

# **Prevalence of ear disease and associated hearing loss among primary school students in the Solomon Islands: Otitis media still a major public health issue**

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## **Abstract**

**Objective:** The present study aimed to assess the prevalence of otitis media and associated hearing loss among primary school students in the Solomon Islands.

**Methods:** A total of 604 primary school students (280 males, 324 females) aged 4–15 years were assessed in two primary schools (government, nongovernment) in the capital city Honiara. School-based ear examinations were performed, including otoscopy and tuning-fork tests. Students were referred to the ENT Clinic for medical intervention and/or pure-tone audiometry assessment.

**Results:** A total of 342 students (56.6%) did not pass their ear examination, with a significantly higher fail rate among younger students ( $p < 0.001$ ). The most common ear pathology was Otitis Media with Effusion (OME) (34.2%), followed by impacted wax (22.8%), and Chronic Suppurative Otitis Media (3.1%). The follow-up attendance rate at the ENT Clinic was 81.1%. Among students with OME in at least one ear, 50% failed audiometry screening in the affected ear. While age was a significant factor for OME, it was not a significant factor for OME-associated hearing loss.

**Conclusions:** Ear diseases with associated hearing loss are a significant public health problem among primary school students in the Solomon Islands. The implementation of routine School Ear and Hearing Programs could be beneficial, and should reduce the national burden of ear diseases.

**Keywords:** Otitis media; Hearing loss; School ear and hearing screening; Pacific Islands

## 1. Introduction

According to the World Health Organisation (WHO), more than two-thirds of the global burden of hearing loss is found in Low and Middle Income Countries (LMICs), with approximately half of these hearing disorders considered preventable [1]. There are 34 million children worldwide living with hearing loss, and 60% of childhood hearing loss is known to be preventable [1].

Infectious diseases and middle ear disorders are recognised as the leading causes of avoidable hearing loss in children. Given the well-known adverse effects of hearing loss on child development, the WHO is leading global efforts to address the major causes of preventable childhood hearing loss, whilst advocating for national programs that enable early detection and intervention for children with hearing impairment [2]. The recent WHO World Hearing Day campaigns promoted school-based hearing screening programs as a major public health initiative to achieve these aims [3-4]. These programs should reduce the global burden of paediatric hearing loss, as well as contribute to major international health and education initiatives under the United Nations Sustainable Development Goals.

The early audiology literature from developing countries largely consists of school-based prevalence studies. In these landmark papers, otitis media was well-established as a leading cause of hearing loss among children attending primary schools [5-9]. Recent reports focus on the implementation of routine school hearing screening programs, and investigating methodologies that are suitable to resource-limited contexts [10-12]. Current research is focused on appropriate equipment, human resource considerations, as well as ensuring acceptable school hearing screening referral rates [13-16]. These efforts should reduce the

well-known burden of childhood hearing loss in LMICs, and optimize educational outcomes for these children.

There is very limited research on childhood hearing loss in the Pacific Islands [17]. Yet, the World Health Organization estimates that this region has among the highest global burden of hearing loss worldwide [1]. An early landmark paper from the Solomon Islands indicated that a significant proportion of hearing loss among children was due to otitis media (OM) [18]. More recently, the Oceania region was reported to have the second highest overall prevalence of hearing loss caused by OM worldwide, as well as the highest global mortality rate due to complications of Chronic Suppurative Otitis Media (CSOM) [19].

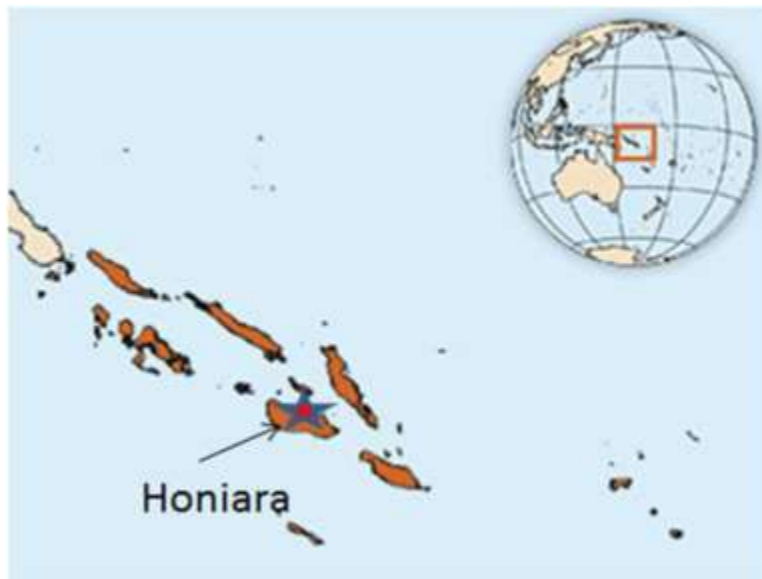
There is also very limited information on hearing health services and school-based hearing screening in the Pacific Islands. An early landmark paper from Guam, however, reported the positive impact of such programs on reducing the burden of otitis media [20]. This study found that, although the incidence of hearing loss remained high, the school-based hearing screening program facilitated early diagnosis and treatment of acute episodes of otitis media, and minimized the number of cases progressing to advanced and chronic stages of middle ear disease. The lack of access to health services continues to be a major contributing factor to advanced stages of ear disease in children in the Pacific Islands, as reported in recent studies from Papua New Guinea [21-22].

