The Relationship Between Risk Factors And Hearing Loss In Infants With Otoacoustic Emissions

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Abstract
Background: Hearing loss is a common disorder that frequently affects newborns. Hearing screening in newborns is a program to reduce the number of hearing loss events worldwide. In addition, Otoacoustic Emissions (OAEs) are objective screening tools in newborns. This study aimed to determine the relationship between risk factors and hearing loss in infants with hearing screening otoacoustic emissions.
Subjects & Methods: This study uses an analytic retrospective study designed by taking secondary data from medical records of infants at Dr. Soetomo Hospital for five years (2017-2021). The inclusion criteria for the study sample were infants under one-year, complete medical records, infants with risk factors and normal, and infants who had been screened for hearing with the first stage of Otoacoustic Emissions.
Result: The most common risk factors for infant hearing loss were premature, low birth weight, and NICU care. There is an association between risk factors and hearing loss in the first screening stage with OAE. Hearing loss in infants was 36%, and infants with normal hearing were 64%, both with and without risk factors.
Conclusion: There are several risk factors for infant hearing loss, such as premature, low birth weight, and NICU care. Infants with hearing loss were a lower percentage than infants with normal hearing, both with and without risk factors.

Keywords: Risk of factors, hearing loss, infants, OAE, human and health.

Background

Hearing loss is a disorder with a high incidence that is often found in newborns. Recent statistics show that hearing loss ranges from 1-3 out of 1000 live births in healthy newborns to 2-4 out of 100 admitted to the Neonatal Intensive Care Unit (NICU). Hearing loss can be seen in at-risk or non-risk infants. The prevalence ranged from 0.09 to 2.3% in low-risk infants and 0.3 to 14.1% in high-risk infants. High-risk factors associated with hearing loss in infants are commonly found in cases of hyperbilirubinemia, low birth weight, low Apgar scores, intensive therapy for up to 7 days, and congenital abnormalities. [1,2] One of the most common hearing loss is congenital abnormalities. Genetic factors cause approximately 50% of children with congenital hearing loss. Then, the remainder is due to environmental factors such as prenatal or perinatal disease, or the cause is unknown. [3,4] According to the Joint Committee on Infant Hearing (JCIH), the risk factors which influence the incidences of congenital hearing loss are mother-fetal infection, family history of hearing loss, gestational diabetes, low birth weight, hyperbilirubinemia, birth asphyxia, mechanical ventilation for five days or more, premature birth, use of ototoxic drugs and infant with congenital head and facial abnormalities. A hearing function is vital in intellectual and social development during childhood; if it is distributed, it will affect children's personal and social health. Hearing loss or hearing loss from birth will cause impaired speech, language, cognitive, and academic development.[5]

Based on the results of the Basic Health Research (Riskesdas) conducted by the Health Research and Development Agency (Balitbangkes) of the Ministry of Health in 2018, the proportion of deaf children in Indonesia aged 24-59 months was 0.11%.[6] The World Health Organization (WHO) estimates that 466 million people, or more than 5% of the global population, require rehabilitation due to hearing loss, 34 million of whom are children. By 2050, out of 700 million people, one in every ten will have hearing loss.[7] The incidence of sensorineural hearing loss ranges from 1 to 3 per 1000 live births in healthy infants and 2 to 4 per 100 in high-risk infants.[3]

Hearing screening in newborns is a program to reduce the number of hearing loss events worldwide.[5] Infants should be screened for hearing loss before one month, repeat tests can be done before three months, and interventions can be given before six months of age.[8] Newborn hearing screening programs should be family-centered, allowing families to make decisions for their children.[9] The World Health Organization (WHO) and The Joint Committee on Infant Hearing (JCIH) recommend Otoacoustic Emissions (OAEs) as objective screening tools in newborns. The primary purpose of the OAE examination is to assess the state of the cochlea, precisely the function of the OHC.[10] The examination results can help screen hearing, especially in newborns, children or individuals with hearing loss disorders, estimate hearing sensitivity within a specific range, screen

