Literature Review

https://doi.org/10.1590/2317-6431-2022-2643en

Audiology Communication Research
ISSN 2317-6431

Audiological monitoring of infants in different newborn hearing screening programs: a systematic review

Monitoramento audiológico de lactentes em diferentes programas de triagem auditiva neonatal: uma revisão sistemática

Déborah Aurélio Temp[1], *Laís Ferreira*[1], *Eliara Pinto Vieira Biaggio*[1]

ABSTRACT

Purpose: To search the literature for guidelines on infant's audiological monitoring, most commonly used procedures, the age at which they are performed, which population should be monitored and the countries that study the subject the most. Besides, the importance and effectiveness of these measures will be discussed.
Research strategy: The review was conducted based on the PRISMA recommendations, registered on the PROSPERO platform. The studies were searched for in the electronic databases Medline (Pubmed), Web of Science and SciELO, using the descriptors hearing, neonatal screening and follow up.
Selection criteria: studies reporting the audiological monitoring were included. No filters on year and language of publication were used.
Results: A total of 432 articles were found and 21 were included in this study, mostly produced in developed countries. The Auditory Brainstem Response and the Behavioral Assessment were the most frequently used procedures. As to age and population, most infants are subjected to audiological monitoring up to three years of age and have Risk Factors for Hearing Loss in their clinical history.
Conclusion: The studies pointed that there is no standard among the protocols for performing audiological monitoring, but it was possible to identify agreement as to the age at which such monitoring takes place and which population should be monitored. However, although there is some disagreement, the assessment methods used in the studies are effective in detecting mild, progressive and/or late hearing loss, in addition to false negative cases.

Keywords: Follow-up; Neonatal hearing screening; Hearing loss; Audiology; Infant

RESUMO

Objetivos: Buscar na literatura informações quanto aos aspectos que guiam o monitoramento audiológico infantil, descrevendo os procedimentos utilizados, a idade em que são realizados, qual a população monitorada e os países que mais estudam sobre o assunto. Além de discutir a importância dessa etapa e a eficácia desses aspectos. **Estratégia de pesquisa:** A revisão foi conduzida com base nas recomendações PRISMA e registrada na plataforma PROSPERO. Os estudos foram pesquisados nas bases de dados eletrônicas Medline (Pubmed), Web of Science e SciELO, com os descritores *hearing, neonatal screening e follow up*. **Critérios de seleção:** Foram incluídos estudos que descrevessem o monitoramento audiológico. Não foram empregados filtros do ano de publicação, tampouco para os idiomas dos mesmos. **Resultados:** Foram encontrados 432 artigos e 21 foram incluídos nesse estudo, sendo que a maioria foi produzida em países desenvolvidos. O Potencial Evocado Auditivo de Tronco Encefálico e a Avaliação Comportamental foram os procedimentos mais utilizados. Quanto a idade e população, a maioria realiza o monitoramento até os três anos e em crianças com Indicadores para a Deficiência Auditiva. **Conclusão:** Os estudos demonstraram que não há padrão entre os protocolos para a realização do monitoramento audiológico, porém foi possível identificar que as pesquisas apresentam uma maior concordância quanto a idade em que tal monitoramento acontece e qual a população que deve ser monitorada. Entretanto, embora haja discordâncias, os métodos de avaliação utilizados pelos estudos são eficazes para a detecção de perdas auditiva de caráter leve, progressivo e/ou tardio, além dos casos de falso negativo.

Palavras-chave: Monitoramento; Triagem auditiva neonatal; Perda auditiva; Audiologia; Lactente

Study carried out at Federal University of Santa Maria – UFSM – Santa Maria (RS), Brasil
[1]Departamento de Fonoaudiologia, Universidade Federal de Santa Maria – UFSM – Santa Maria (RS), Brasil
Conflict of interests: No.
Authors' contribution: DAT was responsible for study design, collection, analysis and interpretation of data and writing of the manuscript; LF was responsible for study design, collection, analysis and interpretation of data; EPVB was responsible for study design, analysis and interpretation of data and guidance of the manuscript.
Funding: None.
Corresponding author: Déborah Aurélio Temp. E-mail: deborahaurelio@gmail.com
Received: February 27, 2022; Accepted: July 18, 2022

INTRODUCTION

The importance of hearing for social, speech, language and cognitive development is already established in the literature[1-3]. In addition, it is also known that early diagnosis and intervention are essential for the deficits caused by hearing loss to be reduced and for the child's global development to occur in a more satisfactory manner[4,5].

For this process to occur effectively, the Neonatal Hearing Screening (NHS) program is the most validated strategy to identify suspected hearing loss[6-8]. The protocol commonly used in this screening must be performed using equipment that allows to obtain electrophysiological measurements[5]. Among these measures, the Transient Otoacoustic Emissions (TOAE) are used for those newborns who do not have any Risk Factors for Hearing Loss (RFHL)[5,6] and the Automatic Auditory Brainstem Response (a-ABR) for those who have[5,6]. Through this screening, the first audiological assessment of the newborn is carried out, initializing the audiological diagnosis and early intervention processes, when necessary, as well as the audiological monitoring (AM)[5,6].

