The prevalence of hearing impairment in secondary school children with otitis media with effusion: A cross-sectional study in Pokhara, Nepal

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Intercalation in International Health BMedSc
Abstract and key words

Abstract (146 words)

Objective: A cross-sectional study to estimate the proportion of cases of otitis media with effusion (OME) associated with a significant hearing impairment in children aged 9-16 years and whether the otitis media with effusion significantly affected hearing level.

Methods: Sixty-four secondary school children (age range) with otitis media with effusion underwent pure tone audiometry measuring the average hearing threshold and air-bone gap. Each ear was analysed separately and comparisons made between OME and control ears.

Results: The prevalence of significant hearing impairment in ears with otitis media with effusion was higher (12.8%, 95% CI 5-19.9%) than ears without otitis media with effusion (5%, 95% CI 0-11.8%). Median mid-frequency pure tone average was 13.8dB (IQR 3.8-23.8) in ears with otitis media with effusion compared to 11.9dB (IQR 4.7-19.1) in those without. 3.1% children had a bilateral hearing impairment.

Conclusion: OME in this cohort does not significantly affect hearing thresholds and the prevalence of a bilateral hearing impairment due to OME is relatively low in Nepal.

Key Words:

Otitis media with effusion; hearing loss; developing countries, Nepal
Otitis media with effusion (OME) is a common paediatric condition and 80% will have had at least one episode by the age of 10 years.\textsuperscript{1} Although more than half of the cases will resolve spontaneously,\textsuperscript{2} approximately a third have recurrent OME and episodes may last for a year or more.\textsuperscript{3-5} Symptoms are few and vary in severity with time and age but there are important potential sequelae with the most common presenting feature being hearing loss\textsuperscript{6} OME is said to be the most common cause of acquired hearing loss in children.\textsuperscript{7} Case control studies have identified certain risk factors for OME such as age below 6 years, a large number of siblings, low socioeconomic status, passive smoking and frequent upper respiratory tract infections.\textsuperscript{8,9} Although common in developed countries,\textsuperscript{10-12} the link between OME and poverty and malnutrition\textsuperscript{13-14} makes the prevalence even higher in developing countries. Due to this high prevalence, the proportion of cases complicated by hearing loss makes OME an important contributor to childhood hearing loss in developing countries.

Nepal is one of the poorest countries in the world, 31% of people live below the national poverty line,\textsuperscript{15} Given the link between OME and poverty, it is unsurprising that Nepal has one of the highest documented prevalences of OME worldwide.\textsuperscript{10-12,16-18} A previous unpublished study in Nepal has shown the prevalence to be 27% in the 3-8 year age group.\textsuperscript{19} More developed nations exhibit a prevalence of approximately 6.5%,\textsuperscript{10} the difference is self evident and a relatively benign condition in developed countries, becomes a condition of significant public health impact in the developing world.

In Nepal itself, Little and colleagues estimate that 55.2% of hearing impairment in the school age group is associated with otitis media or its sequelae.\textsuperscript{20} Onset of hearing impairment early in life can lead to adverse effects on speech and language acquisition, subsequently impacting a child’s education and employment opportunities.\textsuperscript{21} Hearing loss is of particular importance in developing countries where emphasis is placed on speech comprehension for those that are uneducated or illiterate. Cohort studies have revealed that children who have had OME may still have diminished hearing in the future,\textsuperscript{22} and with 25% of hearing impaired people in the world developing hearing loss during childhood,\textsuperscript{23} it is imperative that public health strategies are focussed at an early age.
The prevalence and level of hearing loss in OME is not well documented and existing literature uses various definitions and methodologies. The hearing loss associated with OME is usually fluctuant depending on the amount and viscosity of the fluid in the ears, and is usually conductive in nature. Studies at tertiary care centres report that some degree of hearing loss is present in up to 92% of paediatric patients with OME, and the greatest loss is usually in the lowest frequencies, including those of speech perception. The hearing loss is reported to range from normal hearing to moderate hearing loss (0-55dB). Moderate hearing loss only occurs in 5-10% of OME cases. Although this degree of hearing loss is less disabling, it is more likely to be missed, especially in OME where it may be the sole presenting feature and can still result in communication difficulties.

