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PREVALENCE AND FACTORS RELATED TO HEARING IMPAIRMENT AMONG MAINSTREAM PRIMARY SCHOOL CHILDREN IN RURAL SOUTHERN INDIA

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ABSTRACT:

Background and objective: Hearing impairment among children is a momentous health problem which has adverse consequences on their functional development and academic performance. In this context the present study was conducted to determine the prevalence and factors related to hearing impairment among primary school children in rural Kerala, India.

Materials and methods: 1160 children between 5-10 years were subjected to otoscopy and tuning fork testing. Children with abnormal tuning fork test results were further evaluated by pure tone audiometry and tympanometry.

Results: The prevalence of hearing impairment was 8.10%. The mean value of hearing loss was 32.36dB with a standard deviation of 8.95dB. Permanent and possibly progressive sensorineural type of hearing loss was detected in 4.3% of cases, whereas treatable conductive type hearing loss was in 95.7% of cases.

Conclusions: Majority of the aetiological factors of hearing impairment identified were preventable or treatable. This highlights the relevance and requirement of effective school screening programmes for eliminating these preventable cases of deafness from our community, as there is no such well-established programme in the country.

Keywords: cerumen, child health, hearing loss, otitis media with effusion, prevalence, suppurative otitis media.

INTRODUCTION:

The sense of hearing enriches our lives and enables us to participate in social life. It plays a critical role in the development of speech and language in children. Nevertheless hearing impairment among school-going children is still a momentous health problem in the developing world.

Prevalence of hearing impairment among rural school children reported by various Indian studies is about 9.3–11.9%[1, 2, 3]. WHO has estimated that about 50% of causes of hearing impairment are preventable and 30% are treatable, though not preventable[4]. Therefore overall 80% of all cases of deafness are avoidable. Hence early identification of risk factors of deafness and timely intervention in the childhood itself is of high significance in eliminating the preventable

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cases of deafness from our community. It is a well-established fact that moderately severe to profound hearing impairment in children has a detrimental and devastating effect on their linguistic, social, scholastic and emotional development. Such major degrees of hearing impairment are easily identified by parents or teachers in early age itself and are dealt with.

Meanwhile, even mild degrees of hearing loss is also proven to have adverse effects on the functional development and scholastic performance of children[5,6,7].Nevertheless, children with this type of hearing impairment are not readily identified and are often mistaken for having attention deficit disorder, learning disabilities or cognitive disorders[8]. Therefore an effective school hearing screening programme is essential for the detection of such children, thereby ensuring early intervention and prevention of complications.

Relevance of a school hearing screening programme in addition to new born screening is further highlighted by the fact that for every 10 children with permanent bilateral hearing impairment detected by universal newborn screening, there are other 5 to 9 children with late onset hearing impairment[9]. About 10-20% cases of permanent childhood hearing loss are late in onset and are unlikely to be detected by neonatal hearing screening programmes[10]. Furthermore, the prevalence of permanent hearing loss is estimated to increase from 3/1000 in infants to 9-10/1000 in the school age population[11]. Therefore, even after successful implementation of neonatal hearing screening programmes, many school children are likely to have undetected hearing impairment, which can be detected by effective school hearing screening programmes.

Efforts put forth to bring the children with hearing impairment to manstream by providing effective therapeutic as well as rehabilitative services will create a rights-based and barrier-free society for these differently able persons. In this context a study was conducted to determine the prevalence and factors related to hearing impairment and the pattern of ear disease among primary school children.

MATERIALS AND METHODS:

This is a prospective cross-sectional study conducted in rural Trivandrum district, Kerala state, India from December 2012 to September 2014.

Inclusion criteria

Children of the mainstream schools in the age group of 5-10 years, who attend the school on the day of the screening programme.

Exclusion criteria

Children in special schools

Sampling technique

Random sampling technique.

Sample size

It is calculated by the formula $4pq/d^2$, where p = Available local prevalence rate in the target population (from comparable studies[1,2]), i.e. 11.9.

q = 100-p

d = Relative precision (20% of previous prevalence)

Hence required sample size = 741

Tools/instruments

1 . The questionnaire

- Personal details - name, age, sex
- Antenatal history- gestational diabetes, hypertension, hypothyroidsm, exanthematous fever, typhoid
- Perinatal history - prematurity, low birth weight, neonatal respiratory distress or ventilator dependence, neonatal jaundice, neonatal sepsis
- Past medical history - meningitis, mumps, measles, head trauma, ototoxic drug intake, significant noise exposure
- Past or present otological history - ear pain, ear discharge, hearing impairment, tinnitus, blocked sensation in ear.