disorders of the middle ear with moderate or severe degrees, and examine functional hearing loss. The second stage of hearing screening examination is carried out on infants who are referred with positive hearing screening results in the first stage in the neonatal unit, infants with negative screening results who have risk factors, and newborns who have not been screened in the first stage.[1] Screening second-stage hearing using Otoacoustic Emissions has been used in large-scale screening programs to avoid false-positive or negative results.[17]
This study aimed to determine the relationship between risk factors and hearing loss in infants screened for hearing at the Outpatient Unit ENT Neurotology Division, Dr. Soetomo hospital Surabaya.

Subjects & Methods
This type of research used an analytic retrospective study design by taking secondary data from medical records of infants at Dr. Soetomo hospital Surabaya for five years, from January 2017 to December 2021. Sampling was carried out on every patient who met the study inclusion criteria.
The inclusion criteria for the study sample were infants under one-year, complete medical records, infants with risk factors and normal, and infants who had been screened for hearing with the first stage of Otoacoustic Emissions. The study exclusion criteria were infants over one year and incomplete medical records. There are two categories for the OAE test results: pass and refer. Bilateral pass indicates that neither ear is affected by hearing loss, unilateral pass indicates that only one ear is affected, and bilateral refer indicates that both ears are affected.

Research data were collected and arranged in tables, then analyzed to evaluate risk factors for hearing loss in infants in the first stage with Otoacoustic Emissions using SPSS with Spearman's test. This research has obtained ethical feasibility from the ethics committee of Dr. Soetomo hospital Surabaya.

Result
Based on data from medical records, it was found that 412 babies who had risk factors and normal and had Otoacoustic Emissions hearing screening from January 2017 to December 2021. The sex distribution of the baby can be seen in the following table.

Table 1. Distribution Characteristics of Infants

Variable	n	Percentage (%)
Sex		
Male	219	53%
Female	193	47%
Age		
< 1 month	117	28.4%
1-3 month	205	49.8%
> 3-6 month	51	12.4%
> 6-12 month	39	9.5%
Risk Factors		
Yes	358	87%
No	54	13%
Gestational age		
< 37 weeks	327	79%
≥ 37 - 42 weeks	85	21%
Birth weight		
< 2500 g	331	80%
≥ 2500 g	81	20%

Table 1 shows more male patients than female patients, namely 219 male infants (53%) and 193 female infants (47%). Infants who underwent hearing screening for the first time were mainly at the age of 1-3 months, as many as 205 infants (49.8%), followed by the period under one month as many as 117 infants (28.4%), aged more than 3 to 6 months as many as 51 infants. (12.4%), and at least 39 infants (9.5%). The characteristics of infants with risk factors for hearing loss based on gestational age were mainly at the period of preterm gestation below 37 weeks of pregnancy, as many as 327 infants (79%) and above 37 weeks of gestation, as many as 85 infants (21%). Based on the birth weight of most babies with low birth weights below 2500 grams, 331 babies (80%). Babies with birth weight above or equal to 2500 grams were 81 babies). Babies who have risk factors for hearing loss are 358 babies (87%), while babies without risk factors are 54.

Table 2. Distribution of Otoacoustic Emissions Hearing Loss Screening

Result	Otoacoustic Emissions	
	n	Percentage (%)
Pass-Pass	235	57%
Pass/Refer	76	18%
Refer-Refer	101	25%
Total	412	100%

The hearing screening results for Otoacoustic Emissions infants had the most bilateral pass (pass-pass) results, with OAE results of as much as 235 (5%). The unilateral pass (pass-refer) results in OAE were 76 (18%). The results of the Otoacoustic Emissions examination were 101 (25%) (Table 2).

