RMJ Ramathibodi Medical Journal

Rama Med J | Original Article

Universal Newborn Hearing Screening and Incidence of Hearing Loss in Ramathibodi Hospital: A 5 Years Experience (2014 to 2018)

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Background: Congenital hearing loss is an important factor affecting a child's speech and language development. The quality of universal newborn hearing screening and hearing intervention program plays an important role in assisting children with permanent hearing to achieve appropriate speech and language development.

Objectives: To assess outcomes of the revised Ramathibodi Hospital universal newborn hearing screening (RUNHS) during 2014 to 2018, and to analyze the incidence of hearing loss in infants.

Methods: This study was a retrospective analysis, all newborns delivered at Ramathibodi Hospital from January 1, 2014, to December 31, 2018 were included. Data were collected from medical records and evaluated the RUNHS outcomes compared with benchmarks. Descriptive statistics were used to analyze data.

Results: Of 18 597 newborns, the screening coverage rate was 99.8%, and the referral rate was 2.5%. The follow-up rate was 92.5%, and the diagnosis rate within 3 months of age was 20.1%. Among infants diagnosed with hearing loss, 42.9% received hearing aids by 6 months of age. The incidence of congenital permanent hearing loss was between 0.5 and 1.9 per 1000 live births.

Conclusions: The outcomes met the benchmarks for coverage and referral rate, but the diagnosis and hearing aid fitting rate did not meet the criteria. As of the incidence, the amount of children with congenital hearing loss in this study was similar to those reported by others.

Keywords: Newborn, Hearing screening, Hearing loss, Outcome

Rama Med J: doi:10.33165/rmj.2022.45.4.258412

Received: June 28, 2022 **Revised:** November 7, 2022 **Accepted:** December 16, 2022

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Introduction

Hearing loss is one of several hidden birth disorders. It can affect a child's speech and language, cognitive and social-emotional development, and result in academic failure and poor quality of life.[1, 2] The severity of those deficits depends on types (bilateral, unilateral congenital permanent sensorineural hearing loss [SNHL], and permanent conductive hearing loss [CHL] or auditory neuropathy), degree, and configuration of hearing loss. The incidence of hearing loss in infants is approximately 1.5 to 3.3 cases per 1000 infants.[3-6] Early detection and intervention with appropriate medical management are essential to overcome challenges faced by children with hearing loss.[2, 7-9] In fact, those infants who receive appropriate intervention before 6 months of age have significantly better speech and language development than those who received the intervention later.[2]

In 1990, the newborn hearing screening (NHS) program was adopted as part of the early hearing detection and intervention (EHDI) system as an effective and widely used program for early detection of hearing loss in infants.[10-13] Two main purposes of the NHS program are 1) to identify newborns who are likely to have congenital hearing loss and might need a further evaluation, and 2) to identify the late onset of hearing loss in newborns with medical conditions.[1] In the general NHS program, otoacoustic emissions (OAEs) or automated auditory brainstem responses (AABR) are used for newborn hearing screening. All infants who fail the screening are then referred for further audiological evaluations such as diagnostic auditory brainstem response (ABR) and/or auditory steady-state response (ASSR). After diagnosis with permanent hearing loss, infants will receive early intervention, including fitting with hearing devices and habilitation to improve speech and language development. However, the design of NHS varies across settings, typically because of screening tool availability, personnel, infant hometown, length of stay, and parental attitude toward hearing loss.

The Joint Committee on Infant Hearing (JCIH) supports the notion of regular performance evaluation and continuous quality improvement.[1] Thus, JCIH recommends that high-quality EHDI programs should attain minimum requirements of benchmarks and quality indicators resulting from a consensus of experts' opinions.