2. Otoscopy

All the lower primary school children in the study sample were subjected to otoscopic examination by residents pursuing Masters in Otorhinolaryngology and positive findings were noted down.

3. Tuning fork testing

Rinne, Weber and absolute bone conduction tests were performed in all children, using 512 Hz tuning fork. Those children with abnormal or equivocal test results were subjected to audiometric assessment.

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4. Pure tone audiometry

Audiometric assessment was conducted by a qualified audiologist in the quietest room in each school, using a calibrated Classic I portable audiometer. Those children having air conduction threshold levels more than 20dB at any of 0.5K, 1K, 2K or 4K frequencies were considered to have 'possible hearing loss'. Such children were referred to the ENT department in our tertiary care centre for further detailed evaluation of air and bone conduction thresholds in a sound protected environment, on a later date. A pure tone average above 25 dB at 0.5K, 1K, 2K and 4K Hz was considered as abnormal. Hearing impairment was grouped to mild (26-40dB HL), moderate (41-55dB HL), moderately severe (56-70dB HL), severe (71-90dB HL) or profound (>90dB HL), according to WHO classification.

5. Tympanometry

Tympanometric assessment was done using a portable GSI Autotymp Tympanometer in children having any abnormal otoscopic or tuning fork test findings.

6. Data collection process

At first, all primary schools in the specified area were enumerated. From this, 12 schools were selected by random sampling technique. The study details were explained to the school management and consent was obtained. A detailed questionnaire was issued before the date of screening to be filled in by the parents, which contains details pertaining to the antenatal, perinatal and childhood medical history as well as informed consent, so that the children could bring back the questionnaire on the date of screening.

A total of 1160 lower primary school children were included in the study. During screening, otoscopic examination and tuning fork testing were done in all children. Pure tone audiometry and tympanometry were performed by quailified audiologists, in children with abnormal initial findings.

After confirming hearing loss by pure tone audiometry, appropriate therapeutic interventions were initiated. Children with impacted wax were prescribed wax solvents and directed for further follow up in our hospital, during which wax removal and otoscopic examination was done and the incidence of any tympanic membrane or middle ear pathologies co-existing with wax was ruled out.

Acute and chronic otitis media were diagnosed based on tympanic membrane findings. Otitis media with effusion was diagnosed on the basis of tympanic membrane findings and type 'B' tympanogram. Cases having tympanic membrane retraction and type 'C' tympanogram were diagnosed to have Eustachian tube dysfunction (without effusion).

7. Data analysis

The data collected was entered in Microsoft Excel and was analysed using SPSS software. The factors related to hearing impairment which were analysed include age, sex, antenatal, perinatal & past medical history and various ear examination findings. Bi-variable analysis using Chi square test and Odd's ratio with 95% confidence interval was used to find out the association between hearing impairment and various factors related to it. *P* value less than 0.05 was considered to be statistically significant. Binary logistic regression was used for finding out the independent predictors of hearing impairment.

RESULTS:

A total of 1160 school children were included in the study. The age-gender distribution of the study subjects is shown in Table I. The mean age was 7.68. Out of the 1160 children, 578 (49.8%) were boys and 582 (50.2%) were girls.

1. Hearing impairment– prevalence, characteristics and aetiological factors

The prevalence of hearing impairment in the present study was 8.10%, i.e. 94 out of 1160 children were detected to have some degree of hearing impairment by pure tone audiometry, even though 145 cases were initially evaluated in view of abnormal or equivocal tuning fork test results.

Of these 94 cases, 90 (95.7%) had conductive and 4 (4.3%) had sensorineural type of hearing loss. Moreover, out of the 94 cases with hearing impairment, 24 cases (25.53%) had right sided, 33 cases (35.11%) had left sided and 37cases (39.36%) had bilateral involvement.