Table 3. Distribution of Risk Factors For Hearing Loss In Infants

Risk Factors	n	Percentage (%)	Hearing Loss	
			Bilateral	Unilateral
Premature	327	79%	52	62
LBW	293	71%	50	57
Asphyxia	69	17%	12	13
Hyperbilirubinemia	71	17.2%	13	12
NICU care	133	32%	19	26
Perinatal infection	9	2%	2	2
Congenital abnormalities	25	6%	6	3
Family history of deafness	3	0.72%	1	0
No risk factors	54	13%	9	13

The highest frequency was premature babies, with 327 babies, and the second was followed by low birth weight (LBW), with 293 babies. One hundred thirty-three babies were treated in the NICU care for more than five days, 69 babies with asphyxia, 71 babies with hyperbilirubinemia, and 25 with congenital abnormalities. The risk factors for perinatal infection were nine babies, and at least three babies had a family history of deafness. In infants without risk factors for hearing loss, as many as 54 infants.

Table 4. Relationship Between Risk Factors For Hearing Loss and Hearing Screening

Risk Factors	Otoacoustic Emissions			n	*p*
	Refer-Refer	*Pass/Refer*	*Pass-Pass*		
No	13 (3%)	18 (4%)	23 (6%)	54 (13%)	
One	15 (4%)	4 (1%)	16 (4%)	35 (8%)	
two	32 (8%)	26 (6%)	74 (18%)	132 (32%)	0.009
≥ three	41 (10%)	28 (7%)	122 (30%)	191 (46%)	
Total	101 (25%)	76 (18%)	235 (57%)	412 (100%)	

The relationship between risk factors for hearing loss was carried out in the first screening stage, Otoacoustic Emissions, with a p-value of 0.009 ($p < 0.05$). This indicates a significant result that there is a relationship between risk factors for hearing loss and the effects of Otoacoustic Emissions screening. Bilateral refers (25%), and unilateral (18%) outcomes differed slightly from pass results (57%) for one or more risk factors. The highest number was found in 191 infants (46%), with more than three to six risk factors recorded in medical records. The results of the Otoacoustic Emissions test increased with risk factors for hearing loss of more than three as many as 41 infants (10%) in refer, 28 infants (7%), and 122 infants (30%).

Discussion

According to the 2013 Riskesdas research results, the prevalence of hearing loss in Indonesia is 2.6%. In 2018 in Indonesia, the proportion of children with deafness was 0.11% in 24 to 59 months. *The World Health* Organization (WHO) estimates that around 466 million people worldwide have hearing loss, of which 34 million are children.[7] Early symptoms are challenging to be detected or recognized. Parents only become aware of hearing loss in children when there are no responses to loud sounds or late speaking.[9] Initial identification of hearing loss allows children to develop significantly improved language skills compared to young children. Early recognition of language offers many benefits in the form of rehabilitation for verbal communication, such as auditory-verbal and auditory-oral therapy, and alternative means of communication, including sign language, bilingual materials, and lipreading approaches.[9] They are then diagnosed later. Internationally, the

recommended age for diagnosing hearing loss in children is three months. If hearing loss has been confirmed, intervention should begin as soon as possible, before six months of age.[1]

The first objective of the universal newborn hearing screening program was to detect hearing loss in newborns before leaving the hospital within 72 hours and to identify newborns with normal hearing but risk factors for hearing loss. Age 1-3 months is essential for the early detection of hearing loss in newborns. Hearing screening is done in the first month and diagnosing hearing loss occurs within three months. If hearing loss has been confirmed, prompt initiation and appropriate intervention in a 6-month-old child. [1]

Research conducted in Katowice, Poland, stated that babies at risk of hearing loss were found at gestational age below 33 weeks and low birth weights under 1500 grams. Deficient birth weight.[9] Otoacoustic emissions (OAE) are acoustic signals from the mechanical processes of the cochlea's outer hair cells that inform the cochlea's good condition. Unlike the research conducted at Dr. Soetomo hospital Surabaya, the study found that bilateral hearing loss reached 94.69% compared to unilateral hearing loss (5.31%).[13] Approximately 40% or more of children who are first diagnosed with unilateral hearing loss are at risk of further hearing loss, and about one in six develop bilateral hearing loss. There is a growing consensus that children with unilateral hearing loss are at risk for difficulty in school and speech and language problems. It is crucial to identify patients with bilateral or unilateral hearing loss, even in the absence of risk factors.[14]

