Newborn Hearing Screening: Experiences of Different Countries

Triagem Auditiva Neonatal: Experiências de Diferentes Países

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SUMMARY

Introduction: The Newborn Hearing Screening (NHS) has been implemented in several countries.
Objective: The purpose of this study was to identify and report the experiences of different countries with the NHS.
Method: We searched the MEDLINE, BIREME, SciELO, LILACS, PubMed, Google Scholar, Science Direct, CAPES journals, and the websites of the Support Group Universal Newborn Hearing Screening (GATANU), Joint Committee on Infant Hearing, International Association of Logopedics and Phoniatrics, American Academy of Pediatrics (AAP), and research in scientific events and textbooks as needed. The keywords used were: newborn hearing screening, universal newborn hearing screening, newborn hearing screening, and universal newborn hearing screening.
Data Synthesis: We found that TAN programs are being conducted in approximately 55 countries effectively and successfully. The predominant procedure is the assessment of evoked otoacoustic emissions (SOAE).
Conclusion: There are increasing efforts to improve the quality of programs, universal TAN and development of relevant legislation.
Keywords: newborn screening, newborn, hearing loss.

RESUMO

Introdução: A Triagem Auditiva Neonatal (TAN) tem sido implementada em diversos países.
Objetivo: O propósito deste estudo foi conhecer e relatar as experiências de diferentes países com a TAN.
Método: Realizou-se busca nas bases de dados MEDLINE, BIREME, SCIELO, LILACS, PUBMED, GOOGLE SCHOLAR, Science Direct, periódicos CAPES e nos sites do Grupo de Apoio a Triagem Auditiva Neonatal Universal (GATANU), Joint Committee on Infant Hearing, International Association of Logopedics and Phoniatrics e American Academy of Pediatrics (AAP), além da pesquisa em anais de eventos científicos e livros texto, quando necessário. Os descritores usados foram: triagem auditiva neonatal, triagem auditiva neonatal universal, newborn hearing screening e universal newborn hearing screening.
Síntese dos dados: Constatou-se que os programas de TAN vêm sendo realizados em aproximadamente 55 países com eficácia e sucesso. O procedimento predominante é a avaliação de Emissões Otoacústicas Evocadas (EOAEs).
Conclusão: São crescentes os esforços pela melhoria da qualidade dos programas, universalização da TAN e elaboração de legislação pertinente.
Palavras-chave: triagem neonatal, recém-nascido, perda auditiva.

IINTRODUCTION

Early diagnosis of hearing loss directs the planning and introduction of therapeutic measures aimed at disease prevention and improved quality of life of the child and family.

The Newborn Hearing Screening (NHS) aims to accurately and efficiently separate the vast majority of newborns with good hearing, those with hearing loss.

The spread of the consequences of hearing loss on the social, emotional, cognitive and language resulted in the awareness of governments of several countries that have implemented programs TAN.

In several countries, the NHS has been implemented and, despite the barriers encountered, still being performed and perfected according to the possibilities of each site. The literature shows the viability of the NHS and its effectiveness in early detection of hearing loss in children.

The purpose of this study was to discover and report the experiences of several countries with the NHS.

LITERATURE REVIEW

The establishment and maintenance of programs TAN have aroused interest and concern of audiologists, otolaryngologists and pediatricians, given the importance of ensuring early diagnosis and intervention of hearing loss (1).

In developing countries, the Newborn Hearing Screening Program (NHSP) have been conducted since 1986, with India the pioneer (in neonates at risk). Oman was the first country with nationwide NASP and Iran are in pilot studies 28 of 30 provinces. In Singapore the TAN has been performed in immunization clinics. The procedure was rejected by 59% of the families of children aged four months or less (2).

Study MASOUD et al. (2006) reports that in developing countries that Brazil is the largest number of services that provide NAS (237 sites) (3). One hundred and thirty-seven institutions, including hospitals and clinics are registered with the Support Group Universal Newborn Hearing Screening (GATANU). The southeast region, comprising the states of Sao Paulo, Rio de Janeiro, Espirito Santo and Minas Gerais, it shows a greater number of programs TAN (63 services), followed by southern region comprises the states of Rio Grande do Sul, Santa Catarina and Paraná (34 services). The northern region (Acre, Amapá, Amazonas, Rondônia, Roraima, Para and Tocantins), it shows the lowest number of programs registered with GATANU, four in hospitals and in private practice (4).

In Brazil, the first programs of TAN was established in 1987, one in São Paulo Hospital (São Paulo, SP) another at the University Hospital of Santa Maria (Santa Maria). The procedure used in both institutions was the observation of responses behavior (5).

