	192 100%
Home + school	17 14.8%	31 20.0%	48 100%
Total	115 100%	155 100%	270 100%
p-value	0.000*	0.000*	0.001*
Non-effective use	40	30	70
Grand total	155	185	340

Captions: FM system = Frequency Modulation System; n = absolute frequency, % = percentages.

Pearson's Chi-Square (χ^2) Association Test

* $p < 0.05$ statistically significant

DISCUSSION

The present study sought to investigate the outcomes of the public policy for granting FM Systems in a hearing health center through the analysis of 340 medical records. Of the records, 155 were from children and 185 from adolescents, all fitted with the device and studying in Elementary or Middle School in a public school. All of them had returned for a post-fitting consultation, coming from all regions of the country.

We discovered most participants use the device, demonstrating adherence to the FM System. We found it interesting that, of the 40 children who did not use FM Systems, only one returned the device, and of the 30 adolescents, 20 returned it. The return of FM should be viewed through a healthy perspective since it may be associated with the transfer of the decision-making process from the parents to the adolescent, who might decide on the use of electronic devices and remote microphones regardless of the decision of those responsible for them. It is also important to remember that these decisions are often associated with the individual's psychosocial and emotional development¹⁹.

Most patients have an FM System, and more than half of the adolescents received it in 2014, shortly after the enactment of the Ordinance that granted it through the Brazilian public health system (*Sistema Unificado de Saúde - SUS*)³. These data corroborate another study that found that the number of devices granted

progressively decreased between 2014 and 2017, probably due to previously repressed demand²⁰.

In this research, children and adolescents reported using the device effectively at school and at home; however, its adherence is higher at home among adolescents. There are several daily situations where the FM System might be helpful, such as watching television, listening to music on other educational aids (like computers and tablets), and even having conversations at home.

These situations should be explored in the search for greater adherence to the use of FM Systems, as these young people were born in a time when science advances at a rapid pace and updates are constant, uninterrupted and integrated. By offering FM Systems that connect to various electronic devices (such as television, landline, cell phone, computer, notebook, tablet, microphone, and music gadgets), HH adolescents have access to a technological world that only normal-hearing people could access. Thus, allowing HH adolescents to have some of the chances and opportunities for knowledge and growth that are natural to this phase of life.

The covid-19 pandemic transformed academic and work scenarios and made these technologies mandatory since working and studying from home obligate people to connect to at least one of the equipment mentioned above.

Therefore, the Brazilian public health system must offer remote microphone systems that follow the evolution of the technological market to these children and adolescents. In December 2019, six years after its publication, the Ordinance granting the FM System³ was revised through a public consultation (SCTIE 69/2019) conducted by a national commission that analyses the incorporation of technologies in the Brazilian public health system (*Comissão Nacional de Incorporação de Tecnologias no SUS - CONITEC*), linked to the Ministry of Health²¹. In February 2020, a unanimous recommendation was made about expanding the granting of FM Systems to HH individuals regardless of age and educational level at which they are enrolled; however, aspects related to replacing equipment or updating its technology were not discussed.

Nonetheless, this recommendation has not yet been implemented, establishing the judicialization of health as fundamental in achieving access to this right²²; which is concerning since our research showed that the main cause for children not using FM Systems is device breakage.

The complexity of adhering to FM Systems' use is another aspect to be considered. It is much more complex than simply handing the device over to patients and their family members and expecting the subject to successfully use it without articulating with parents, teachers and health professionals²³. The multi-disciplinary team considers a follow-up appointment a determining factor in adherence to FM Systems since it is the moment to conduct tests to check if the device (transmitter and receiver) is functioning correctly and to verify complaints regarding everyday problems. Guidance on handling and caring for the device is fundamental: the professional must ensure that the information provided is well understood by the family, which will disseminate this knowledge, especially to the school¹⁷.

It is worth mentioning that the hearing health center where this study was conducted uses the protocol suggested by the AAA's guide of good practices for fitting remote microphone systems¹⁸, which consists of a speech-in-noise test, verification of electroacoustic characteristics and questionnaires¹⁷.