Each baby has one to more than three risk factors that may cause hearing loss. Infants without risk factors for hearing loss accounted for 5% of the 412 infants. This is the possibility of an unknown hearing loss factor or can occur due to asymptomatic genetic factors. Research in the Netherlands revealed that about 33% of children with hearing loss are without a clear cause of bilateral or unilateral hearing loss.[7] Other studies suggest that about 4.88% of infants with hearing loss without risk factors require attention.[15] Genetic factors cause about 50% of children with congenital hearing loss. Non-syndromic genetic hearing loss does not have any visible abnormalities of the outer ear or medical problems; however, it can be associated with anomalies of the middle ear and inner ear. [4]

Research conducted by Warsaw, Poland, found that 86.61% of infants screened for a hearing had risk factors. The frequency of the highest risk factors in this study differed slightly from this study, where the most common studies found were hyperbilirubinemia (71.51%), premature under 33 weeks (63.25%), and ototoxic drugs (62, 11%).[1] The Nigerian study's most common risk factors for hearing loss were asphyxia at 40.8%, premature under 34 weeks (36.3%), and low birth weight (21.4%).[13] A Poland study obtained the OAE test results, which referred to 62 infants (17.66%). Checked. The study stated that the risk factors for LBW (26.5%) and maternal infection (40%) were significantly associated with risk factors for hearing loss.[19]

Based on the Joint Committee on Infant Hearing (JCIH) in 2007, risk factors that support hearing loss in infants include premature birth under 34 weeks, low birth weight, children with a family history of hearing loss, hyperbilirubinemia, craniofacial anomalies, associated syndromes. With hearing loss and severe asphyxia at birth.[14] Research in Poland suggests that premature birth <34 weeks and low birth weight have no significant effect on hearing loss in infants. The study found that the risk factors for premature birth were 5.84% and low birth weight (LBW) 5.97%.[15] In contrast to the findings of other studies, hearing loss increased in infants born prematurely at 25 weeks by 11%.[20] Hearing loss in premature babies is complex; even if it's just early, it's unlikely to impact hearing severely. It is generally associated with multiple other risk factors that can affect hearing synergistically. Premature infants receiving aminoglycoside therapy, which is often used as a first-line antibiotic in newborns and widely used in the neonatal intensive care unit (NICU), can damage the cochlea and vestibular organs and produce irreversible hearing loss by causing hair cell death. [20]

Asphyxia and hyperbilirubinemia in this study ranged from 19-20% in infants with risk factors. In several studies, severe asphyxia and hyperbilirubinemia were independent risk factors for hearing loss. In a Polish study, infants with hyperbilirubinemia were 2.2% and asphyxia with 2.6%. Although hyperbilirubinemia is not an essential factor in hearing loss, it is known that it can produce selective injury to the brainstem auditory nuclei and damage the auditory nerve and ganglion cells. Severe asphyxia after birth can cause irreversible harm to the cochlea's outer hair cells and stria vascularis. Still, there is no precise threshold level of hypoxia at which hearing may be damaged.[20] Research in Poland found that the highest frequency of risk factors was a syndrome related to hearing loss by 15.5%, which is a genetic factor with symptoms; other risk factors such as congenital craniofacial abnormalities (7.27%), perinatal infection TORCH ranks third (8, 22%), and a family history of deafness of 5.55%.[15]

Conclusion

The most common risk factors for infant hearing loss were premature, low birth weight, and NICU care. There is a correlation between risk factors and hearing loss in the first stage of Otoacoustic Emissions screening. Infants with hearing loss were a lower percentage than infants with normal hearing, both with and without risk factors.

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There is no declaration of interest statement to declare

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