The AM consists of following up and monitoring the development of the auditory function in the infant population, after the screening stage of the NHS is completed[5,6,8]. Furthermore, during this process, in order to monitor the overall children's communicative development, the analysis of speech and language issues are also covered[9]. This procedure is justified by the fact that the protocols commonly used in the screening stage are not capable of identifying mild, progressive and/or late hearing losses, in addition to false negative cases.

Furthermore, unlike the screening stage, in which protocols that guide the performance of procedures are already established and validated, when it comes to AM the same does not occur. Despite recommendations on the topic[5,6], there is still no standard protocol for this practice and several procedures are performed differently around the world.

According to an international reference remarkable in the area, this process must be carried out in all children, regardless of whether or not they have any of these indicators[5]. However, in Brazil, the reference Committee in the area suggests this type of monitoring to be performed only in newborns with RIHL[6]. For newborns without RIHL and with outcomes considered normal by the adopted criteria, the aforementioned national committee recommends hearing health care guidance, recommending also a chart for monitoring the development of auditory and language skills, so that the family can observe these aspects[6]. Offering AM to all newborns regardless of the presence of RIHL is still not feasible in most parts of the national territory, as the current reality of hearing health programs cannot meet the quality indicators proposed by the reference documents in the area, both for the screening stage as well as the following stages, such as the AM, of the NHS[10]. In addition, it is noted in clinical practice that the health services that perform the AM target their efforts only for those children who present some sort of RIHL, which further alerts the need of well-established protocols in relation to this step.

Divergences on the subjects who must undergo AM, the age at which this monitoring should take place and the procedures used in it are not well established in the literature, nor in clinical practice. Therefore, this study aims to contribute to the scientific and clinical society, with a literature search on the aspects that guide the performance of infant's AM, describing the main procedures used, the age at which they are performed and which population should be monitored. In addition to describing which countries researched the topic the most, discussing the importance of AM and analyzing the efficiency of such aspects.

PURPOSE

This systematic review aimed to find studies that report how the AM stage of the NHS is performed in different hearing screening programs.

RESEARCH STRATEGY

The search for scientific articles was carried out in July 2021 and conducted by two independent researchers (DAT, LF) in the electronic databases Medline (Pubmed), Web of Science and SciELO. The selection of keywords was made based on a previous search of the descriptors normally used in the world literature on the subject, generating the following: hearing, neonatal screening and follow up. The search was performed with the boolean operator "and" and was made as shown in the following example: (hearing) and (neonatal screening) and (follow-up). It is noteworthy that no filter was used during the search. There was no restriction on languages, place of origin of the studies, nor filters referring to the years of publication.

SELECTION CRITERIA

The question that guided the systematic review was formulated based on the acronym PICOS (patient, intervention, comparison, outcomes and study design) which generated the following question: "What protocols are used in AM in different NHS programs, what is the age at which this monitoring is performed, and which population should be monitored?" Where the P refers to children who have already undergone the screening stage of NHS and must subsequently undergo the AM and the I refers to the interventions that each screening program uses in their respective AM. As for C, this systematic review did not aim to compare the interventions carried out in different programs, but rather to list them for greater knowledge on the subject for the scientific and clinical society. Regarding the outcomes, they refer to the procedures chosen by each program, whether behavioral, physiological or electrophysiological.

As for S, the following type of studies were included: randomized controlled trials, prospective, cohort, longitudinal, follow-up and cross-sectional studies.

The selected studies were those that reported how the AM stage of the NHS is performed, i.e., the age at which the AM occurs and the procedures performed. Studies that referred to the AM stage of the NHS but did not describe how it was conducted were excluded. Studies that referred to AM in order to monitor the subject to establish an audiological diagnosis were also excluded, as these do not answer the guiding question of this systematic review.

DATA ANALYSIS

The selection of the studies was performed by two independent researchers (DAT, LF). Firstly, the title and abstract of the studies were analyzed as to whether they answered the guiding question of the systematic review and provided the necessary information to contribute to this study and depending on it, the article was selected for further full-text reading. If the title and abstract of the article did not fit the objective of this research, it was excluded. Those studies that were selected in the first stage and read in full but did not effectively describe what was being researched were also excluded. Furthermore, when there was any divergence in the selection of the studies, a third researcher (EPVB) was responsible for analyzing it and deciding whether it would be included or not in the research.

Synthesis of the results

After the articles were selected and read in full, the following information was removed from them: author of the study, year of publication, country in which the population was studied, as well as when and how the AM was performed in that particular population. Posteriorly, the data were synthesized in an online table in order to deepen the discussion on the subject.