Despite the high prevalence of OME in Nepal, only Bagshaw et al have investigated for the presence of an associated hearing loss. They found that 17% of cases of OME were complicated by a significant hearing impairment. Their study was in primary school children. Schmitz et al found that abnormal tympanometry indicating OME was associated with increased risk of hearing impairment but this study was carried out in a different age group (What ages, what country) and did not report the magnitude of hearing loss.

The prevalence of hearing loss complicating OME in secondary school children in Nepal is unreported. The high prevalence of OME seen in Nepal in the younger age group may continue into the older age group, suggesting that a significant proportion of secondary school children may be living with hearing impairment, which itself is a barrier to education in school. In western nations, OME with hearing loss is an easily treatable condition. Insertion of a ventilation tube in the ear drum ventilates the middle ear cleft thereby reducing the conductive hearing loss which results from the presence of a middle ear effusion. Alternatives include hearing aid use and education aids, e.g making teachers and parents aware of the hearing loss and it’s nature, sitting position in class, avoidance of background noise, amplification such as sound field systems in classrooms. ( NB I would beware over emphasising grommets in treatment of glue ear, it is a contentious subject in UK, partly because whilst effective in short term there is poor evidence of benefit long term and because of cost implications to health service) Lack of resources and access to medical care may mean that the burden of this disease is particularly heavy in Nepal, and intervention may be in the form of social or education action or the provision of a hearing aid to minimise the hearing loss.
Both the high prevalence of OME in Nepal and the lack of studies into this age group warranted an urgent need to highlight the magnitude and severity of the problem. This study aimed to determine the proportion of OME cases which are complicated by hearing impairment amongst secondary school children. An accurate picture of the percentage suffering with hearing impairment in Nepal could enable the provision of better public health initiatives to focus on prevention, early detection and management of OME, therefore alleviating some of the social and economic burdens of hearing impairment.

**Materials and methods**

**Study design**

This was a cross-sectional point prevalence study, nested within a primary survey of the prevalence of OME.

**Inclusion Criteria**

- Children aged between 9 and 16, attending secondary school
- Children in whom clinical, otoscopic and tympanometric findings indicated a diagnosis of OME. OME is defined as:
  - The presence of a Type B tympanogram

**Exclusion Criteria**

- Children with impacted cerumen, a perforated eardrum or ventilation tube in place
- Children with ear pain and a clinical finding of acute otitis media
- Children with hearing loss patterns on pure tone audiometry not associated with OME

**Sample recruitment**

Participants were recruited from the larger prevalence survey of OME, within which this study was nested. A convenience sample of pupils was drawn from three secondary schools (one government school, two private schools) in Pokhara, an urban city in central Nepal. A Nepali interpreter was used to collect data on demographical and environmental variables, including age, gender, the number or siblings, smoking exposure (determined by whether a parent
smokes). The type of school attended, was used as a proxy measure for socioeconomic status (SES). (Private school indicated high SES and government school indicated low SES).

Who are the controls? Did you use the normal ear of children with ome on other side, that would not be good idea, as ome is often bilateral and even if tymp is normal then there might be some minor degree of et dysfunction and hearing loss on other side. Should use completely unaffected children I think to prevent that confounding factor.

Data collection

Children identified as having OME in the primary study underwent pure tone audiometry using an Amplivox 260 audiometer, calibrated to BS EN ISO 8253-1 standards and noise attenuating TDH-39 audiocups. Ambient noise levels in the test environment were established using a CEM DT-805 sound level meter; testing was paused if ambient noise levels exceeded 45dBA. Bilateral pure-tone air conduction (AC) thresholds were recorded at 0.25, 0.5, 1, 2, 4 and 8kHz. Unmasked bone conduction (BC) thresholds were measured at 0.5, 1, 2 and 4kHz and, where necessary, masking was applied.