The following year, the Hospital Israelita Albert Einstein, started the first program of TAN that used electrophysiological method (Potential Auditory Brainstem Response - ABR) and had speech pathologist in the neonatal team. Initially covered only neonates with risk factors for deafness, but gradually expanded to all children in the Neonatal Intensive Care Unit (NICU).From 1999 the assessment of evoked otoacoustic emissions (SOAE) was being used (6).

In Europe, TAN programs involve the whole continent, and now cover more than 90% of Austria, Belgium (Flemish part), Denmark, Croatia, England, Luxembourg, the Netherlands and Poland. A partial implementation has been made in Germany, Italy, Lithuania, Malta, Spain, Sweden, Switzerland and Wales. Already the French part of Belgium, Cyprus, France and Ireland are in advanced stage, while the Czech Republic, Estonia, Finland, Greece, Hungary, Latvia, Norway, Portugal, Romania, Scotland, Slovakia, Slovenia and Turkey are in pilot phase (7).

The NASP TRIAM England around 1700 children every day and are recognized as the most advanced in the world. More than 3400 children with hearing loss have been identified (8).

In setting standards for programs TAN *American Academy of Pediatrics* (AAP, 1999) (9) suggested that they were universal, false-positive rate of less than or equal to 3%, the referrals to the stage of diagnosis did not exceed 4% and the procedures used were SOAE and / or ABR. Still, the NHS should be performed before discharge, between the first 24 and 48 hours of life.In case of failure, the retest should be performed within a month. The diagnosis should be completed before three months of life and intervention begun before six. TAN programs should be evaluated according to the rules of the AAP (1999).

The NHS has a universal character when they are screened at least 95% of newborns (AAP, 1999). There are reports of Universal Newborn Hearing Screening (UNHS) in Mexico (Monterrey) (10), Spain (Cantabria) (11), Germany (Hamburg) (12), United States (USA) (states with implemented legislation (13), State of Mississippi

Table 1. Institutions, municipalities / cities and states or countries that employ only SOAE in the implementation of the NHS.

Country	County / State or Location	Institution
South Africa (29)	Pretoria / Gauteng	NC
Germany (12)	Hamburg	Marien Hospital
Saudi Arabia (25)	NC	NC
Austria (30)	NC	NC
Brazil (24)	Sao Paulo / SP	Hospital Israelita Albert Einstein
Slovakia (26)	Limbova	Children's University Hospital
Spain (31)	Gijón / Asturias	Hospital Cabueñes
Philippines (32)	Manila	Philippine General Hospital
Greece (33)	Athens	Hippokration Hospital
Italy (34)	Rome	CN
Iran (3)	Tehran, Mashad	NC
Pakistan (35)	Lahore	NC
Poland	Poznan (36)	Hospital of the University of Poznan
	Zabrze (37)	Silesian Medical Academy
Qatar (38)	Doha	NC

Table 2. Institutions, city / states or localities and countries using SOAE in the NHS and in case of failure or RN's with risk factors for hearing loss, evaluate ABR for diagnosis.

Country	County / State or Location	Institution
Spain	Cantabria (11)	NC
	Valladolid (39)	Hospital Universitario de Valladolid
France (16)	Eure	Eure Geographic Department
Israel (40)	NC	NC
Italy (41)	Milan	NC *
Jordan (42)	NC	NC
Malásia (42)	Kuala Lumpur	Hospital Universitário de Kebangsaan Malásia
Taiwan (43)	NC	Mackay Memorial Hospital

* Institution that has implemented TAN, UO Neurologia, Dipartimento di neuropathophysiology and Neonatology Clinic of the Istituti di Perfezionamento. SOAE: Evoked Otoacoustic Emissions; TAN: Newborn Hearing Screening; NB: newborn; ABR: Auditory Evoked Potential Brain Stem, NC: Not applicable information cited in the study.

(14), New Mexico (15), France (Eure) (16), Norway (County Ostfold) (17), public hospitals in Singapore (2), Western Australia (Perth) (18), Nigeria (19, 20), South Africa (21) and Hong Kong (22).

The acceptable rates of false-positive according to the AAP (1999) is equal to or less than 3%. The countries that met this criterion were Mexico (10) and USA (23).

The rate of referral to diagnosis was less than 4% (AAP, 1999) Brazil (24), Norway (County Ostfold) (17), Saudi Arabia (25), Nigeria (20), Slovakia (Limbova) (26), Oman (27), Singapore (28) and Mexico (10).

The procedures set forth by the AAP (1999) are SOAE and / or ABR. The most commonly used in programs for the NHS in different countries are presented in Tables 1, 2, 3 and 4.

In addition to the procedures set out in Tables 1, 2, 3 and 4, Mexico (Monterrey) (10) NAS was performed using the Automatic Response Auditory Brainstem Response (Automated Auditory Brainstem Response - AABR) and

Table 3. Institutions, cities / states or localities and countries using SOAE in the NHS, and in case of failure, AABR.