Risk of bias

The methodological quality of each study was analyzed using the Study Quality Assessment Tools (QAT) tool (Supplementary Material). Two of the authors (DAT, LF) independently performed the evaluation of each study. The tool contains criteria where evaluators must answer for each of these "Yes", "No", "Cannot Determine" (CD), "Not Applicable" (NA) or "Not Reported" (NR). Subsequently, the studies were classified based on the score of responses referring to "YES" or "NA", at which > 80% refers to a "good" study, 50-79% to a "fair" and <50% to a "bad" quality study. A paper classified as "good" has a lower risk of bias, a "fair" indicates that the study is susceptible to bias but these do not invalidate the results found, and a "bad" indicates a significant risk of bias. If any discrepancy was found in the classification made by the two evaluators, the evaluators discussed the study in order to obtain a consensus on its classification.

Protocol and register

The study was conducted based on the PRISMA recommendations (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)[11]. The systematic review protocol was approved and published on the PROSPERO platform under registration number CRD42021258325.

RESULTS

Through the search strategies already described, 432 articles were found, at which 23 were excluded due to being duplicates in the databases researched. In the subsequent stages of the research, 388 articles were excluded because the articles did not match the study design accepted in this review or did not fit the guiding question. Furthermore, most of these were excluded because they used the term "follow-up" addressing issues related to children's audiological diagnosis for hearing loss, a topic that is not consistent with the present systematic review.

The research stages as well as the number of studies assessed in all these stages, are presented in the flowchart in Figure 1.

Table 1 presents, in detail, the 21 articles included in the review and their main aspects, such as the study's country of origin, population, procedures and the age at which these procedures occur. In some studies, the analysis of topics considered important were not found, and in the table they are represented by a "-" when this occurred. It is noteworthy that, during the risk of bias assessment, the lack of such topics was considered.

DISCUSSION

This systematic review is the first to address how the AM stage of the NHS is carried out internationally. Heterogeneous results regarding countries, population, age and procedures were found during the research. This review contributes to guide the academic and clinical society on the main aspects related to AM. In addition to alerting them about the lack of protocols and well-established discussions on the subject, given the importance of the AM for the infant's health[5].

Procedures

During the research, four articles did not specify which procedure was performed in the AM[21,24,26,28]. One of them performs monitoring through an interview[25] and the other through a questionnaire[29]. The first one, as this subject was not the focus of the research neither discusses nor concludes the efficiency of the AM through an interview. In regard to the questionnaire, the authors concluded that it can be used as a screening tool in places that do not have equipment to carry out objective procedures, in addition to being useful for AM as it can help to identify late and/or progressive hearing loss[29].

Currently, there is no specific document or guideline suggesting which measures should be performed in the AM, whether behavioral or electrophysiological. Besides that, no information about the specificity of the procedures is available in the literature either. The other articles included in this systematic review were divided into several behavioral and/or electrophysiological measures, as shown in Table 1. Among these, the most used procedures were ABR[9,14,17,18,20,22,29,30] followed by the Behavioral Assessment[14,20,30]. The procedures cited above are proved to be effective, as both measures can ideed meet the aim of the AM, in detecting mild, progressive and/or late hearing losses that are not detected in the screening stage of the NHS or that may have been cases of false negatives[5].

Although AM procedures are not yet well established and that this study does not propose an ideal protocol, it is believed that regarding the choice of methods, a protocol for children's audiological assessment that takes into account age, developmental level and neuromotor conditions of the child

Table 1. Details of the articles included in the systematic review and their main aspects assessed