Statistical Analysis

Statistical analysis was carried out using Statistical Package for the Social Sciences (SPSS) version 16. Each ear was analysed as one separate case. Pure-tone averages were calculated for each ear by taking the mean of individual AC thresholds across defined frequency ranges. Low frequency pure-tone average (LPTA) was defined as the mean AC threshold at 0.25, 0.5 and 1kHz, middle frequency pure-tone average (MPTA) as the mean AC threshold at 0.5, 1, 2 and 4kHz and high frequency pure-tone average (HPTA) as the mean AC threshold at 1, 2 and 4kHz. The proportion of ears with significant hearing impairment was calculated, as defined on the basis of the World Health Organisation (WHO) as a MPTA of >25dB. The type of hearing loss in each ear was classified into conductive hearing loss (as defined by the presence of an air-bone gap of >10dBHL), sensorineural hearing loss or mixed hearing loss. The severity of hearing loss was classified as mild (25-40dBHL), moderate (41-60dBHL) or severe (61-80dBHL) at low, middle and high pure-tone averages, adapted from WHO criteria and proportions calculated with 95% confidence intervals.
Tests for normality were undertaken for continuous variables. Average hearing levels were calculated for both OME and normal ears and the Mann-Whitney U test was used to see if these averages were significantly different. The average hearing threshold was calculated for each frequency. The hearing loss in each ear was classified as conductive (as defined by an air-bone gap of >10dB), sensorineural (average BC threshold at 0.5-4kHz > 25dB) or mixed (air-bone gap >10dB and BC threshold >25dB) and the percentages with 95% confidence intervals were calculated. Binary logistic regression was used to establish whether there was an association between clinical, demographical and environmental variables and the presence of significant hearing impairment. Significance levels were set at p<0.05.

**Ethical considerations**

Ethical approval was obtained from the University of Birmingham BMedSc Population Sciences and Humanities Internal Ethics Review Committee and local permission was granted by the International Nepal Fellowship prior to data collection. (need a phrase to explain who INF are and the study relationship to them) Due to the age range of the study, verbal consent was sought from the children according to their competency at the point of entry to the primary study. Written consent was obtained from the headmasters of the schools, since in Nepal it is acknowledged that they act *in loco parentis* during the school day.

Data were anonymised and stored securely to ensure confidentiality. Confidentiality was only breached when serious pathology was detected and a referral was deemed necessary.

**Results and analysis**

64 children were identified to have OME in the primary study (out of how many examined?). (how many excluded with wax) The children ranged from 9 to 15 years of age, with a median age of 11 years. Thirty children (46.9%) were male and 34 (53.1%) were female. Forty seven (73.4%) children attended a private school and 17 (26.6%) attended a government school. Nineteen (29.7%) had exposure to cigarette smoke at home (are they boarders?).

Twenty-two children (34.4%) had bilateral OME and 42/64 children (65.6%) had unilateral OME. In those with unilateral disease, the right side was affected in 26 (61.9%) children, and the left in 16 (38.1%). Data was therefore collected on 128 ears, 86 (67.2%) of which had OME. Two ears without OME were excluded from the analysis – one due to having a typical noise induced
hearing loss (more detail needed, was it a congenital mid freq sn loss?, NIHL v unlikely in this age group unless strong history) and one due to the presence of a perforation. Therefore 126 ears were included, 86 (68.3%) with OME and 40 (31.7%) without OME.

Prevalence and degree of hearing impairment

The prevalence of significant hearing impairment was higher in ears with OME (12.8%, 95% CI 5.7-19.9%) than in the control (see my note above, I am unclear who the controls are) group (5%, 95% CI 0-11.8%) but this difference was not statistically significant (p=0.22). The numbers of participants with mild, moderate and severe hearing impairments as defined by pure-tone averages can be seen in Table I: there was no significant difference in these proportions in the study and control groups. The median MPTA for ears with OME was 13.8dB (IQR 3.8 – 23.8). This shows worse hearing than the control group whose MPTA was 11.9dB (IQR 4.7 – 19.1) but again this difference was not found to be statistically significant (z=-1.2, p=0.23).

This all seems too complicated why not just analyse 1. All frequencies tested and 2. Low frequencies.

Also I have lost track, did you define snhl as any threshold for bc below zero, that would give a lot more snhl than is real and probably result in too many mixed and snhl in the analyses.

**TABLE I – Prevalence of hearing impairment based on pure tone averages in the two study groups (OME and non-OME controls)**

