Original Article

Prevalence of Hearing Loss and Associated Factors among Neonates in Zanzibar

[1]Abraham Z.S, [2]Alawy K., [3]Massawe E.R, [3]Ntunaguzi D., [3]Kahinga A.A, [3]Mapondella K.B

[1] Department of Surgery, University of Dodoma-College of Health and Allied Sciences
Box 259, Dodoma-Tanzania
[2] Department of Otorhinolaryngology-Mnazi Mmoja Hospital, Zanzibar
[3] Department of Otorhinolaryngology-Muhimbili University of Health and Allied Sciences
Box 65001- Dar es Salaam-Tanzania.

ABSTRACT

Background: Congenital hearing loss is one of the abnormalities reported at birth. Of 4 000 infants born deaf each year, more than half have a hereditary disorder. Even though it may be hereditary, some children develop hearing loss later in life. Genetic sensorineural deafness (SNHL) includes a range of disorders that affect infants, children and adults with affected individuals presenting with varying degrees of deafness, which may be unilateral or bilateral. About 50% of cases of congenital deafness are genetic with 70% being non-syndromic and the remaining 30% syndromic. Genetic/Congenital hearing loss is differentiated from acquired hearing loss with identification of perinatal conditions such as TORCH infections, Hyperbilirubinemia or trauma. Children who are identified with hearing loss at early stages of life have ended up with improved quality of life. There is paucity of data on congenital hearing loss in Tanzania and thus the aim of this study was to address this gap.

Methods: Eight months Hospital based, descriptive cross sectional study from May to December 2016 conducted in three hospitals and one health Centre where neonatal hearing screening was done in Zanzibar. Data was collected using a three staged protocol neonatal hearing screening with OAE and AABR, and other information was collected clinically using specialized forms and check list. A total of 600 neonates were recruited and data was analyzed using SPSS program version 21.

Results: This study enrolled 600 neonates. Among these, 323 (53.8%) were females and 277 (46.2%) were males. Among neonates who underwent 1st OAE, 36.2% **failed** the test and went for second test. For those who underwent 2nd OAE, 13.8% failed the test and went for AABR. 41.4% of those who went for AABR **failed** and went for Diagnostic ABR and among these only 3 (25%) **failed**. Three neonates were diagnosed with hearing loss and they were all males, with bilateral SNHL, making a prevalence of 0.5%. Among those with hearing loss 33.3% had severe SNHL and 66.7% profound SNHL. The most frequent risk factors were ototoxic medications use (11.8%), low APGAR score (11%), family history of childhood hearing loss (7%) and hyperbilirubinemia(2.5%). Hyperbilirubinemia was the only risk factor significantly associated with hearing loss (p=0.001).

Conclusion: The prevalence of hearing loss in neonates was found to be 0.5% and was more common in males. Hearing loss was bilateral, of sensorineural type and associated with some risk factors like ototoxicity, low APGAR score and

Corresponding Author:
Dr. Zephania Saitabau Abraham,
Department of Surgery,
University of Dodoma,
College of Health and Allied Sciences,
Box 259-Dodoma, Tanzania
Email: zsaitabau@yahoo.com

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hyperbilirubinemia.

INTRODUCTION

Hearing impairment is the most frequent sensory deficit in human populations, affecting more than 360 million people in the world (1,2,3). Consequences of hearing impairment include inability to interpret speech sounds, often producing a reduced ability to communicate, delay in language acquisition, economic and educational disadvantage, social isolation and stigmatization(1). Hearing loss is an important public health concern with a lot of economic costs and social consequences.

It is officially estimated in Tanzania that there are approximately 20,000 deaf children. However, comparison with other neighboring countries puts this figure four to five times higher, thus it is possible to find over 80,000 deaf children in towns and hidden in villages (4).

Despite the presence of certain figures of neonates suffering from hearing loss which shouldn't be neglected, there are no any studies in Tanzania and particularly Zanzibar which have unveiled the existing gap. Thus this is the first study in Zanzibar and in the United Republic of Tanzania to account for the prevalence of hearing loss in neonates and associated risk factors.