First author	Type of the study	Main Objective of the study	Country	Population	Procedures	Age of the procedures
Hosford-Dunn et al.[12]	longitudinal	-	USA	With RFHL	VRA, "play audiometry" "Crib-0-Gram".	1 year, 2 or 3 years. Complete audiological follow-up at 3 years old
Tucker & Bhattacharya[13]	not declared	To assess ARC for severe bilateral HL	England	With and without RFHL	ARC	7 to 9 months, 18 months and complete audiological follow-up at 3 years old
Fowler et al.[14]	coorte	To predict whether the UNHS would identify SNHL caused by CMV	USA	CMV	Frequency-specific ABR, behavioral audiometry, speech audiometry, immitanciometry	3 to 8 weeks, 6 and 12 months and posteriorly, "annually"
Norton et al.[15]	prospective multicenter	To determine the performance characteristics of TOAE, DPOAE ABR, at the corrected ages of 8 to 12 months	USA	With IRDA	VRA	8 to 12 months of corrected age
Norton et al.[16]	prospective multicenter	To determine the accuracy of TOAE, DPOAE and ABR to predict behavioral hearing status at 8 to 12 months of corrected age	USA	With IRDA	VRA	8 to 12 months of corrected age
Ari-Even Roth et al.[17]	coorte	To study the prevalence of HL in newborns with ELW at birth and evaluate the effectiveness of TOAE as a screening tool	Israel	Premature/low weight	bone ABR and click ABR	1 month after discharge and audiological follow-up in "regular periods" up to 3 years
Iwasakiet al.[18]	prospective	To assess the audiological outcome of long-term follow-up of infants with asymptomatic CMV infection	Japan	CMV	Frequency-specific ABR, behavioral audiometry	Intervals from 6-12 months to 4 years
Barboza et al.[9]	descriptive retrospective	To verify the occurrence of HL and its correlation with RFHL in babies from a UNHS service	Brazil	With RFHL	ABR	6 months
Wilson et al.[19]	retrospective	To assess long-term audiological outcomes in a neonatal follow-up program	Canada	Congenital Diaphragmatic Hernia	Standard audiometry according to the age, OAE, immitanciometry	8, 18 months, 3 years
Beswick et al.[20]	retrospective	To investigate the RFHL most likely to predict the occurrence of postnatal HL	Australia	With RFHL	Otoscopy, tympanometry, ABR, VRA, DPOAE and TOAE, "play audiometry". Tests chosen according to the age of the children.	RFHL congenital infection: 3, 6 months and then every 6 months until 2 years, with discharge assessment within 3 years. RFHL family history: at 6 months and then every 6 months until 2 years, with discharge assessment at 3. Missing RFHL: single consultation from 9 to 12 months and then discharge assessment at 3.5 years old
Wood et al.[21]	retrospective	To evaluate the UNHS performance in England	England	Newborns that passed the a-ABR but not in the TOAE	-	8 months
Karimian et al.[22]	prospective	To assess the prevalence and the prognosis of the cCMV infection in Iran	Iran	CMV	ABR	ABR at 12 months. Regular visits at 2, 4, 6, 9 and 12 months
Yılmazer et al.[23]	not declared	To present the results of the follow-up of NB after UNHS and determine the age of diagnosis, adaptation of hearing aids and cochlear implant in NB with HL	Turkey	With RFHL	a-ABR	1 week
Molini et al.[24]	retrospective	To examine the results of the program and its evolution in the first 2.5 years of implementation	Italy	With RFHL	-	6 in 6 meses, up to 3 years
Sabbag & Lacerda[25]	observational, retrospective and quantitative	To analyze the flow of the UNHS in FHS through tracking and monitoring of children	Brazil	With and without RFHL	Interview	0-1 year
Dumanch et al.[26]	retrospective	To analyze the association between the RFHL and audiological status in early childhood and the follow-up rates of children approved or referred by RFHL	USA	With RFHL	-	3 years

Legend: RFHL: Risk Factors for Hearing Loss; VRA: Visual Reinforcement Audiometry; ARC: Audiometry Response Craddle; HL: Hearing Loss; UNHS: Universal Newborn Hearing Screening; SNHL: Sensorineural Hearing Loss; CMV: Citomegalovírus; ABR: Auditory Brainstem Response; TOAE: Transient Otoacoustic Emissions; DPOAE: Distortion Product Otoacoustic Emissions; ELW: Extremely Low Weight; a-ABR: automatic- Auditory Brainstem Response; cCMV: congenitus Citomegalovírus; NB: Newborn; FHS: Family Health Strategy.

Table 1. Continued...

First author	Type of the study	Main Objective of the study	Country	Population	Procedures	Age of the procedures
Turchetta et al. [27]	retrospective	To present and discuss the preliminary results of the UNHS program in the Lazio region	Italy	With RFHL	TOAE, ABR, immitanciometry	6 in 6 months for the first 3 years, then annually for the next 3 years
Foulon et al.[28]	prospective	To determine the prevalence of HL in children with CMV. To analyze the possible determinants RFHL and to propose recommendations to NB screening and follow-up.	Belgium	CMV	-	Between 5 and 12 months, then annually until 4 years
Schaefer et al. [29]	not declared	To investigate the feasibility to use the LittlEARS® Auditory Questionnaire (LEAQ®) as part of the newborn hearing screening program in Germany	Germany	With and without RFHL	Questionnaires and specific exams according to the results	3 years
McInerney et al. [30]	retrospective	To assess the adherence of families to the recommendations for continuous monitoring of infants with RFHL	USA	With RFHL	Otoscopy, tympanometry, behavioral audiometry, sound field audiometry, frequency-specific ABR, DPOAE. According to age	3 and 6, then every 6 months until 24-30 months
Basonbul et al.[8]	retrospective	To present auditory results for children with DS during the first 8 years of life and assess these results in the context of current screening guidelines.	USA	Down Sindrome	ABR or behavioral audiometry. According to the child 's development	6 in 6 months up to 3-4 years. Afterwards annually or when necessary

Legend: RFHL: Risk Factors for Hearing Loss; VRA: Visual Reinforcement Audiometry; ARC: Audiometry Response Craddle; HL: Hearing Loss; UNHS: Universal Newborn Hearing Screening; SNHL: Sensorineural Hearing Loss; CMV: Citomegalovírus; ABR: Auditory Brainstem Response; TOAE: Transient Otoacoustic Emissions; DPOAE: Distortion Product Otoacoustic Emissions; ELW: Extremely Low Weight; a-ABR: automatic- Auditory Brainstem Response; cCMV: congenitus Citomegalovírus; NB: Newborn; FHS: Family Health Strategy.