<table>
<thead>
<tr>
<th>Pure-tone average* (OME ears, n=86)</th>
<th>Degree of hearing impairment</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mild or worse, &gt;25dBHL</td>
<td>Moderate or worse, &gt;40dB</td>
<td>Severe, &gt;60dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>95% CI†</td>
<td>No.</td>
<td>%</td>
<td>95% CI†</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>LPTA</td>
<td>15</td>
<td>17.4</td>
<td>9.4-25.5</td>
<td>7</td>
<td>8.1</td>
<td>2.4-13.9</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>MPTA</td>
<td>11</td>
<td>12.8</td>
<td>5.7-19.9</td>
<td>5</td>
<td>5.8</td>
<td>0.9-10.8</td>
<td>2</td>
<td>2.3</td>
</tr>
<tr>
<td>HPTA</td>
<td>10</td>
<td>11.6</td>
<td>4.8-18.4</td>
<td>4</td>
<td>4.7</td>
<td>0.2-9.1</td>
<td>2</td>
<td>2.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pure-tone average* (control ears, n=40)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LPTA</td>
<td>4</td>
<td>10</td>
<td>0.7-19.3</td>
<td>2</td>
<td>5</td>
<td>0-11.8</td>
<td>1</td>
</tr>
<tr>
<td>MPTA</td>
<td>2</td>
<td>5</td>
<td>0-11.8</td>
<td>1</td>
<td>2.5</td>
<td>0-7.3</td>
<td>1</td>
</tr>
<tr>
<td>HPTA</td>
<td>2</td>
<td>5</td>
<td>0-11.8</td>
<td>1</td>
<td>2.5</td>
<td>0-7.3</td>
<td>1</td>
</tr>
</tbody>
</table>
Low frequency pure-tone average (LPTA)=(threshold values at (why not include 250Hz as this is lowest freq and you tested it and it is the most affected by glue?) 0.5, 1 and 2kHz)/3, middle frequency pure-tone average (MPTA)=(0.5, 1, 2 and 4kHz)/4, high frequency pure-tone average (HPTA)=(2, 4 and 8kHz)/3. 95% confidence interval.

Bilateral OME

Among the 22 participants (44 ears) with bilateral OME, 8/44 ears (18.2%) had a significant hearing impairment (air conduction thresholds >25dB) compared with 3/42 ears (7.1%) in children with unilateral OME. This difference was found not to be statistically significant (X²=2.35, p=0.13). (is that due to lack of power, sounds significant) Among the participants with bilateral OME, only 2/22 (9%) had a bilateral hearing loss >25dB – these two children have a hearing impairment which, in view of the fact that it is bilateral as opposed to unilateral, has the potential to significantly affect their academic development in an adverse manner. No participants with unilateral OME were found to have a bilateral hearing impairment.

Among the 64 participants, the prevalence of having a significant hearing impairment in one or both ears was 17.2% (11/64). The prevalence of hearing impairment in one or both ears in participants with bilateral OME was higher (6/22, 27.3%) than those with unilateral OME (5/42, 11.9%) but this difference was not found to be statistically significant (p=0.17). This is all too complex and detailed and loses sight of the ball! At end of day we want to know how many kids had signif loss in both ears, plus a how many had signif loss in one ear only. It is probably here but I am getting bogged down in detail!

Type of hearing loss

A further four ears with OME and two ears without OME were excluded from this part of the analysis since they could not be classified by type of hearing impairment (due to lack of masking). Therefore 120 ears, 82 study ears and 38 control ears, were eligible for inclusion.

Fifty eight out of 82 (70.7%) OME ears, and 23/38 (60.5%) of control ears were found to have some degree of hearing loss. (what do you mean by hearing loss? Do you mean a threshold more than 0db, if so that is not a loss because there is a normal range of hearing, and you were not in a totally sound proof environment, best to say actual threshold level rather than loss) The prevalence of conductive, sensorineural and mixed hearing loss in these ears is described in Table II. The proportions of different types of hearing loss were not found to be significantly
different between the study and control ears. The average hearing thresholds are illustrated in Figure I.

**TABLE II. Prevalence of conductive, sensorineural and mixed hearing loss in all OME and control ears that have some degree of hearing loss.**

<table>
<thead>
<tr>
<th>Type of hearing loss</th>
<th>Conductive</th>
<th>Sensorineural</th>
<th>Mixed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
</tr>
<tr>
<td>OME ears with hearing loss (n=58)</td>
<td>54 (93.1)</td>
<td>2 (3.4)</td>
<td>2 (3.4)</td>
</tr>
<tr>
<td>Control ears with hearing loss (n=23)</td>
<td>22 (95.7)</td>
<td>0</td>
<td>1 (4.3)</td>
</tr>
<tr>
<td>p value</td>
<td>p=1.0^a</td>
<td>p=1.0^a</td>
<td>p=1.0^a</td>
</tr>
</tbody>
</table>

^aFisher's Exact test p value

Of the 54 cases of OME that had a purely conductive hearing impairment, 4/54 (7.4%) had a significant hearing impairment (MPTA air conduction thresholds >25dB). However among those ears that had a sensorineural hearing loss as a part of their pathology (i.e. a purely sensorineural hearing loss or a mixed hearing loss) 4/4 (100%) had a significant hearing impairment (p<0.001) (see Figure 1). Even if the four ears with OME that were excluded from this analysis were found to have had a purely conductive hearing loss, this result would still be statistically significant (p<0.001).