In 1997, Ramathibodi Hospital, Thailand, implemented the NHS program called Ramathibodi Hospital universal newborn hearing screening (RUNHS). Jariengprasert et al[14] reported the incidence of hearing loss in infants was 1.7 per 1000 newborns in the RUNHS program. To follow JCIH recommendations, outcomes of RUNHS were evaluated from 2012 to 2013.[15] Five main quality indicators were used as benchmarks to monitor outcomes of the program. These include 1) coverage rate - the percentage of newborns completing hearing screening by 1 month of age should exceed 95.0%, 2) referral rate - less than 4.0% of all newborns could fail hearing screening before hospital discharge, 3) follow-up rate - more than 95.0% of all infants who did not pass the hearing screening should return for follow-up, 4) audiological diagnosis rate - the percentage of infants completing a full audiological evaluation by 3 months of age should exceed 90.0%, and 5) intervention rate - 90.0% of the infants with confirmed hearing loss should receive amplification and aural habilitation by 6 months of age.[1, 16]

Chouyboonchum et al[15] reported a high coverage rate of 99.1%, yet some quality indicators of the RUNHS program were lower than benchmarks - referral rate was 5.0%, follow-up rate was 89.1%, and audiological diagnosis rate for 3 months of age was 80.2% (normal transient evoked otoacoustic emissions [TEOAE] or normal ABR). Therefore, the RUNHS program was revised by the audiology team, and a new protocol was developed to improve the outcomes mainly by 1) confirming the first outpatient follow-up appointment or recommending other hospitals near to their home and following up with the hospital, and 2) ensuring appointments for ABR took place within 3 months of age.

This study aimed to assess outcomes of the revised RUNHS program from 2014 to 2018 against the 4 quality indicators compared with benchmarks recommended in the JCIH position statement, and analyze the incidence of hearing loss in infants of RUNHS accordingly.

Methods

Study Group

This study was a retrospective analysis of the RUNHS outcomes for the 5 years from 2014 to 2018. The study was approved by the Committee for Research, Faculty of Medicine, Ramathibodi Hospital, Mahidol University (No. MURA2019/882 on September 16, 2019). All newborns delivered at Ramathibodi Hospital, Thailand from January 1, 2014, to December 31, 2018 were included in this study.

RUNHS Protocol

The RUNHS program was modified following the results reported by Chouyboonchum et al.[15] All newborns were registered daily on the RUNHS datasheet, managed by well-trained audiologists to ensure that all newborns received TEOAE screening within the first 36 hours after birth. Screening results were recorded in the same document so that all infants who did not pass the first hearing screening were rescreened the following day(s) until hospital discharge (typically no more than 3 days). At hospital discharge stage, typical infants who passed the screening were discharged from the RUNHS program, and those who still failed the screening returned for rescreening by 1 month after discharged. For high-risk infants, however, those who passed the screening were followed up for monitoring at 6 months, and those who failed the screening returned for rescreening by 1 month after discharged (Figure 1A).

In the outpatient stage, all infants who needed rescreening (from the inpatient stage) were evaluated with OAE at their first follow-up appointment. Those who passed were discharged from the RUNHS program, while those who failed were referred for an AABR the following month. Those who passed an AABR at 35 dBnHL were discharged from the program, and those who were referred undergo a comprehensive ABR within the next 2 weeks as part of the full diagnostic protocol. The RUNHS protocol allowed all infants who did not pass their hearing screening to receive a comprehensive diagnosis with air conduction and/or bone conduction ABR, ASSR, and tympanometry within 3 months of age, especially for normal infants. Note that high-risk infants who passed rescreening or were found to have normal hearing sensitivity by ABR diagnosis (not exceeding 35 dBnHL), had their hearing status monitored until at least complete conventional audiometry could be performed (Figure 1B). To ensure that patients did not miss their appointments, audiologists telephone families to confirm the day before an appointment.

The RUNHS outcomes were evaluated by reviewing newborn hearing screening reports recorded by audiologists. The audiological diagnosis results and hearing aid fitting information of the infants were reviewed via electronic medical records (EMRs) from Ramathibodi Hospital.

Statistical Analysis

To evaluate the RUNHS outcomes, the percentage of each quality indicator was calculated and compared with the benchmark. Lastly, the incidence of hearing loss was analyzed and reported. Descriptive statistics (mean, median, and standard deviation [SD]) were computed using STATA version 11.0 (StataCorp. Version 11. College Station, TX: StataCorp LP; 2009).