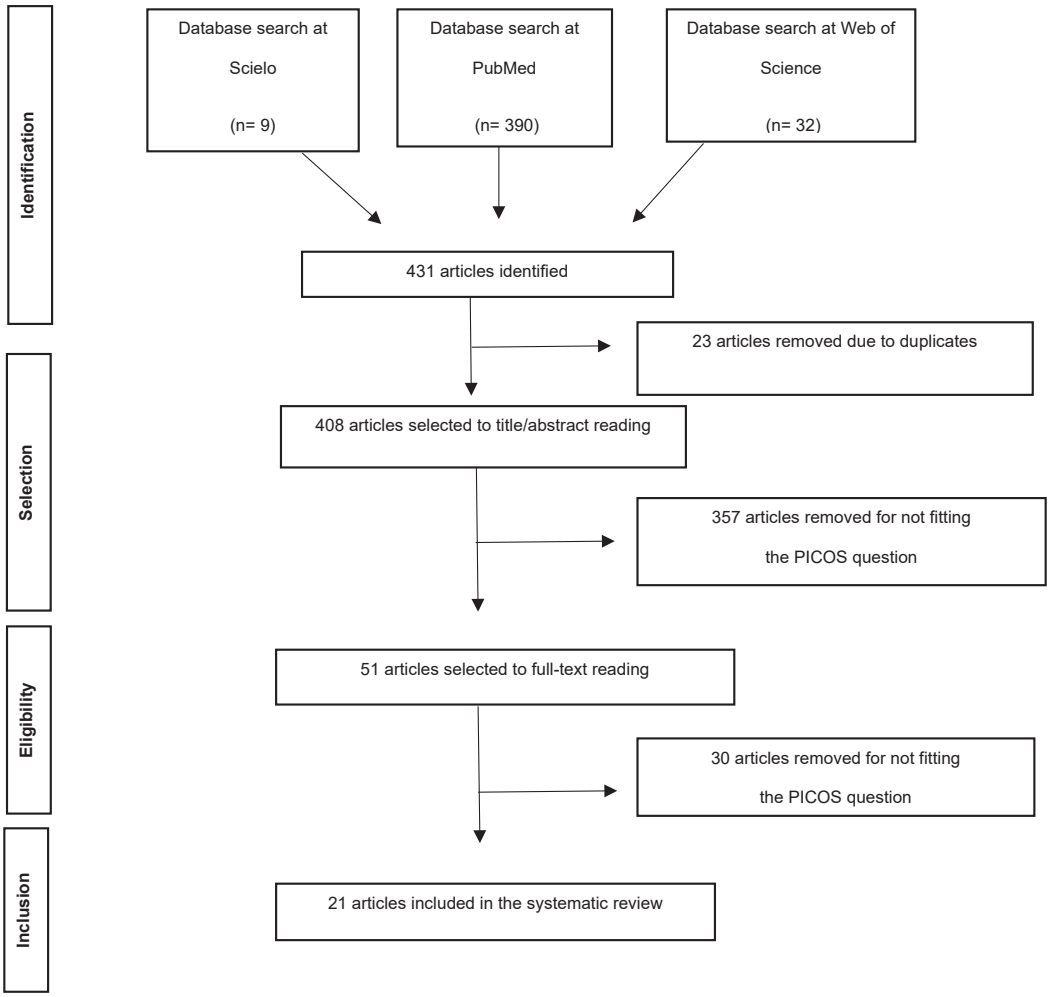

Figure 1. Flowchart of the article selection steps
Subtitle: PICOS: patiente intervention comparison outcomes study design

can be an important guide when choosing the procedures for this stage of the NHS program[31].

Population

The population was divided into different categories. Children with and without RFHL, those with RFHL but without any specification of which risk factor, and those where studies only discuss a specific RFHL. According to the Joint Committee on Infant Hearing (JCIH)[5], all children must undergo AM due to mild, progressive and/or late hearing loss. However, in this literature review, it was observed that, despite this recommendation, most countries and hearing screening programs choose to monitor only those children who present any type of RFHL[8,9,12,14-18,20,22-24,26-28,30].