**FIGURE I** – average air conduction (AC) thresholds for normal (control) ears (without OME), all study ears with OME, and study ears with OME classified by type of hearing loss.


Low frequency hearing loss

Unexpectedly, since 60.7% of control ears had some degree of hearing loss and a significant proportion had higher thresholds at lower frequencies (Figure I), further analysis at the lower frequencies was undertaken.

Two (5.3%) out of thirty-eight control ears had a low frequency hearing loss (LFHL), defined as a low frequency pure-tone average (LPTA) of >25dB averaged over 0.25, 0.5 and 1kHz, compared with 12/82 (14.6%) study ears. This difference was not statistically significant (p=0.22). The median LPTA among study ears and control ears was 18.3dB (IQR 7.5–29.1) and 16.7dB (IQR 10–23.4) respectively. This difference was not statistically significant (z=-0.81, p=0.42). The prevalence of conductive, sensorineural and mixed hearing loss in all OME and control ears that have a LFHL can be seen in Table III.

TABLE III. Prevalence of conductive, sensorineural and mixed hearing loss in all OME and control ears that have a low frequency hearing loss (LFHL)

<table>
<thead>
<tr>
<th>Type of hearing loss</th>
<th>Conductive</th>
<th>Sensorineural</th>
<th>Mixed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>OME ears with LFHL (n=12)</td>
<td>8</td>
<td>66.7</td>
<td>2</td>
</tr>
<tr>
<td>Control ears with LFHL (n=2)</td>
<td>1</td>
<td>50.0</td>
<td>0</td>
</tr>
<tr>
<td>p value</td>
<td>p=1.0a</td>
<td>p=1.0a</td>
<td>p=1.0a</td>
</tr>
</tbody>
</table>

Fisher’s Exact test p value

The prevalence of LFHL in study ears with a purely conductive loss was 14.8% (8/54) but in those ears that had a sensorineural component this prevalence increased to 100% (4/4). This difference was statistically significant (p<0.001) and found to be consistent with the finding in the middle frequencies, as described earlier. Is this relevant?

Linear regression was undertaken with LPTA as the dependent variable and OME was not found to be significantly associated with LPTA, suggesting that the presence of OME has no influence on the degree of low frequency hearing loss in this population.

Risk factors for hearing impairment in cases of OME
The whole sample of 86 ears with OME was included in the regression analysis. Binary logistic regression was performed with the presence of hearing impairment as the dependant variable. Age, gender, socioeconomic status, smoking exposure, laterality and the side affected were all not found to be associated with the presence of hearing impairment.

However when multiple linear regression was performed in the whole sample of 62 children with MPTA in the better ear as the dependant variable, the presence of bilateral OME was found to be weakly positively correlated (R=0.28, p=0.01) with the MPTA. The model estimated that if a child had bilateral OME, their hearing would be 4.38dB worse than if they had unilateral OME (B=4.38, 95% CI 0.52-8.25). However, this model only predicted 7.9% of the variance (R²=0.079) suggesting that there other variables not identified by this study that may better predict the MPTA.

**Discussion**

Hearing impairment is defined by the WHO as a middle-frequency pure-tone average (MPTA) of >25dBHL. This is determined by taking an average of the hearing thresholds at 0.5, 1, 2 and 4kHz and is categorised into mild, moderate, severe or profound hearing impairment. However, the presence of a unilateral hearing impairment is not likely to significantly affect the child in an adverse manner, in order for a child to have a hearing impairment significant enough to adversely affect their speech, language and academic development they must have a bilateral hearing impairment of >25dB.