MATERIALS AND METHODS

Study design and participants

This was a hospital based descriptive cross sectional study conducted between May and December 2016 and included all neonates born at Mnazi Mmoja Hospital (MMH), Kivunge District Hospital and Muembeladu Maternity Hospital in Zanzibar.

Study population

The study included all newborn babies born in the stated hospitals and whose parents consented to participate in the study and newborn babies born at home and those beyond one month of age were excluded from participating in the study.

Sampling method

Convenient sampling was utilized, where the available babies at the time of screening were studied.

Inclusion and exclusion criteria

Newborn babies whose parents consented to participate in the study were included and those above one month of age and/or born at home were excluded from their participation.

Sample size estimation

The estimated sample size N was computed using the **Fischer's formula** as shown below,

$$N = \frac{z^2 pq}{d^2}$$

Where;

N = Estimated

of neonates without hearing loss

d= margin of error= 1 %

Therefore; N=542

Adjusting for non-response, we add 10 % of the estimated sample size. Therefore, the Estimated Sample Size was about 600 newborn babies.

Data collection protocols

Screening was done in collaboration with an audiologist of MMH. Physical examination was done to every **neonate** before initial screening to rule out anomalies associated with neonatal hearing loss. The head, and the face were inspected and palpated, and the mouth opened using tongue depressor and inspected, and ear canals inspected using otoscope to rule out craniofacial anomalies. The skin of the **neonate** and eyes were also inspected for yellowish discoloration and this was considered as a sign of hyperbilirubinemia. Apgar score, history of meningitis, mechanical ventilation, and ototoxic drug use were obtained from the files. Family

history of hearing loss was obtained from the parents or caretakers. Every new born whose parents/caretakers consented for the study, was screened initially using OAE before hospital discharge. In this study the OAE and AABR machines used were automated, i.e. they give PASS or REFFER results on the screen ready to be read and recorded and do not require screener's interpretation. If the result was PASS, parents/ caretakers were counseled and the neonate was discharged home. If the result was FAIL/REFFER, the neonate discharged and parents counseled and rescheduled for second screening using OAE in two weeks' period. For PASS results, baby discharged home, but for FAIL/REFFER results baby was referred to MMH for AABR in one-week period. Before commencement of AABR;otoscopy and tympanometry were done by PI and Audiologist to rule out middle ear pathology (conductive hearing loss) and results recorded, and then AABR was done by the Audiologist on the same day. If the results were PASS, the neonate was discharged. For the REFFER result, the baby was scheduled for diagnostic ABR in one-week period. The neonate was given chlorohydrate solution to achieve a calmness situation, then a Diagnostic ABR was done to confirm the retro cochlear pathology and gave the severity of the problem. Neonates who passed the initial screening and discharged, but readmitted again few days before neonatal period to end were included in the study and rescreened again after discharge and were considered as new candidates. Special designed forms were used to collect and compile all information. These forms consisted of 5 parts:

- **Part one: general information**

  This consisted of name of the screening center, serial number of the form, telephone number of the parent/caretaker and sex of the baby.

- **Part two: risk factors assessment**

  All of the Joint committee on infant hearing (JCIH) named risk factors were assessed with the exception of intrauterine infections which were not investigated at MMH during the study period.

- **Part three: screening results.**

  All PASS and REFFER results were recorded in this part.

- **Part four: type and severity**

  The type and severity of the confirmed hearing loss were recorded in this part

- **Part five: tympanometry results**

  Tympanometry results, including the type of tympanogram were recorded.

Data analysis

Data analysis was done using the Statistical Package for Social Sciences (SPSS) version 21. P-value of <0.05 was considered statistically significant. Prevalence of hearing loss was calculated by taking all neonates confirmed with hearing loss (HL) as a numerator divided by all neonates screened in all hospitals during the study period as the denominator.

Ethical considerations

Ethical review and clearance to conduct the study was sought from Muhimbili University of Health and Allied Sciences Ethical Review Board. Permission to conduct the study was requested from the Ministry of Health Zanzibar and from respective hospitals.

Written informed consent was sought from the parents of newborn babies before recruiting them into the study.

Study limitation

Intrauterine infections as one of JCIH risk factor for neonatal hearing loss could not be assessed.