Results

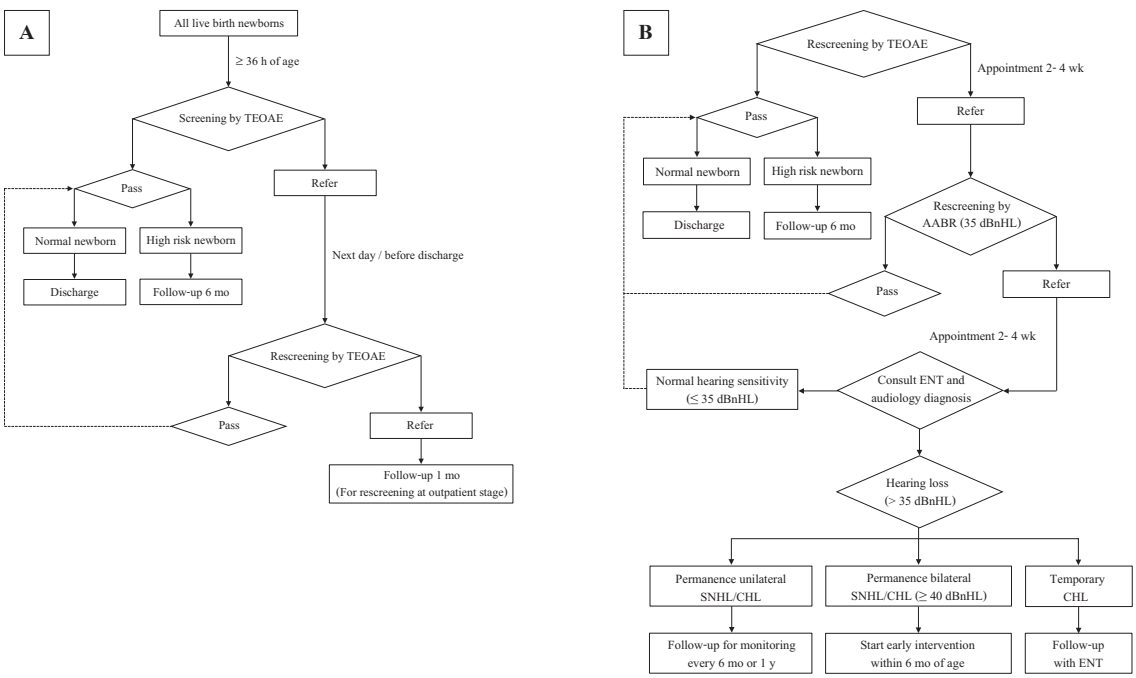
Outcomes of the RUNHS Program

From 2014 to 2018, a total of 18 867 newborns were delivered at Ramathibodi Hospital, Thailand, and 270 newborns did not survive. Out of 18 597 live newborns, 18 557 newborns (99.8%) were screened using TEOAE, while 40 newborns (0.2%) were not screened before hospital discharge because they were either referred to another hospital or immediately discharged. Prior to hospital discharge, there were 2 indicators: 1) the screening coverage rate refers to the percentage of newborns screened for hearing loss by TEOAEs over the total occurrence of births reported in Ramathibodi Hospital, and 2) the referral rate implies the percentage of newborns who failed hearing screening in at least 1 ear at hospital discharge in relation to the total number of newborns screened.

The screening coverage rate ranged from 99.5% to 99.9% (mean [SD], 99.8 [0.2] %), well above the minimum requirement of 95.0% suggested by JCIH. This result confirms that the system that ensures all newborns are screened before hospital discharge is efficient.

For the screening results, a total of 18 091 newborns (97.5%) passed the TEOAE screening in both ears, whereas 466 newborns (2.5%) failed the screening in either 1 or both ears. The referral rates ranged from 1.4% to 3.4% (mean [SD], 2.5 [0.7] %) (Table 1).

Figure 1. Flow Chart of the RUNHS Program



Abbreviations: AABR, automated auditory brainstem response; CHL, conductive hearing loss; ENT, ear nose throat doctor; RUNHS, Ramathibodi Hospital universal newborn hearing screening; SNHL, sensorineural hearing loss; TEOAE, transient evoked otoacoustic emissions.
A, Hospital discharge stage. B, Outpatient stage.