The mean value of hearing loss was 32.36dB with a standard deviation of 8.95dB. Out of the 94 cases with hearing impairment, the majority (87 cases i.e.,

92.6%) had mild degree of hearing loss (26-40dB HL). Moderate (41-55dB HL), moderately severe (56-70dB HL), severe (71-90dB HL) and profound (>90dB HL) degrees of hearing loss was detected in 5(5.3%), 0(0.0%), 1(1.1%), 1(1.1%) cases respectively.

Considering the aetiology of hearing impairment, the major proportion (42.6% in the right side and 45.7% in the left side) was contributed by impacted wax. The distribution of various aetiological factors is shown in Figure I and II.

2. Factors associated with hearing impairment

Bi-variable analysis using chi-square test was done to find out the association between hearing impairment and various socio-demographic factors. Prevalence of hearing impairment was more in 5-7 yrs age group (8.5%) compared to 8-10 yrs age group (7.7%); more among boys (8.8%) than girls (7.4%); more among children studying in government schools (9.6%) compared to children in private schools (7.3%). However these differences were found to be statistically insignificant [Table II].

3. Role of antenatal, perinatal and childhood factors in the incidence of sensorineural hearing loss.

Out of the 4 cases with sensorineural hearing loss, 3 had bilateral mild degree of hearing loss and the other child had moderately severe loss in one ear and profound loss in the other ear. Two of the cases with mild loss had maternal history of gestational hypertension as well as perinatal history of prematurity and low birth weight. One of them had childhood history of mumps and measles also. However, it was not possible to make any statistical analyses on the role of these factors in the incidence of sensorineural hearing loss, due to the limited number of cases.

4. Pattern of ear diseases

The pattern of ear diseases is tabulated in Table III. The prevalence of hearing impairment among various ear diseases was analysed and found to be 8.22% in impacted cerumen (58 out of 706 ears), 18.18% in acute otitis media (2 out of 11 ears), 80.00% in otitis media with effusion (48 out of 60 ears), 88.89% in tubotympanic type of chronic otitis media (8 out of 9 ears), 100.00% in atticoantral type of chronic otitis media (1 out of 1 ear) and 3.31% in eustachian tube dysfunction without middle ear effusion (4 out of 121 ears). On performing bi-variable analysis, significant association was detected between hearing impairment and impacted wax [Odds ratio (95% CI) - 2.017 (1.238 - 3.286); *p* value- 0.004], otitis media with effusion [Odds ratio (95% CI) - 214.106 (62.425 - 734.345); *p* value- 0.001] and chronic otitis media tubotympanic type [Odds ratio (95% CI) - 48.761 (5.005 - 475.094); *p* value- 0.001].

DISCUSSION:

1. Study tools

Tuning fork tests, pure tone audiometry and tympanometry were included as our study tools, in addition to the detailed questionnaire collected from the parents of the study subjects and otoscopic examination findings. It has been established that for a hearing screening protocol to be acceptable, the sensitivity and specificity of the tool must be at least 90 95%[12]. In other words it should accurately detect at least 90 95% of persons having hearing loss and it shouldn't fail more than 5 10% of persons having normal hearing[12].

Burkey et al.[13] established the sensitivity of Rinne test using 512 Hz tuning fork in detecting conductive hearing loss more than 10,20, 30 dB by experienced otologists using masking were 89.1, 100 and 100 respectively, when equivocal results are included. In unmasked situations, the sensitivity was 72.5, 92.3 and 100 respectively. Browning et al.[14] found the specificity of Rinne test using 512 Hz tuning fork to be more than 90%. Hence the acceptance of tuning fork tests as the primary screening tool in our study is justifiable.

In this study, all children with abnormal or equivocal tuning fork test results were subjected to audiometric assessment. Children with air conduction threshold levels more than 20dB at any of 0.5K, 1K, 2K or 4K Hz frequencies were considered to have 'possible hearing loss' and were referred to the ENT department, for further detailed evaluations. According to American National Standards Institute, the cut off intensity levels for identifying hearing impairment varies between 20 to 30dB[12]. In literature, there is evidence for greater sensitivity of screening level at 20dB HL than 25dB HL in identifying 'minimal hearing loss' and 'educationally significant hearing loss'[15]. The sensitivity/specificity rates for identifying minimal hearing loss at 20 dB HL screening levels were 100/53

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respectively. For detecting educationally significant hearing loss, these rates were 100/92.2 respectively[16]. Hence we used 20dB HL as the cut off screening level for referring the children after the preliminary audiometric assessment.