Here we mean the TORCH infections and perhaps add the component of genetic screening which is absent

RESULTS

Gender Distribution of the Screened Neonates

Among 600 neonates included in the study, 323 (53.8%) were females and 277 (46.2%) were males with a ratio of 1:1 9 (Table 1)

Table 1: Distribution of gender among the screened neonates

		Neonates	Percentage (%)
Gender	Female	323	53.8
	Male	277	46.2
	Total	**600**	**100**

Prevalence of hearing loss by gender

Among all neonates (600) who participated in the study, only 3(0.5%) were confirmed to have hearing loss and they were all males. (Table 2)

Table 2: The prevalence of neonatal hearing loss by gender

	Hearing loss			P value
Gender	Yes	No	Total	
Female	0(0%)	323(53.8%)	**323(53.8%)**	**0.0001**
Male	3(0.5%)	274(45.7%)	**277(46.2%)**	
Total	**3(0.5%)**	**597(99.5%)**	**600(100%)**	

Lateralization of hearing loss among the screened neonates.

Among the screened neonates, only three were diagnosed to have hearing loss and they were all bilateral. (Table 3)

Table 3: Lateralization of hearing loss among the screened neonates.

		Lateralization					P value
		Right ear	Left ear	Bilateral	Normal	Total	
Hearing loss	Yes	0(0%)	0(0%)	3(0.5%)	0(0%)	**3(0.5%)**	**0.0001**
	No	0(0%)	0(0%)	0(0%)	597(99.5%)	**597(99.5%)**	
	Total	**0(0%)**	**0(0%)**	**3(0.5%)**	**588(98%)**	**600(100%)**	

Prevalence of hearing loss by type among neonates

Among neonates screened only 3 confirmed and all have SNHL (Table 4)

Table 4: The prevalence of hearing loss by type among neonates screened

		Hearing loss			P value
		Yes	No	Total	
Type of HL	CHL	0(0%)	0(0%)	**0(0%)**	**0.0001**
	MHL	0(0%)	0(0%)	**0(0%)**	
	SNHL	3(0.5%)	0(0%)	**3(0.5%)**	
	NORMAL	0(0%)	597(99.5%)	**597(99.5%)**	
	Total	**3(0.5%)**	**597(99.5%)**	**600(100%)**	

CHL-Conductive hearing loss

SNHL-Sensorineural hearing loss

MHL-Mixed hearing loss

Hearing loss by severity among the screened neonates

Among those confirmed with hearing loss, one neonate (33.3%) had severe SNHL and two neonates (66.7%) have profound SNHL (Table 5)

Table 5: The distribution of hearing loss by severity among neonates screened

		Hearing loss			
		Yes	No	Total	P value
Severity	Mild	0(0%)	0(0%)	**0(0%)**	**0.0001**
	Moderate	0(0%)	0(0%)	**0(0%)**	
	Severe	1(33.3%)	0(0%)	**1(0.2%)**	
	Profound	2(66.7%)	0(0%)	**2(0.3%)**	
	Normal	0(0%)	597(100%)	**597(99.5%)**	
	Total	**3(100%)**	**597(100%)**	**600(100%)**	

Risk factors associated with hearing loss among neonates

On multiple regression,hyperbilirubinemia was found to be significantly associated with neonatal hearing loss *[P value (Pearson's X^2) at 95%CI = 0.001]*.(Table 6)

Table 6: The risk factors associated with hearing loss among neonates screened

	Hearing loss			
Risk factors	Yes	No	Total	P value
Family history	1(0.2%)	42(7%)	43(7.2%)	0.078
	3(0.5%)	**597(99.5%)**	**600(100%)**	
Underweight	0(0%)	12(2%)	12(2%)	0.804
	3(0.5%)	**597(99.5%)**	**600(100%)**	
Craniofacial anomaly	0(0%)	10(1.7%)	10(1.7%)	0.821
	3(0.5%)	**597(99.5%)**	**600(100%)**	
Syndromic hearing loss	0(0%)	1(0.2%)	1(0.2%)	0.943
	3(0.5%)	**597(99.5%)**	**600(100%)**	
Birth asphyxia	0(0%)	66(11%)	66(11%)	0.542
	3(0.5%)	**597(99.5%)**	**600(100%)**	
Hyperbilirubinemia	1(0.2%)	15(2.5%)	16(2.7%)	**0.001**
	3(0.5%)	**597(99.5%)**	**600(100%)**	
Ototoxic medication use	1(0.2%)	71(11.8%)	72(12%)	0.254
	3(0.5%)	**597(99.5%)**	**600(100%)**	
Assisted ventilation	0(0%)	26(4.3%)	26(4.3%)	0.712
	3(0.5%)	**597(99.5%)**	**600(100%)**	