Table 1. Newborns Undergoing Hearing Screening Using TEOAE and the Newborns Screening Results at Hospital Discharge Stage During 2014 to 2018

Characteristic	No. (%)					
	Year					
	2014	2015	2016	2017	2018	Total
Live birth newborns	3697	3706	3820	3717	3657	18 597
Hearing screening						
Screen	3678 (99.5)	3702 (99.9)	3817 (99.9)	3713 (99.9)	3647 (99.7)	18 557 (99.8)
Pass	3586 (97.5)	3651 (98.6)	3688 (96.6)	3614 (97.3)	3552 (97.4)	18 091 (97.5)
Refer	92 (2.5)	51 (1.4)	129 (3.4)	99 (2.6)	95 (2.6)	466 (2.5)
Not screen	19 (0.5)	4 (0.1)	3 (0.1)	4 (0.1)	10 (0.3)	40 (0.2)

Abbreviation: TEOAE, transient evoked otoacoustic emissions.

The first outpatient stage has 2 indicators: 1) the follow-up rate for rescreening is the percentage of infants rescreened at the first outpatient stage over those who failed hearing screening at the hospital discharge stage, and 2) the diagnosis rate is the percentage of infants who underwent comprehensive audiological evaluation by 3 months of age over those infants who failed their rescreening.

All newborns who failed hearing screening at the hospital discharge stage were then rescreened by TEOAE approximately 1 month after discharge. Out of 466 infants who were referred to the outpatient stage, 3 infants died, the family of 1 infant rejected the follow-up, and 10 infants were followed up at other hospitals near their homes. Five infants were born with medical complications and remained admitted to the hospital for more than 4 months. Therefore, there were 447 infants considered in the rescreening process. Of these, 265 infants passed their TEOAEs or AABR at 35 dBnHL in both ears; 149 infants were referred for a full diagnosis, and 33 infants were lost to follow-up. Specifically, the follow-up rate for rescreening over the 5-year period ranged from 87.8% to 95.7% (mean [SD], 92.5 [3.3] %).

Of 149 infants, 30 infants (20.1%) were fully diagnosed using ABR, ASSR, and high frequency tympanometry (HFT) before 3 months of age, while 75 infants (50.3%) were diagnosed after 3 months of age. Unfortunately, 44 infants (29.5%) were not diagnosed and lost to follow-up at that stage. Five infants born with medical complications were diagnosed with hearing impairment between 1 and 5 months (median, 2 months) after hospital discharge. Considering only 30 infants received a full diagnosis within 3 months of age, the diagnosis rate ranged from 8.8% to 33.3% (mean [SD], 20.1 [9.5] %). Of 105 infants diagnosed, there were 12 infants with bilateral permanent hearing loss (both SNHL and CHL) of more than 35 dBnHL in the better ear (Table 2).

For families opting for amplification, it is recommended that 95.0% of infants with confirmed bilateral hearing loss receive amplification devices within 6 months of age. However, this study found only 58.3% (7/12) of infants were fitted with hearing aids, and that 3 infants (42.9%) received hearing aids within 6 months of age. Five infants were not fitted with hearing aids because parents rejected them. Note that the median age of infants fitted with hearing aids was 8 months (rang, 4 - 14; mean [SD], 7.9 [3.3] months) (Table 3).

Table 2. Hearing Rescreening and Diagnosis of Referred Infants at Outpatient Stage During 2014 to 2018

Characteristic	No. (%)					
	Year					
	2014	2015	2016	2017	2018	Total
Referred infants at hospital discharge stage	90	51	124	92	90	447
Hearing rescreening						
Rescreen	79 (87.8)	47 (92.2)	115 (92.7)	88 (95.7)	85 (94.4)	414 (92.6)
Pass	46 (58.2)	22 (46.8)	81 (70.4)	61 (69.3)	55 (64.7)	265 (64.0)
Refer	33 (41.8)	25 (53.2)	34 (29.6)	27 (30.7)	30 (35.3)	149 (36.0)
Not rescreen	11 (12.2)	4 (7.8)	9 (7.3)	4 (4.3)	5 (5.6)	33 (7.4)
Hearing diagnosis of referred rescreening infants						
Diagnose	19 (57.6)	16 (64)	25 (73.5)	22 (81.5)	23 (76.7)	105 (70.5)
Age ≤ 3 mo	4 (12.1)	5 (20)	3 (8.8)	8 (29.6)	10 (33.3)	30 (20.1)
Age > 3 mo	15 (45.5)	11 (44)	22 (64.7)	14 (51.9)	13 (43.4)	75 (50.4)
Not diagnose	14 (42.4)	9 (36)	9 (26.5)	5 (18.5)	7 (23.3)	44 (29.5)