Various studies have shown that for identifying the maximum number of cases of newly detected hearing loss, a single failure in any of the frequencies must be considered as a failure[12]. The American Speech Language Hearing Association (ASHA-1990) screening guidelines recommended screening at 500, 1000, 2000 and 4000 Hz frequencies[12]. FitzZaland et al[17] while evaluating the screening ability of 20 dB HL at 1000 & 2000 Hz and 25 dB HL at 500 & 4000 Hz have found out that 15% of children with confirmed conductive hearing loss had failed only at 500 Hz level. Therefore in our study, children with air conduction threshold levels more than 20dB at any of 0.5K, 1K, 2K or 4K Hz were considered to have 'possible hearing loss' and were evaluated further. After detailed evaluation, the hearing impairment was classified to mild (26-40dB HL), moderate (41-55dB HL), moderately severe (56-70dB HL), severe (71-90dB HL) and profound (>90dB HL) as per the WHO guidelines[18].

2. Socio demographic factors

In this cross sectional study conducted among school children in rural Kerala, out of the 1160 children in the age group of 5-10 years, 49.8% were boys and 50.2% were girls. As per Indian population census 2011, the only Indian state where the number of females is higher than that of males is Kerala (1084 females per 1000 males)[19]. This pattern of sex ratio is reflected in present study also (1007 females per 1000 males).

Table-I: Age - gender distribution (n=1160)

Age (in years)	Male		Female		Total	
	n	%	n	%	n	%
5	15	1.3	16	1.4	31	2.7
6	99	8.5	97	8.4	196	16.9
7	154	13.3	159	13.7	313	27.0
8	130	11.2	133	11.5	263	22.7
9	136	11.7	155	13.4	291	25.1
10	44	3.8	22	1.9	66	5.7
Total	578	49.8	582	50.2	1160	100.0

3. Prevalence and characteristics of hearing impairment.

The prevalence of hearing impairment among rural children in the present study (8.10%) is considerably higher than that among urban children in the same state (2.2%) as observed in a study by Ebenezer et al.[19]. However this is lower than the prevalence among rural children in neighbouring states like Karnataka and Tamilnadu (11.9%)[1,2] and also the urban areas of a Northern state (9.3%)[3]. Reports regarding the prevalence of hearing impairment from neighbouring countries including Nepal, Myanmar etc. vary between 5.5% and 21.63%[20,21].

As this was primarily a hearing screening study, children having normal hearing in spite of ear wax were not followed up further. Tympanic membranes of such children were not visualized. Hence a proportion of cases having tympanic membrane or middle ear pathologies but with normal hearing, might have been missed while estimating the prevalence of ear diseases

In present study, 95.7% of hearing loss was of conductive type. Similar studies in India also showed 87.1% to 91.2% of conductive hearing loss among the total hearing loss cases[2,3]. The overall prevalence of sensorineural hearing loss in the present study was 0.34%, which also accounted for 4.3% of cases of hearing impairment, similar to a comparable study in Kerala[19].

4. Aetiology of hearing impairment

The major proportion (42.6% in the right side and 45.7% in the left side) of hearing impairment in our study was contributed by impacted wax. In other Indian studies also, the most important aetiological factor was detected to be impacted wax, contributing to 41.9 - 86.3% of cases with hearing impairment[1,3,19].

The proportion of hearing impairment contributed by otitis media with effusion was disproportionately high in the present study (36.1-37.1%) compared with some Indian studies[3,19] (3.5-6.5%), but this is in accordance with another study by Jacob et al.[2] in rural south India (41.9%) and various studies in Egypt[22] (30.7%) and Saudi Arabia[23] (34.9%). Chronic otitis media contributed to 4.3-9.8% of hearing

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Table - II: Hearing impairment versus demographic factors.