Country	County / State or Location	Institution
England (44)	NC	NC
Norway (17)	Ostfold County,	NC
Oman (27)	NC	NC

SOAE: Evoked Otoacoustic Emissions; TAN: Newborn Hearing Screening; AABR: Automated Auditory Brainstem Response (Automatic Response Auditory Brainstem Response) NC: Not applicable information cited in the study.

Table 4. Institutions, cities / states or localities and countries using SOAE and / or AABR in implementing the NHS.

Country	County / State or Location	Institution
China (45)	Shanghai, Bijing, Shandong	CN
Hong Kong (46)	Hong Kong	CN
Nigeria (19, 20)	Lagos	NC
Singapore (2)	Singapore	NC

SOAE: Evoked Otoacoustic Emissions; TAN: Newborn Hearing Screening; AABR: Automated Auditory Brainstem Response (Automatic Response Auditory Brainstem Response) NC: Not applicable information cited in the study.

Table 5. Countries / Institutions that mentioned the age at which the NHS was carried out.

Country / Institution	Age at attainment of Hearing Screening
Brazil / Hospital Israelita Albert Einstein (24)	Second or third day after birth or before discharge for newborns admitted to NICU.
Spain / Hospital Cabueñes (31)	Median age of 71 days
Spain / University Hospital of Valladolid (39)	Less than six months
Greece / NC (33)	More than 36 weeks
Italy / NC	36 hours after birth (Milan) (41)
Italy / CN	Second or third day of life (Rome) (34)
Nigeria / NC (20)	Average age of 2.6 months
Norway / NC (17)	Second day of stay in nursery
Poland / Poznan University Hospital (36)	Second or third day of life
Taiwan / Mackay Memorial Hospital (43)	Average age of 52.

NB: Newborn; NICU: Neonatal Intensive Care Unit; NC: Not applicable information cited in the study.

failure mode was performed ABR. South Africa (21) was used to EOAEPDs associated with high frequency tympanometry and Limbova (Slovakia) (47) was used to search the EOAETs and in case of failure, the performance of tympanometry. Norway (Oslo) (48) and Australia (Perth) (18) the use of SOAE AABR was associated in all stages of screening. In the states of Mississippi (14) and NC (USA) (23) to screening was performed only with ABR. In a study conducted from March 2000 to December 2002 in Taiwan (49) newborns were screened with SOAE associated with ABR.

According to the AAP (1999), the NHS must be held between the first 24 and 48 hours of life. Table 5 shows the ages in which the NHS is carried out in different countries.

Brazil (24), Italy (Rome (34) and Milan (41)) and Poland (36) (Hospital of the University of Poznan) all children were screened at the recommended period.

The AAP (1999) also notes that the NHS should be performed before hospital discharge. Publications that provide such information only in Malaysia (Hospital *Universiti Kebangsaan Malaysia)* (42) and South Africa (Gauteng) (29) NAS did not follow the norm of the AAP.

In case of failure in the NHS, the retest must be completed within one month after the first screening (AAP, 1999). This approach was adopted in Brazil (Sao Paulo) (24), Italy (Milan) (41) and France (Eure) (16). Malaysia (Hospital *Universiti Kebangsaan Malaysia)* (42) children were retested at two and, if the new fault, after three months, and in South Africa (Gauteng) (29) and second test was performed six weeks after failing to first hearing screening.

Publications from ten countries cited the time of completion of stage of diagnosis: USA (Colorado (50, 51) Mississippi (14)), Spain (Cantabria) (11), Italy (Sicily) (52), Austria (30, 53) Germany (7, 54), Singapore (2) Saudi Arabia (25), Nigeria (20), South Africa (55) and Mexico (Monterrey) (10). The diagnosis was made within the period recommended by 100% of the cases only in Monterrey (Mexico) (10). In the state of Colorado (USA) (51), from 1992 to 1999 the diagnosis was done before 3 months in 71% of newborns screened. Nigeria (20) the age at diagnosis ranged from 46 to 360 days. In other countries the average age of diagnosis ranged between 3.9 months (Mississippi / USA) (14) and 39 months (Germany) (54).

USA (50), Austria (53) and Germany (54) the age of

identification of hearing impairment in children not screened was higher than those who carried out the NHS. Colorado (USA) (50) the diagnosis was made, albeit belatedly, before six months in 84% of children subjected to TAN and only 8% of children not screened. In Austria (53) and Germany (54) the children who did not undergo the NHS had hearing loss diagnosed on average at 37.6 and 17.8 months respectively. Have the children screened were diagnosed to complete 3.9 (Austria (53)) and 3.1 months of age (Germany (54)).