Incidence of Hearing Loss in the RUNHS Program

Of infants undergoing comprehensive audiological diagnosis in the period of this study, 49 infants had hearing loss (hearing sensitivity more than 35 dBnHL). Of these 49 infants, 51.0% (25/49) of infants had a temporary conductive hearing loss. In some cases, this was related to a syndrome such as cleft lip and palate (11 infants), Down syndrome (1 infant) and collodion baby (1 infant), while 12 infants had suspected middle ear dysfunction with effusion unrelated to syndromes. Among 49.0% (24/49) of infants with permanent hearing loss were further classified into 11 infants with unilateral SNHL, 11 infants with bilateral SNHL, and 2 infants with permanent CHL (1 had unilateral CHL with an anomaly of the outer ear, and another had bilateral CHL with CHARGE syndrome). Therefore, the incidence of congenital permanent hearing loss (SNHL and CHL) in infants was between 0.5 and 1.9 per 1000 live births (mean [SD], 1.3 [0.5] per 1000 live births) for this study. The incidence of unilateral SNHL and bilateral SNHL ranged between 0.3 and 1.1 per 1000 live births (mean [SD], 0.6 [0.3]), and 0.3 and 1.1 per 1000 live births (mean [SD], 0.6 [0.5]), respectively (Table 4).

Table 3. Management Intervention for Permanent Hearing Loss Infants During 2014 to 2018

Management	No. (%)				
	Years				
	2014	2015	2016	2017	2018
Hearing loss ≥ 40 dBnHL both ears	4	2	0	2	4
Fitted hearing aid	3 (75)	0	NA	1 (50)	3 (75)
Age of onset hearing aid					
Median (range), mo	8 (4 - 9)	NA	NA	14	6 (5 - 9)
Mean (SD), mo	7 (2.7)	NA	NA	14	6.67 (2.1)
Rejected hearing aid and required follow-up	1 (25)	2 (100)	NA	1 (50)	1 (25)

Abbreviations: NA, not applicable; SD, standard deviation.

Table 4. Congenital and Permanent Hearing Loss in Infants for the 5 Years Study

Type of Hearing Loss	No. (% per Live Births)				
	Year				
	2014	2015	2016	2017	2018
Infants with hearing loss	6 (0.16)	4 (0.10)	2 (0.05)	7 (0.19)	5 (0.14)
Unilateral SNHL	2 (0.05)	2 (0.05)	2 (0.05)	4 (0.11)	1 (0.03)
Bilateral SNHL	4 (0.11)	2 (0.05)	0	1 (0.03)	4 (0.11)
Unilateral CHL	0	0	0	1 (0.03)	0
Bilateral CHL	0	0	0	1 (0.03)	0

Abbreviations: CHL, conductive hearing loss; SNHL, sensorineural hearing loss.

Discussion

The goal of NHS programs is to detect neonatal hearing loss - especially permanent hearing loss - as early as possible, and make appropriate referrals for diagnosis and intervention to ensure appropriate speech and language development.[7, 17] The JCIH recommends benchmarks to control the quality of newborn hearing screening programs, and requires a high standard.[1] At Ramathibodi Hospital, the coverage rate of newborn hearing screening at

the hospital discharge stage met the criteria of the JCIH (> 95.0%) both for the total 5-year study period (99.8%) and for each year of the study (99.5% - 99.9%).

The coverage rate was higher than that reported in programs in Malaysia, Belgium, Italy, Germany, Spain, and Western Australia.[18-23] The high coverage rate is likely because of the recheck system used before hospital discharge by pediatricians and charge nurses. In addition, the hospital had enough audiologists to provide a daily newborn hearing screening service. Most importantly, we developed a hearing screening record, an intra-document for transferring test information among audiologists, including patient's hospital ID, date of birth, and test results with remarks. This document reminds the audiologist to retest an infant's hearing each successive day until hearing screening is complete or the infant is discharged from the program. The total loss of the RUNHS program was only 0.2% (40 of 18 597 newborns) at the hospital discharge stage. A major cause (26/40 newborns) of the loss was the unavailability of audiologists to undertake newborn hearing screening at the hospital discharge stage. However, most of those newborns (18/26 newborns) were followed up for screening at 1 month after discharge, while 14 out of 40 newborns were referred to other hospitals (depending on their national health insurance or to be closer to their hometown). There were only 8 newborns lost to hearing screening and follow-up in the RUNHS program.