DISCUSSION

Many studies on hearing loss in developing countries have focused in groups other than neonates such as mining workers, school children and elderly people. In Tanzania, no any study has bridged the existing gap and thus the aim of this study was to address the gap.

In this study 600 neonates were included, 323 (53.8%) were females and 277 (46.2%) were males. These include 200 neonates delivered at MnaziMMoja referral hospital, 150 neonates delivered at Kivunge hospital, 150 delivered at Mwembeladu maternity hospital and 100 neonates from Mpendae health center.

Among 600 neonates screened 3 neonates were confirmed to have hearing loss making a prevalence of 0.5%. This appears to correlate with other global statistics which is between 0.1% to 0.6% (1,2).

Findings in this study were comparable to those published by De Capua et al (5) in Italy where he reported 3(0.56%) babies to have hearing loss.

Findings from this study were slightly higher compared to the study by Mehl et al (6). 3%, Ulusoy et al 0.1%(7) and Oliveira et al 0.2% (8). This could be explained by poor economic status of Zanzibar population which increases the occurrence of risk factors and hence high prevalence. Also these differences may be explained by different screening protocols and real difference in hearing loss incidence in the world.

Abu Shaheen et al (9), reported a prevalence of 1.5% which is higher contrary to what can be depicted in our study. The difference may be explained by large sample size of the Abu Shaheen study.

Al-Meqbel et al (10) in Kuwait reported that, the prevalence of neonatal hearing loss was 11.5%. This is higher compared to the findings of this study. The reason for higher prevalence is that, in his study, Al-Meqbel enrolled only neonates at risk for hearing loss.

A study by Gouri et al (11) in India revealed a prevalence of 5.3%. The findings are higher compared to this study. In his study Gouri, included both neonates at risk and those without risk factors. And he also included other risk factors apart from those mentioned by JCIH.

Among all neonates (600) who participated in this study only 3(0.5%) were confirmed with hearing loss and they were all males. This corresponds to the findings by Dora Jerina Jose et al (12) in Trivandram, India who confirmed 2 male neonates to have hearing loss. The findings are contrasted by Abu Shaheen et al (9) in Jordan and Al Maqbel et al (11) in Kuwait which showed no gender predominance on neonatal hearing loss. Since this study employed every baby who appeared at the screening Centre, male predominance over females might be an incidental findings and still no known anatomical and genetic differences between male and females in ear structures can explain such observation.

Among neonates screened in this study only 3 diagnosed to have hearing loss and they were all bilateral. This correlates closely to the study by Ulusoy et al (7) who reported that 68.18% of the babies with hearing loss were bilateral and 31.82% had unilateral loss. In Colorado, Mehl et al (6), reported 79.8% of bilateral cases in contrast to 20.2% of unilateral. These findings suggest that hearing loss in infants most commonly is bilateral. The reason is that most of the risk factors associated with neonatal hearing loss exerts their effects bilaterally(13,14).

In this study, all neonates (100%) with hearing loss had SNHL. This corresponds with most of the studies. De capua et al (5) reported 100% of neonates diagnosed with hearing loss had SNHL. The same observation was reported by *Dora Jerina Jose et al (12) in Trivandram, India.*

Mehl et al (6) reported that 75% of the neonates with hearing loss had SNHL while 25% had CHL. Abu Shaheen et al (9) concluded that of those with hearing loss 61.1% was sensorineural, 32.2% was conductive and 6.7% was mixed. In his study, Abu Shaheen enrolled both babies born and attended different health sectors and he also enrolled babies beyond 1 month of age. These observations concluded that hearing loss in neonates most commonly is of sensorineural type and this can be explained by the effects of mentioned risk factors and genetic on cochlea and auditory pathways.