The data crossing regarding the effective use of FM Systems and the place of school enrollment did not indicate a significant correlation, in agreement with Barreiros's study²⁴. In this research, 63 children participated, and the authors concluded that the effective use of FM Systems was not influenced by the characteristics

of the school, except for a tendency of greater use in private schools. This result may indicate that greater attention should be given to parents of public school students.

It is commonly assumed that the higher the level of education of parents/guardians, the higher the academic performance expectations for their children. For families with higher education levels, perhaps it is more evident that the lack of use of FM Systems can lead to difficulties in the academic and social development of HH students, which could be evidenced by the association between the mother's education level (high school and higher education) and greater adherence to the use of the device. These findings corroborate the observation of authors²⁵ who researched North American children and noticed that parents or guardians with a higher level of education tended to value the technology used at school, which resulted in greater adherence to FM Systems in the school routine.

Comparing the data from children and adolescents regarding difficulties with using the FM System, we observed that, despite the statistical associations not being significant, adolescents tended to have more difficulties than children. We might explain this tendency by the year FM System's policy was implemented: 2013, so most of these adolescents were already in this stage of their lives when they started to use the device.

Thus, as a limitation of this study, we point out the importance of future analyses regarding the influence of the age of the first fitting as part of the hypothesis for the adolescents who participated in this study. Future studies may analyze the behavior of young people who have been fitted with the device since childhood. We hypothesize that when HH children are helped to understand and accept their hearing limitations and receive support before reaching adolescence, they can develop coping strategies before going through the physical and hormonal changes of that life's stage, which often influence the rationalization of events¹⁵.

Adolescents reported embarrassment as their main reason not to use their FM Systems. They mentioned the desire not to feel different from their peers and/or the embarrassment of asking each teacher to use the device, which was also shown in another study 14, and that, given their need to cope, they chose to give up using it. Adolescents reported more embarrassment in using the FM System than children, regardless of whether they were effectively using it.

The lack of support from the teachers was associated with the non-effective use of FM Systems, especially by the children. In another study⁸, other reasons were also mentioned for the non-use or partial use of FM Systems, such as the teacher's excessive body noise and the fear of taking the device to school. These findings reiterate the importance of teachers' understanding regarding the correct use of the device and how much they influence the non-effectiveness of its use in the classroom.

In addition, as explained in the technical document emitted by the Ministry of Education, the *Nota Técnica nº 28/2013/MEC/SECADI/DPEE*²⁶, teachers' continued education must be guaranteed in order for them to be qualified to use FM Systems. Brazilian teachers have accounted in their work schedule a time slot that must be allocated to extracurricular activities (*Horário de Trabalho Pedagógico Coletivo – HTPC*). This slot would be the ideal time for this type of training, in which specialized professionals could be brought to school to guide the teachers on site.

However, teachers' continued education must go beyond explaining technical aspects of the proper use of FM Systems; it must seek the teachers' understanding regarding their responsibility to guarantee adequate conditions for their students' learning²⁷. Finally, we expect the data presented in this study to support the need to review the Public Ordinances related to FM Systems so HH children and adolescents can learn on an equal basis with other students, seeking an effective educational inclusion that improves their academic career and facilitates their entry into the job market, thus achieving an independent life.

Hence, we emphasize the importance of providing guidance and awareness of FM Systems' benefits to patients and their family members during the fitting appointment and follow-up consultations to guarantee effective use.

CONCLUSION

In this study, it was concluded that:

- 79.4% of the 340 individuals fitted with the FM System effectively use the device,
- Individuals who use the FM System effectively are those who have fewer problems with equipment or hearing aid breaking,
- Adolescents use FM Systems more than children do,

- Adolescents use FM Systems at home, in situations such as watching TV, listening to music, and using a computer and tablet, more than children do,
- for adolescents, embarrassment is the most significant difficulty in using FM Systems; for children, lower adherence to the device is associated with a lack of support from teachers,
- Among those who do not use the FM System, adolescents return the device to the health center more often than children,
- There is a correlation between effective use and the mother's higher educational level for both groups,
- The type of school (public or private) does not influence the consistency of device use.

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Author contributions:

CS: study design, data collection, analysis, writing original draft;
 LAC: writing original draft, review, and editing;
 BCSB: study design, data collection, analysis, writing review;
 ECB, RTSJ: study design, supervision, writing review.