The referral rate of the RUNHS program at hospital discharge stage met the indicators of the JCIH (< 4.0%) both for the total study period (2.5%) and each individual year of the study (1.4% to 3.4%). Note that the referral rate reported in this study was reduced to a half of which reported in the previous study.[15] The experience of testers (our audiologists had more than 2 years of experience in the RUNHS service) and the rescreening before discharge were important factors that ensured a low referral rate, even though we used TEOAE for hearing screening.

The overall first follow-up rate of our program was 92.6% which was higher than the result from the previous study.[15] The lowest rate was 87.8% in 2014. The first follow-up rates increased continually to more than 90.0% for the following 2 years and to 95.0% in 2017. From 2015, we concentrated on reducing the loss to follow-up rate and informed the parents of newborns who failed hearing screening at the hospital discharge stage about the importance of the following processes and early detection and intervention. Those processes resulted in increasing the first follow-up rate. In the last 2 years of the study (2017 and 2018), we supplemented the parent contact process by confirming rescreening appointments, recommending other hospitals near the homes of families who could not follow-up, and following up hearing screening results of the newborns when the parents brought them for rescreening at other hospitals. Those processes further improved the first follow-up rate up to 95.0% in our program.

The study indicated 70.5% of the infants who failed hearing rescreening at the outpatient stage were diagnosed with hearing impairment for the overall study period. The rate of infants diagnosed with hearing impairment was lowest in 2014 (57.6%). This number increased consistently to more than 75.0% in the final 3 years of the study (73.5% in 2016, 81.5% in 2017, and 76.7% in 2018). The percentage of infants diagnosed with hearing impairment within the first 3 months of age was between 8.8% and 33.3% in 2014 to 2018, and 20.1% for the entire 5-year period. These rates are lower than the criteria of the JCIH (> 90.0%). At present, this issue is being resolved by developing a protocol for early diagnosis that includes creating a 'fast track' with the ear, nose, and throat (ENT) clinic for early appointments, being aware of ABR testing appointments within 3 months of age, and encouraging parents about the importance of early diagnosis and intervention.

In the 5 years of the study, 12 infants had bilateral permanent hearing loss (both SNHL and CHL) with more than 35 dBnHL in the better ear, and only 7 infants (58.3%) received hearing aid fitting. Two infants had multiple abnormalities, which precluded fitting a hearing aid and the parents refused hearing aid fittings for them. Three infants had mild to moderate SNHL (40 - 55 dBnHL),

and their parents opted to follow-up by monitoring the degree of hearing loss and speech and language development, instead of hearing aid fitting. If speech and language development were delayed, the parents agreed that hearing aid fitting should then occur. Out of 7 infants fitted with hearing aids, 3 (42.9%) were given these within 6 months of age. This rate was lower than the JCIH recommendation (> 95.0%). The other 4 infants were delayed in their hearing aid fitting (occurred after 6 months of age) due to delayed diagnosis. This issue is concerning and needs to be rectified to ensure the full benefit of the newborn hearing screening program is realized, and optimal speech and language development of infants with permanent hearing loss occurs.

Our study reveals the incidence of permanent hearing loss in infants is between 0.5 and 1.9 per 1000 live births (mean [SD], 1.3 [0.5]). This is similar to the incidence of hearing loss in US infants (1.7 per 1000 live birth newborns) in 2018 and 2019.[24, 25]

Conclusions

The current RUNHS program met the indicators recommended by the JCIH for coverage and referral rate, but the diagnosis and hearing aid fitting rate did not meet the criteria. These aspects are challenging but must be improved to ensure the full benefits of the newborn hearing screening program are realized, and that the speech and language development of all infants with permanent hearing loss is supported. As of the incidence, the amount of children with congenital hearing loss in this study was between 0.5 and 1.9 per 1000 live births which is similar to those reported by others.