**Prevalence and degree of hearing impairment**

Our study found that the prevalence of significant hearing impairment (>25dBHL) in an ear affected with OME was 12.8%. This is higher than the findings of Bagshaw et al who found the prevalence of significant hl in primary school children with OME in a similar urban Nepali population was 4%. Why might this difference be? (it could be that in older children with ome they are the worst cases, which have persisted longest and some may also have some secondary effects of longstanding ome on status of drum, e.g. may be grossly retracted, atelectatic, some ossicular damage like erosion of long process incus.) The prevalence of moderate hearing impairment (>40dBHL) in this study was found to be 5.8%, comparable to Roberts and colleagues’ estimate of 5-10%. The definition of hearing impairment used in this study was that as defined by WHO since it was thought that this definition may be more suitable to use in an international study than that of the British Society of Audiology (BSA) which defines hearing
impairment at a level of >20dB. If the BSA definition was used, this would increase the prevalence to 22% (19 out of 86 ears affected with OME).

In our study the median MPTA for ears with OME was 13.8dB. This is slightly less/better than the 17dB MPTA reported by Bagshaw et al\textsuperscript{19} who investigated the effect of OME amongst primary school children in Nepal. Since a limitation of the study conducted by Bagshaw and colleagues was that ambient noise was not monitored, this may have led to an increase in false positives in their study, meaning the higher threshold in their study compared to ours may be partly artefactual. Despite the fact that the prevalence of OME among students in urban Nepal is high, the MPTA suggests that on average the level of hearing impairment which results from this is not significantly different to control ears and is not at a level (>25dB) which would compromise the student (see Figure 1). This applies on average but I think you had a couple with worse loss for whom it would be a problem

\textit{Bilateral OME}

Only two (3.2\%) children out of the 62 eligible for analysis were found to have a bilateral hearing impairment. Both of these children had bilateral OME. This illustrates that the proportion of children who are likely to suffer a significantly adverse hearing outcome associated with OME is relatively low. However this prevalence is still higher than the 1.5\% reported for urban primary school children in Nepal. Again, if the BSA definition for hearing impairment was used, the prevalence of bilateral hearing impairment would rise to 9.7\% (6/62). Linear regression suggested that the presence of bilateral OME would lead a worse hearing threshold by 4.38dB (95\% CI 0.52-8.25). not sure what this last sentence means This is comparable to evidence from a cohort study undertaken in New Zealand which indicated that children with bilateral OME have poorer hearing levels compared with other children\textsuperscript{22} and a study undertaken by Lo and colleagues, who reported a difference of 6.6dB between the hearing thresholds of children with bilateral and unilateral OME.\textsuperscript{35} There have been no published studies which provide an estimate of the prevalence of bilateral OME in Nepal. However, an unpublished study in this age group reports the prevalence to be 12.9\%,\textsuperscript{36} suggesting that 0.47\% of all children (attending school) have a clinically significant (bilateral) hearing impairment attributable to OME. Schmitz and colleagues reported the prevalence of clinically significant hearing impairment in Nepali adolescents aged 15 to 23 to be 1.5\%, although the definition of hearing impairment was more rigorous at >30dB.\textsuperscript{31} From this, with
caution it can be inferred that OME may be the cause of up to 31% of all hearing impairment in Nepal, all of which may be preventable or at least treatable.

*Type of hearing loss*

When the nature of the hearing impairment in the OME ears is classified into conductive, sensorineural or mixed and these subgroups are analysed it becomes apparent that ears with a sensorineural loss (whether in isolation (can’t be in isolation if they also have OME?) or as part of a mixed hearing loss) have an increased tendency towards significant hearing impairment (>25dB). While the prevalence of a significant hearing loss among patients with OME with a purely conductive hearing loss was 7.4%, the incidence of a significant hearing loss amongst those patients whose hearing impairment was contributed to by a sensorineural hearing loss was 100%. Since these two prevalences were found to be significantly different it can be suggested that it is the presence of the sensorineural hearing loss, rather than the conductive component, which makes the hearing loss significant (>25dB). There was no significant difference in the prevalence of a sensorineural hearing loss between the OME (4/82, 4.9%) and non-OME (1/38, 2.6%) groups, suggesting that the presence of OME does not increase a child’s risk of having an associated sensorineural hearing loss.