According to the AAP (1999) and the *Joint Committee on Infant Hearing* (JCIH) (2007) (56) the intervention should be started before six months of age. Publications that reported the time it was made the contribution, the suggested course of action was adopted only in Italy (Sicily) (52) and Austria (53) in children who carried out the NHS. In another publication from that country (30), 1990-2006, 61% of children screened were referred to appropriate intervention by six months, versus only 4% of children who did not attend the NHS. Germany (54) age of children screened at the time of intervention had a median of 3.5 months and screened children do not age at diagnosis had a median of 21 months.

Spain (Cantabria) (11) only 50% of the children began treatment before six months. Mexico (Monterrey) (10), although 100% of diagnoses are made within this period, all children diagnosed after the intervention had six months of age. Cuba (57) the intervention started on average at 10 months of age in Singapore (2) to 42.4 months and the state of Mississippi (USA) (14) to 6.1 months.

In Brazil there are laws making it mandatory in the NHS states of Paraná, Pernambuco and Sao Paulo (5), Santa Catarina, Minas Gerais, Piauí, Rondônia and Mato Grosso do Sul (58). The bill (the federal) No 697/07 (in progress), provides for the compulsory examination Evoked Otoacoustic Emissions - OAE ", known as" the OAE test "for all newborns in the country (58).

In Germany, there are legislative efforts to deploy a TANU as regular procedure offered to all newborns (7).

United States (U.S.) states where TAN is required by law, according to the *Centers for Disease Control and Prevention* (2007) *(59),* are Arkansas, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Illinois , Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey. New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Virginia, West Virginia, Wisconsin and Wyomin.

As noted by Green et al. (2007) (13) in the USA the rate of completion of NHSP in states that have legislation is higher than the others. Triaram states that 95% of newborns were mostly those with implementing legislation.

Discussion

A growing number of countries aware of the necessity of implementing programs TAN. These programs will significantly increase the rate of early diagnosis of hearing loss in children and are being implemented efficiently and effectively in various locations.

TAN programs are being implemented as part of health systems in about 55 countries, where the search for improvements is increasing. In countries where TAN is not yet implemented, is an arduous struggle for its implementation.

The implementation of programs for the NHS both in developed countries as in developing bumps into obstacles such as lack of suitable environment for the testing, few professionals and prepared for such a task, lack of professionals who undertake the TAN at the end of week, lack of services for monitoring and control, and especially, little information about the benefits provided to deaf children (60), both by professionals and the general population. This complicates the process of universalization of TAN and leads to a large number of dropouts before completion of all steps necessary (44).

It is necessary to carry out awareness programs about the importance of newborn hearing screening and the benefits provided by this program.

One of the main consequences of the lack of legislation in favor of NAS is the late diagnosis of hearing loss in children and the low rate of children screened. The age of identification of hearing impairment in children not screened is higher than that of children who underwent TAN (50, 53, 54). Due to this, many countries are making efforts to adopt and implement laws to implement the NHS and thereby ensure that all children have their hearing tested in a timely fashion.

The universal and binding of the NHS has been highlighted extensively, so that no child with a hearing disability ceases to be diagnosed and receive the assistance necessary for an adequate social, psychological, educational and linguistic. Yet it was observed that despite the recommendations of the AAP (1999) and JCIH (2007), there are many programs that practice selective hearing screening.

It was found that the NHS is being applied in some places, after the third month of life, which delays diagnosis and intervention.

The procedures most frequently used are common to developed and developing countries. The most widely used procedure in the NHS has been examining SOAE. In case of failure the most frequent is the retest with SOAE and only in the event of another failure, children are referred for evaluation of diagnostic ABR or AABR. What proved to be highly variable across studies was the time set for the children who failed the screening return for retest. This time ranged from seven days (Santa Maria / Brazil) to two months (Malaysia) (54).

The NHS has proved a highly effective and feasible procedure. Its relevance lies in the reduction in children's age at diagnosis and intervention, especially in places filled legislation.

Thus, the path seems to be the search for improvements in existing programs, implementing new programs and legislation of laws that support you.

Final Comments

The consequences of hearing loss and relevance of the NHS are still matters unknown to the general population. Therefore, it is necessary to disseminate knowledge about these two issues, hoping to change behavior and incorporation of TAN as a routine procedure among professionals and parents.

Over the past 10 years, research period for the preparation of this text, TAN programs are being conducted in approximately 55 countries with very effectively and successfully, with the primary procedure analysis SOAE. Are increasing efforts to improve them according to the standards set by the AAP (1999) and by JCIH (2007) and for the reduction of obstacles encountered and elaboration of specific legislation.

Finally, it is necessary to unite efforts by professionals, parents and governments, so that programs can meet their goals TAN in favor of an increasing number of deaf children and their families.

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