Acknowledgments

We thank audiology team at Ramathibodi Hospital for testing and completing data collection, and Michelle Pascoe, for editing a draft of this manuscript.

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การศึกษาผลการให้บริการตรวจคัดกรองการได้ยินในทารกแรกเกิดและอุบัติการณ์ของการเกิดการสูญเสียการได้ยินของโรงพยาบาลรามาธิบดีในระยะเวลา 5 ปี (พ.ศ. 2557 - พ.ศ. 2561)

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บทนำ: การสูญเสียการได้ยินแต่กำเนิดเป็นปัจจัยสำคัญที่ทำให้เด็กมีพัฒนาการด้านภาษาและการพูดล่าช้า การพัฒนาและควบคุมคุณภาพการให้บริการตรวจคัดกรองการได้ยินในทารก การตรวจวินิจฉัยการสูญเสียการได้ยิน และการฟื้นฟูสมรรถภาพทางการได้ยิน เป็นส่วนสำคัญที่ช่วยให้เด็กได้รับการช่วยเหลือตั้งแต่อายุน้อย และช่วยเพิ่มโอกาสให้เด็กมีพัฒนาการทางภาษาและการพูดที่ดีขึ้น

วัตถุประสงค์: เพื่อประเมินการให้บริการตรวจคัดกรองการได้ยินในทารกแรกเกิดของโรงพยาบาลรามาธิบดีในปี พ.ศ. 2557 ถึง พ.ศ. 2561 และศึกษาอุบัติการณ์ของการเกิดการสูญเสียการได้ยินในทารกแรกเกิด

วิธีการศึกษา: การศึกษาแบบย้อนหลังของข้อมูลการตรวจคัดกรองการได้ยินในทารกแรกเกิดทุกราย ณ โรงพยาบาลรามาธิบดี ตั้งแต่ 1 มกราคม พ.ศ. 2557 ถึง 31 ธันวาคม พ.ศ. 2561 เก็บข้อมูลจากเวชระเบียนและประเมินการให้บริการตรวจคัดกรองเปรียบเทียบกับเกณฑ์มาตรฐาน การวิเคราะห์ข้อมูลใช้สถิติเชิงพรรณนา

ผลการศึกษา: จากข้อมูลทารกแรกเกิด จำนวน 18,597 คน อัตราความครอบคลุมการให้บริการตรวจคัดกรองการได้ยินทารกแรกเกิด คิดเป็นร้อยละ 99.8 และอัตราการส่งต่อทารกที่ผลตรวจคัดกรองการได้ยินไม่ผ่าน คิดเป็นร้อยละ 2.5 ขณะที่อัตราการกลับมาตรวจซ้ำของทารก คิดเป็นร้อยละ 92.5 และทารกร้อยละ 20.1 ได้รับการตรวจวินิจฉัยการสูญเสียการได้ยินภายในช่วงอายุ 3 เดือน ทารกที่สูญเสียการได้ยินร้อยละ 42.9 ได้รับการใส่เครื่องช่วยฟังภายในช่วงอายุ 6 เดือน อุบัติการณ์การสูญเสียการได้ยินแต่กำเนิดอยู่ระหว่าง 0.5 ถึง 1.9 คนต่อทารกแรกเกิดมีชีพ 1,000 คน

สรุป: อัตราความครอบคลุมการให้บริการและอัตราการส่งต่อทารกที่ผลตรวจคัดกรองการได้ยินไม่ผ่าน อยู่ในเกณฑ์มาตรฐาน ขณะที่อัตราการตรวจวินิจฉัยการสูญเสียการได้ยินและอัตราการใส่เครื่องช่วยฟังยังคงไม่ผ่านเกณฑ์ สำหรับการสูญเสียการได้ยินแต่กำเนิดพบอุบัติการณ์ใกล้เคียงกับการศึกษาอื่น

คำสำคัญ: ทารกแรกเกิด การตรวจคัดกรองการได้ยิน การสูญเสียการได้ยิน ผลลัพธ์

Rama Med J: doi:10.33165/rmj.2022.45.4.258412

Received: June 28, 2022 **Revised:** November 7, 2022 **Accepted:** December 16, 2022

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