*Low Frequency Hearing Loss (LFHL)*

It is also interesting to note that a majority (22/38, 57.9%) of control ears also had an unexpected conductive hearing loss more so at the lower frequencies (Figure I) (exactly! So they might have low grade OME with no flat tympanogram? Can also appear to get low freq los sif their ambient noise). The median LPTA in our study was 18.3dB, which is lower/better hearing than the 24dB reported by Fria et al. The median LPTA in ears with and without OME was not significantly different, suggesting that the LFHL in this population is not caused by OME. The lack of a statistically significant difference between the study and control ears, where the prevalence of LFHL and the proportions of type of hearing loss contributing to this hearing loss are concerned, suggests that the tendency to a low frequency hearing loss may be inherent among Nepali ears. Since this study did not expect to find a low frequency hearing loss (which mostly was conductive) in ears that were considered normal, the reasons for this can only be theorised by looking at other studies. A cohort study done by Silva and colleagues found that children that had bilateral OME in childhood remained with a hearing loss up to 6 years after resolution even though their ears were otologically normal. Thus, it can only be hypothesised that this
incidental finding may be as a result of previous ear disease in childhood and therefore warrants further investigation.

**Limitations**

Our study was the first to estimate the proportion of cases of OME that also had a significant hearing impairment in secondary schoolchildren in Nepal, although a number of limitations need to be considered when interpreting the results yielded by this study.

Firstly, through using a cross-sectional study design, the proportion of cases with sustained hearing loss that would therefore be eligible for treatment has not been established. Since the hearing loss in OME is more likely to be fluctuant, a prospective study design would have been more valuable but was not feasible due to resource constraints. Also, it may not be appropriate to extrapolate the results from this cohort of school children to all Nepalese children since in 2006, the secondary school attendance rate was reported to be 41.7%. There may be differences in the environmental and socio-economic factors which make this cohort different from children in more rural areas and as such generalised deductions cannot be made about the prevalence of OME and its effect on hearing among secondary school children in Nepal. Equally, children with a more pronounced hearing impairment as a consequence of OME may have dropped out of mainstream schooling at a younger age, due to poor academic progress and achievement, and as such the results yielded may not apply to all children of secondary school age because the worst cases may have been missed by this sampling process. I think Richard bagshaw found more severe glue and hearing in rural children.

The small numbers in our study reduces its power and therefore the likelihood of finding statistical significance in the relationships and associations it aims to investigate. With greater numbers and study power it may be that certain associations - such as the association of OME with certain risk factors, the association of OME with a significant hearing impairment and the relevance of the low-frequency hearing impairment identified – may prove to be significant.

The study participants were identified on the basis of having unilateral or bilateral OME. The normal ears (i.e. the non-OME ears of those students who had unilateral OME) were used as the control group. This may not be appropriate, given that these ears may still have pathological changes despite the absence of a frank middle ear effusion. This would have the effect of diluting the significance of any findings in the OME ears and could result in a false lack of
statistical significance in the relationships being investigated. It may be more appropriate to use the ears of secondary school children who don’t have OME as the control group.

Lastly, the audiometric testing environment was not ideal. While audiometric testing was paused where ambient noise exceeded 45dBA, and this is comparable with the practice adopted in other studies, and noise protecting head phones were used\textsuperscript{31} BSA guidelines recommend a test environment of <35dBA.\textsuperscript{38} An excessively noisy test environment would yield results which suggest worse hearing thresholds than are actually the case.

In conclusion, while the prevalence of OME in Nepali secondary school children is high, the prevalence of a bilateral significant hearing impairment (>25dB) in association with this, which is therefore likely to compromise a child’s education, is low. This would suggest that the cost-benefit balance of a national screening programme for OME among secondary school children would be unfavourable. Furthermore it seems overwhelmingly that it is those children who have a sensorineural component to their hearing impairment who are statistically likely to suffer a hearing loss which is significant in its severity. However a cross-sectional study including rural and urban children in and out of the formal school structure would better answer this question.

A significant proportion of ears, both with and without OME, have a low frequency hearing loss. This finding merits further investigation to establish whether there is a specific aspect of the ears in the study population which predisposes them to a low frequency hearing loss and could be an area for further research.
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Summary and tables

Summary

• The aim of this study was to investigate the prevalence and degree of hearing impairment in cases of otitis media with effusion in secondary school children in Nepal
• The presence of bilateral hearing impairment in children with OME, which is likely to adversely affect the child, is relatively low
• Significant hearing impairment is more likely if a sensorineural component to the hearing loss is present
• A significant proportion of otologically normal ears also had a low frequency hearing loss that was mostly conductive in nature
• Further research including rural and urban children out of the school structure would evaluate this further

Tables