Demographic factor n (%)		Hearing impairment			Odds ratio (95% CI)	*P* value
		Present	Absent	Total		
Age	5-7 yrs	46 (8.5%)	494 (91.5%)	540 (100.0%)	1.11 (0.73 - 1.69)	0.63
	8-10 yrs	48 (7.7%)	572 (92.3%)	620 (100.0%)		
	Total	94 (8.1%)	1066 (91.9%)	1160 (100.0%)		
Gender	Male	51(8.8%)	527 (91.2%)	578 (100.0%)	1.21 (0.80 - 1.85)	0.37
	Female	43 (7.4%)	539 (92.6%)	582 (100.0%)		
	Total	94 (8.1%)	1066 (91.9%)	1160 (100.0%)		
School	Govt	38 (9.6%)	356(90.4 %)	394 (100.0%)	1.35 (0.88 - 2.08)	0.17
	Private	56 (7.3%)	710 (92.7%)	766 (100.0%)		
	Total	94 (8.1%)	1066 (91.9%)	1160 (100.0%)		

loss cases in our study, which is significantly lower than that in other Indian[3] as well as foreign studies[22] (13.2-23.3%). This lower incidence could be due to better health awareness and utilization of health care facilities in Kerala.

5. Pattern of ear diseases

In present study, the most prevalent ear disease was found to be impacted wax (37.41%). Various south Indian studies also have revealed a prevalence of wax impaction between 29.8-63.0%, which was the most common ear disease[1,2,19]. A prevalence of 60.6-62.0% was reported in other countries in Indian subcontinent[24,25].

Table - III: Pattern of ear diseases (n=1160).

Ear disease	Right only		Left only		Bilateral		Total ears		Total individuals	
	n	%	n	%	n	%	n	%	n	%
External ear										
Wax	81	6.98	81	6.98	272	23.45	706	30.43	434	37.41
Foreign body	1	0.09	0	0.00	0	0.00	1	0.04	1	0.09
Otitis externa	3	0.26	0	0.00	0	0.00	3	0.13	3	0.26
Middle ear										
Acute otitis media	2	0.17	3	0.26	3	0.26	11	0.47	8	0.69
Chronic otitis media tubotympanic type	3	0.26	2	0.17	2	0.17	9	0.39	7	0.60
Chronic otitis media atticoantral type	1	0.09	0	0.00	0	0.00	1	0.04	1	0.09
Otitis media with effusion	7	0.60	5	0.43	24	2.07	60	2.59	36	3.10
Eustachian tube dysfunction	9	0.78	6	0.52	53	4.57	121	5.22	68	5.86
Inner ear										
Sensorineural hearing loss	0	0.00	0	0.00	4	0.34	8	0.34	4	0.34

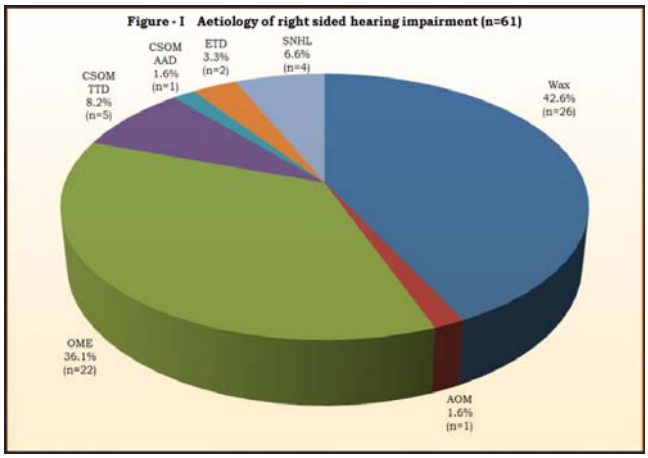

Fig-1: Aetiology of right sided hearing impairment (n=61).

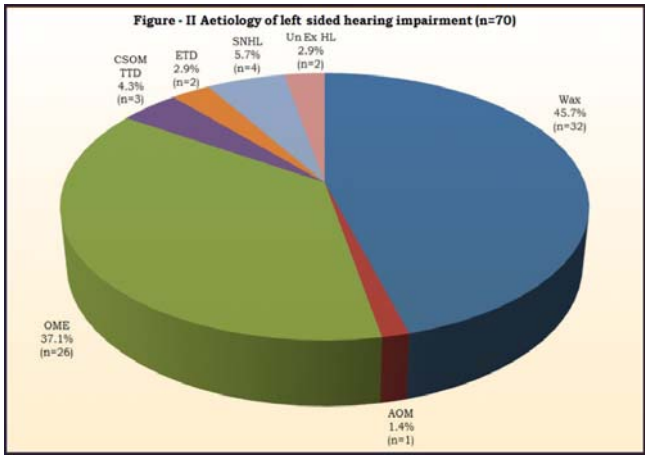

Fig-2: Aetiology of left sided hearing impairment (n=70).