In this study; 33.3% of those confirmed with hearing loss had severe SNHL and 66.6% had profound SNHL. This corresponds to study by Abu Shaheen et al (9) whoreported that 18.9% had mild, 33.1% had moderate, 20.2% had severe and 27.8% had profound hearing loss. The difference may be due to large sample size and different screening protocols.

In this study 246 neonates were at risk of having hearing loss. 72 (12%) used ototoxic medication, 66(11%) had low apgar score, 43 (7.2%) had positive family history of childhood hearing loss, 26 (4.3%) had assisted ventilation 16 (2.7%) had hyperbilirubinemia, 12 (2%) had low birth weight, 10 (1.7%) had craniofacial anomalies, 1 (0.2%) had down syndrome.

Hyperbilirubinemia was significantly associated with hearing loss in neonates (p=0.001) in this study. This correspond to Al Maqbel et al(10), Alaee E.et al (15), Olusanya et al (16) in Nigeria, Abu Shaheen et al (9).Hyperbilirubinaemia causes selective damage to the brainstem auditory nuclei and may also damage the auditory nerve and spiral ganglion cells by interfering with neuronal intracellular calcium homoeostasis (14).Findings are contrasted by Maqbool et al (17) in India.

The reason, may be attributed by timely intervention of neonates with hyperbilirubinemia at GB Pant Hospital.

A baby with hyperbilirubinemia in this study, had also a positive family history of hearing loss and used ototoxic medication, while other babies with single risk factors were not proved to have hearing loss. This explains the synergistic role of risk factors in neonatal hearing loss

Ototoxic medication use was not statistically correlated with hearing loss, in contrast to Abu shaheen et al [9],Alaee E et al (15),though we had large number of babies who used ototoxic drug. This may have been attributed by low dosage given and duration of exposure, as literature reports ototoxicity is related to the dose, time and concurrent use of other ototoxic drug (13,14). Findings in this study showed that family history was not significant as a risk factor for hearing loss in contrast to AbuuShaheen et al (9). This may have been attributed by the wrong response of the caretakers as they could have understood the family history of hearing loss as any loss, instead of permanent childhood hearing loss caused by genetic and mentioned risk factors.

Forty three (7.2%) of the babies in this study had low apgar score but the p value was not statiscally significant. However, Abu shaheen et al (9) showed significant association. The lack of association in

this study is probably due to the smaller sample size. Twelve out of the 600(2%) babies born had a birth weight of less than 1.5kg. None of these babies had hearing loss. The association with low birth weight was not found to be statistically significant (p=0.804). This is against the findings of Abu Shaheen, et al (9) and could be due to the smaller sample size in the present study. The same applied to assisted ventilation, craniofacial anomalies and syndromic features.

In this study, it is found that 2 babies with hearing loss had no identifiable risk factors similar to study done by Oliveira et al (8) in Brazil. This explains the role of consanguinity(which is highly practiced in Zanzibar) and genetics in new-born hearing loss.

CONCLUSION

The prevalence of neonatal hearing loss was found to be 0.5% similar to several other studies in different parts of the world and with all cases reported in males. Hyperbilirubinemia was found to be the main risk factor for neonatal hearing loss and thus its screening should be incorporated into health care protocols in our country. The country should adopt the policy of universal newborn screening for hearing loss so as to lay a basis for early intervention of which it will consequently have an impact in one's quality of life thereafter.

LIST OF ABBREVIATIONS

AABR: Automated auditory brainstem response
ABR: Auditory brainstem response
HL: Hearing loss
JCIH: Joint committee on Infant Hearing
OAE: Otoacoustic emissions
SPSS: Statistical package for social sciences

DECLARATIONS

Ethics approval and consent to participate

The approval to conduct the study was granted by Ethics and Research Committee for Muhimbili University of Health and Allied Sciences

Availability of data and material

The detailed reported information can be obtained from the corresponding authors when needed and from archives of the department of otorhinolaryngology-MUHAS

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

ZAS participated in preparation of the manuscript. KA participated in study design, data collection and analysis. ERM: Participated in design of the study and data analysis. DN, AAK and KBM participated in design of the study.

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