On the other hand, the other document that supported this systematic review[6], suggests the AM to be performed only in children with RFHL, as this guideline was developed in a country at which aspects of early identification and intervention are not yet achieved. Of the 21 articles selected, 16[8,9,12,14-18,20,22-24,26-28,30] corroborate with this document and choose to perform the AM only in newborns with one or more risk factors described by the JCHI[5]. This is also in line with the concept of screening, as it should be a simple process, easy to perform and more likely to detect a certain disease/disability

An increased number of articles reporting AM in children diagnosed with cytomegalovirus was observed[14,18,22,28], when compared to other RFHL. This disease is considered a RFHL[5] and sensorineural hearing loss is shown to be its main complication is[22]. Thus, the monitoring of these children has gained space in the discussions on pediatrics' audiology field, which is really relevant. However, the population with cytomegalovirus is not the only to be submitted to MA, children with other RFHL should also be closely monitored with the same attention.

Age

The reference documents that supported this study, unanimously state that the AM must be performed up to three years of age[5,6]. It was found that most of the articles corroborate with these documents, reporting to perform the AM up to three years or more[8,12,13,17-20,24,26-31]. This age becomes a milestone for infant's AM, as it enables the audiologist to early identify hearing loss of a progressive/or late nature, within the critical period for language acquisition.

Of the selected articles, all reported up to what age the AM was performed, however, only 13[8,12-16,18-20,24,27,28,30] specified at what ages they performed this step. According to the international recommendation[5], most children with RFHL should undergo the AM every 12 months until three years of age. In this literature review, studies were found to perform an even more rigid AM in their populations when compared to the one recommended by the JCIH. Five[8,20,24,25,30] studies perform the AM every six months, until at least three years of age, which becomes a safe periodicity to detect cases of late and/or progressive hearing loss.

In addition, another factor that validates the AM to be performed in the long term is due to the use of ototoxic drugs. Such medications are commonly administered to children who need to be hospitalized in Neonatal Intensive Care Units[26], and these can trigger hearing loss up to approximately three years of age[26]. Thus, NHS programs that perform AM up to less time than these three years, especially in children with RFHL, are liable to not identify the hearing loss as early as it should.

Countries

Although the NHS protocols are already established in most countries in the world, discussions in the scientific community regarding the AM stage were found in studies from only 13 different countries. Among them, the United States stood out, with six articles[8,12,14-16,30], followed by England[13,21], Italy[24,27] and Brazil[9,25], with two articles each. Furthermore, of the 21 selected articles, eight[9,21,23-27,29] studies reported how the NHS program is carried out in their countries.

Also, in a deeper analysis, it is clear that developed countries tend to study the topic more when compared to underdeveloped ones. Of the total number of selected articles, 16[8,12-16,18-21,24,26-30] were produced in already developed countries and the minority remaining[9,17,22,23,25], in underdeveloped countries. Thus, it can be inferred that developing countries are still recruiting their efforts for other actions related to pediatric audiology, such as ensuring the effectiveness of the NHS, which in turn demonstrates that the AM is not their top priority. We also note that this subject is not of great general interest due to the scarcity of publications and debates about the AM worldwide.

In a more profound analysis on the subject in Brazilian territory, it is possible to identify that NHS services have unequal coverage throughout the country[9]. In addition, it is notable in literature and in clinical practice[9], that due to the demand and the delay to complete the protocols already established, Brazilian's hearing health services choose to recruit their efforts and monitor only children with RIHL.

Also, important documents in the area have divergences from each other, making it more difficult to establish well-structured protocols in the country. According to the Brazilian government's NHS Guidelines[32], AM should be performed in all children up to 12 months of age. While the Multiprofessional Committee on Hearing Health predicts that children with RIHL could be reassessed between three and six months of age, and annually until three years of age, or whenever the parents or guardians have any suspicion regarding their hearing acuity[6]. Such divergences between regulations, in addition to the already evident difficulty in meeting the deadlines established for the NHL stages, can make understanding the process and decision-making difficult for professionals that manage the NHS programs.

Some articles did not report or did not specify important aspects for this systematic review. Specifications of all ages in which the AM occurs and details about the procedures were not discussed in most studies, which made a deeper analysis on the subject difficult to be made. Furthermore, due to the lack of specification of these items, it can be noted that there is little agreement in literature about which procedures to use in the AM and the different ages that this should occur. The hypothesis made at the beginning of this study confirmed that well-established protocols and discussions on the subject do not yet have strong relevance in scientific studies and publications.

AM is extremely important for children's health, as it's only with it that audiologists can detect mild, progressive and/or late hearing loss, in addition to false negative cases in the NHS[5].

The establishment of valid protocols is a necessity, since these are not yet well consolidated in the literature nor discussed. For children with the type of hearing loss mentioned above to be diagnosed and early intervened, AM is essential.

CONCLUSION

Most of the studies included in the research used the Auditory Brainstem Response and/or Behavioral Audiometry to perform AM. The population prioritized to receive monitoring was the one with some type of RFHL. As for the age at which the AM was performed, most studies highlighted the need to monitor children up to three years of age. Furthermore, it was concluded that the largest number of studies on the subject are carried out in developed countries. Such procedures, population and age groups are useful for monitoring the auditory function as they are capable of fulfilling the objective of the AM of detecting mild, progressive and/or character hearing losses, in addition to false negatives cases that were not detected in the screening stage of the NHS.