In the present study, 8.25% of ears with wax impaction had associated hearing impairment. A similar study conducted among the urban children of the same district had revealed lower prevalence (3.91%) of hearing impairment among the children with wax impaction[19]. Other external ear diseases like foreign body and otitis externa were found in only 0.09% and 0.26% of children in our study which was comparable with the prevalence detected by another study in a nearby urban area (0.08% and 0.04% respectively)[19]. Among the middle ear pathologies, Eustachian tube dysfunction without middle ear effusion was detected to be the most common disease with a prevalence of 5.86%, higher than the prevalence in a comparable study (2.8%) in urban Kerala[19].

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The prevalence of otitis media with effusion (3.10%) in our study was comparable with other studies in other parts of India and neighbouring countries (3.3-4.7%), but significantly higher than the prevalence detected in urban areas of the same state[19,24,25,26]. In our study, 80.0% of ears having otitis media with effusion had associated hearing impairment. Similar studies in south India also have revealed 50.0-100.0% prevalence of hearing impairment among the cases with middle ear effusion[1,19]. However, it is known that 50-75% of the OME will resolve during 3-6 months without leaving permanent sequelae. Hence these cases are unlikely to cause any permanent hearing impairment and associated developmental or educational deficits.

The prevalence of chronic otitis media was significantly lower in the present study (0.69%) compared to various other studies in India and neighbouring countries (5.2-7.8%)[2,24-26]. The significantly lower prevalence of chronic middle ear disease in our study could be secondary to the better socioeconomic environment, improved health education and effective utilization of health facilities prevailing in Kerala, the most literate state of India[19]. The further lower prevalence of chronic ear disease in a comparable study among the urban children of the same state also indicates the role of favourable socioeconomic factors in urban area compared to rural areas. The inverse relationship between prevalence of chronic middle ear diseases and better socioeconomic background has been established in literature also[21,27,28]

5. Strategy adopted to tackle the problem in our area.

The individual cases having hearing loss identified by the school screening programme were referred to the ENT department in the tertiary care centre for further detailed evaluations, necessary interventions and rehabilitation, after informing the parents with the help of class teachers.

In order to tackle the problem on community basis, we have addressed the following aspects in a Teachers' awareness programme conducted by our institution:

- Adverse developmental and scholastic effects of even mild degrees of hearing loss
- Advantages of early identification and treatment of cases
- When to suspect hearing impairment in class rooms and the methods of identification of probable cases
- Availability of treatment and rehabilitative options

CONCLUSION:

This study has revealed the magnitude of hearing impairment and other otological morbidities prevailing in our rural community. We would like to give special reference to the preventable or treatable cases of hearing loss identified in our study, which constitute the major proportion (95.7%). Children with mild degree of hearing impairment are not readily identified and are often mistaken for having attention deficit disorder, learning disabilities or cognitive disorders. Meanwhile, such degrees of hearing loss is proven to have adverse effects on the functional development and scholastic performance of children, even though the effects are not so detrimental and devastating as in moderately severe to profound hearing impairment. In this context, we would like to highlight the magnitude of the preventable or treatable deafness in our school children and to emphasis on the relevance and requirement of effective school screening programmes for eliminating these types of deafness from our community, as there is no such well-established programme in the country.

LEGENDS:

AOM - Acute otitis media

OME - Otitis media with effusion

CSOM TTD - Chronic otitis media tubotympanic type

CSOM AAD - Chronic otitis media atticoantral type

ETD - Eustachian tube dysfunction

SNHL - Sensorineural hearing loss

Un Ex HL - Unexplained hearing loss.

DISCLOSURES:

(a) Competing interests/Interests of Conflict- None
(b) Sponsorships - None
(c) Funding - None
(d) No financial disclosures
(e) Animal rights-Not applicable

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