REFERENCES

1. Yoshinaga-Itano C, Sedey AL, Coulter DK, Mehl AL. Language of early-and later-identified children with hearing loss. Pediatrics. 1998;102(5):1161-71. http://dx.doi.org/10.1542/peds.102.5.1161. PMid:9794949.
2. Pimperton H, Blythe H, Kreppner J, Mahon M, Peacock JL, Stevenson J, et al. The impact of universal newborn hearing screening on long-term literacy outcomes: a prospective cohort study. Arch Dis Child. 2016;101(1):9-15. http://dx.doi.org/10.1136/archdischild-2014-307516. PMid:25425604.
3. Redondo MDC, Brunner AP. Avaliação clínica da audição da criança: procedimentos e interpretação de resultados. In: Levy CCAL, editor. Manual de audiologia pediátrica. Barueri: Editora Manole; 2015. p. 57-82.
4. Northern JL, Downs MP. Hearing in children. 5th ed. Philadelphia: Lippincott, Williams e Wilkins; 2002.
5. The Joint Committee on Infant Hearing. Year 2019 position statement: principles and guidelines for early hearing detection and intervention programs. J Early Hear Detect Interv. 2019;4(2):1-44.
6. Lewis DR, Marone SAM, Mendes BCA, Cruz OLM, Nóbrega M. Comitê multiprofissional em saúde auditiva COMUSA. Rev Bras Otorrinolaringol (Engl Ed). 2010;76(1):121-8.
7. Lewis DR. Evidências para a realização da Triagem Auditiva Neonatal Universal. In: Bevilacqua MC, Martinez MAN, Balen AS, Pupo AC, Reis ACM, Frota S, editors. Tratado de audiologia. São Paulo: Editora Santos; 2011. p. 495-513.
8. Basonbul RA, Ronner EA, Rong A, Rong G, Cohen MS. Audiologic testing in children with Down Syndrome: are current guidelines optimal? Int J Pediatr Otorhinolaryngol. 2020;134:110017. http://dx.doi.org/10.1016/j.ijporl.2020.110017. PMid:32251971.
9. Barboza ACS, Resende LM, Ferreira DBC, Lapertosa CZ, Carvalho SAS. Correlação entre perda auditiva e indicadores de risco em um serviço de referência em triagem auditiva neonatal. Audiol Commun Res. 2013;18(4):285-92. http://dx.doi.org/10.1590/S2317-64312013000400009.
10. Botasso KC, Lima MCMP, Correa CRS. Analysis of na oupatient child hearing health program: from screening to referral for rehabilitation. CoDAS. 2022;34(4):e20200403. http://dx.doi.org/10.1590/2317-1782/20212020403. PMid:35137893.
11. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. Ann Intern Med. 2009;151(4):W65-94. PMid:19622512.
12. Hosford-Dunn H, Johnson S, Simmons FB, Malachowski N, Low K. Infant hearing screening: program implementation and validation. Ear Hear. 1987;8(1):12-20. http://dx.doi.org/10.1097/00003446-198702000-00003. PMid:3549402.
13. Tucker SM, Bhattacharya J. Screening of hearing impairment in the newborn using the auditory response cradle. Arch Dis Child. 1992;67(7):911-9. http://dx.doi.org/10.1136/adc.67.7.911. PMid:1519957.
14. Fowler KB, Dahle AJ, Boppana SB, Pass RF. Newborn hearing screening: will children with hearing loss caused by congenital cytomegalovirus infection be missed? J Pediatr. 1999;135(1):60-4. http://dx.doi.org/10.1016/S0022-3476(99)70328-8. PMid:10393605.
15. Norton SJ, Gorga MP, Widen JE, Folsom RC, Sininger Y, Cone-Wesson B, et al. Identification of neonatal hearing impairment: summary and recommendations. Ear Hear. 2000;21(5):529-35. http://dx.doi.org/10.1097/00003446-200010000-00014. PMid:11059708.
16. Norton SJ, Gorga MP, Widen JE, Folsom RC, Sininger Y, Cone-Wesson B, et al. Identification of neonatal hearing impairment: a multicenter investigation. Ear Hear. 2000;21(5):348-56. http://dx.doi.org/10.1097/00003446-200010000-00003. PMid:11059697.
17. Ari-Even Roth D, Hildesheimer M, Maayan-Metzger A, Muchnik C, Hamburger A, Mazkeret R, et al. Low prevalence of hearing impairment among very low birthweight infants as detected by universal neonatal hearing screening. Arch Dis Child Fetal Neonatal. 2006;91(4):F257-62. http://dx.doi.org/10.1136/adc.2005.074476. PMid:16531449.
18. Iwasaki S, Yamashita M, Maeda M, Misawa K, Mineta H. Audiological outcome of infants with congenital cytomegalovirus infection in a prospective study. Audiol Neurotol. 2007;12(1):31-6. http://dx.doi.org/10.1159/000096156. PMid:17033163.
19. Wilson MG, Riley P, Hurteau AM, Baird R, Puligandla PS. Hearing loss in congenital diaphragmatic hernia (CDH) survivors: is it as prevalent as we think? J Pediatr Surg. 2013;48(5):942-5. http://dx.doi.org/10.1016/j.jpedsurg.2013.02.007. PMid:23701764.
20. Beswick R, Driscoll C, Kei J, Khan A, Glennon S. Which risk factors predict postnatal hearing loss in children? J Am Acad Audiol. 2013;24(3):205-13. http://dx.doi.org/10.3766/jaaa.24.3.6. PMid:23506665.
21. Wood SA, Sutton GJ, Davis AC. Performance and characteristics of the Newborn Hearing Screening Programme in England: the first seven years. Int J Audiol. 2015;54(6):353-8. http://dx.doi.org/10.3109/14992027.2014.989548. PMid:25766652.
22. Karimian P, Yaghini O, Nasr Azadani H, Mohammadizadeh M, Arabzadeh SA, Adibi A, et al. Prevalence, characteristics, and one-year follow-up of congenital cytomegalovirus infection in Isfahan City, Iran. Interdiscip Perspect Infect Dis. 2016;2016:7812106. http://dx.doi.org/10.1155/2016/7812106. PMid:28070187.
23. Yılmazer R, Yazıcı MZ, Erdim İ, Kaya HK, Özcan Dalbudak Ş, Kayhan TF. Follow-up results of newborns after hearing screening at a training and research hospital in Turkey. J Int Adv Otol. 2016;12(1):55-60. http://dx.doi.org/10.5152/iao.2015.1736. PMid:27340984.

24. Molini E, Calzolaro L, Lapenna R, Ricci G. Universal newborn hearing screening in Umbria region, Italy. Int J Pediatr Otorhinolaryngol. 2016;82:92-7. http://dx.doi.org/10.1016/j.ijporl.2016.01.007. PMid:26857323.

25. Sabbag JC, Lacerda ABM. Rastreamento e monitoramento da Triagem Auditiva Neonatal em Unidade de Estratégia de Saúde da Família: estudo-piloto. CoDAS. 2017;29(4):e20160102. http://dx.doi.org/10.1590/2317-1782/20172016102. PMid:28813070.

26. Dumanch KA, Holte L, O'Hollearn T, Walker E, Clark J, Oleson J. High risk factors associated with early childhood hearing loss: a 3-year review. Am J Audiol. 2017;26(2):129-42. http://dx.doi.org/10.1044/2017_AJA-16-0116. PMid:28475714.

27. Turchetta R, Conti G, Marsella P, Orlando MP, Picciotti PM, Frezza S, et al. Universal newborn hearing screening in the Lazio region, Italy. Ital J Pediatr. 2018;44(1):104. http://dx.doi.org/10.1186/s13052-018-0534-5. PMid:30143030.

28. Foulon I, Brucker Y, Buyl R, Lichtert E, Verbruggen K, Piérard D, et al. Hearing loss with congenital cytomegalovirus infection. Pediatrics. 2019 Ago;144(2):e20183095. http://dx.doi.org/10.1542/peds.2018-3095. PMid:31266824.

29. Schaefer K, Coninx F, Fischbach T. LittlEARS auditory questionnaire as an infant hearing screening in Germany after the newborn hearing screening. Int J Audiol. 2019;58(8):468-75. http://dx.doi.org/10.1080/14992027.2019.1597287. PMid:31012791.

30. McInerney M, Scheperle R, Zeitlin W, Bodkin K, Uhl B. Adherence to follow-up recommendations for babies at risk for pediatric hearing loss. Int J Pediatr Otorhinolaryngol. 2020;132:109900. http://dx.doi.org/10.1016/j.ijporl.2020.109900. PMid:32006864.

31. Gravel JS, Hood LJ. Avaliação audiológica infantil. In: Musiek FE, Rintelmann WF, editors. Perspectivas atuais em avaliação auditiva. Barueri: Manole; 2001. p. 301-322.

32. Brasil. Ministério da Saúde (MS). Diretrizes de Atenção da Triagem Auditiva Neonatal [Internet]. Brasília, DF: Ministério da Saúde; 2012 [citado em 2022 jun 8]. Disponível em: https://bvsms.saude.gov.br/bvs/publicacoes/diretrizes_atencao_triagem_auditiva_neonatal.pdf

Supplementary Material

Supplementary material accompanies this paper.
Table: Risk of bias assessment
This material is available as part of the online article from https://www.scielo.br/j/acr