In view of the current status of childhood hearing loss and hearing healthcare in the Pacific Islands, school-based ear examinations have been recommended as a public health measure to reduce the prevalence of ear disease and associated hearing disorders [17]. The WHO Global

School Health Initiative offers an attractive public health platform for routine ear health assessments. The key aim of such assessments is to facilitate medical, surgical, and educational interventions for children identified with ear disease and hearing loss. Depending on equipment and human resource availability, the school-based ear health examinations could evolve to include hearing screening, diagnostic audiology, and amplification options for students with hearing loss. Another benefit of the WHO Global School Health Initiative is that it presents an opportunity for health promotion activities where one public health message (e.g., Nutrition) may target numerous health conditions, including otitis media and associated hearing loss.

The first author (AK) was invited by the National Referral Hospital ENT Clinic in the Solomon Islands to collaborate in the development of their school outreach services (Figure 1). This is the only ENT Clinic in the country, and it is currently staffed by four senior and two junior ENT registered nurses. For ENT Specialist consultation or surgical intervention, the Solomon Islands is dependent on an annual 10-day visit from the Royal Australasian College of Surgeons Pacific Island Program ENT Visit [23]. Audiology services at the clinic currently consist of pure-tone audiometry assessment in conjunction with ENT Clinic consultation, and are performed by one of the senior ENT nurses with a formal audiometrist qualification (second author, ON). The ENT Clinic is exploring the implementation of community outreach programs and health promotion activities, in order to reduce the number of patients presenting to the ENT Clinic with advanced stages of ear disease and complications due to poorly managed OM. A previous study showed that there is high parental support for a school-based ear and hearing program in the Solomon Islands [24].

In order to recommend a suitable protocol for the ENT Clinic outreach service for schoolchildren, the present study was conducted to assess the prevalence of OM and associated hearing loss among primary school students in Honiara, the capital city of the Solomon Islands. The aims of the study were to (1) provide current data on the prevalence and nature of OM in this population, (2) provide current data on the prevalence and nature of hearing loss associated with Otitis Media with Effusion (OME) in this population, and (3) assess community engagement with the ENT Clinic school outreach program.



**Fig. 1.** Map of the Solomon Islands.

## **2. Methods**

Ethical approval for the study was obtained from the National Health Research and Ethics Committee of the Solomon Islands Ministry of Health and Medical Services, and the University of Queensland Medical Research Ethics Committee. Gatekeeper approval for the study was

also obtained from the Solomon Islands Ministry of Education and Human Resource Development, and the management committees of the participating schools.

### **2.1. Participants**

One government and one non-government primary school in the capital city Honiara were approached for participation in the study. These schools were conveniently chosen because of a pre-existing relationship with the ENT Clinic. According to the most recently available statistics from the Solomon Islands Ministry of Education and Human Resources, there are 515 primary schools in the country, where 79% are government schools, 20% are non-government schools, and 1% are international schools [25]. The distribution is different in the capital city Honiara where there are 12 primary schools: 3 are government-run, 4 are non-government, and 5 are under private education authorities (e.g. International School). The total enrolment of primary school students in Honiara is 9814 students (4768 female, 5046 male) [25].

All students attending the selected schools on the days of data collection were eligible for the study. Students were issued an Information Sheet about the study, as well as Consent Forms for their parents/guardians. Students who returned a signed parent/guardian consent form for participation were included in the study (N.B. Parents/guardians could choose to receive the ENT & Audio Clinic service for their child but have the result excluded from the research study).

A total of 621 students were seen for an ear examination at their school. There were 17 students who were excluded from the study (14 parents/guardians who did not wish their child's result included in the research project; 3 students were older than 15 years). A total of 604 students were, therefore, included in the data analysis (Table 1). The age range of students

was 4 to 15 years, with a mean age of 10.0 years (SD=2.4). Among students seen at the government school (n=401), the age range was 6 to 15 years, with a mean age of 10.6 years (SD=2.1). Among students seen at the non-government school (n=203), the age range was 4 to 15 years, with a mean age of 8.9 years (SD=2.6).

**Table 1.** Participant age, gender, and school distribution.

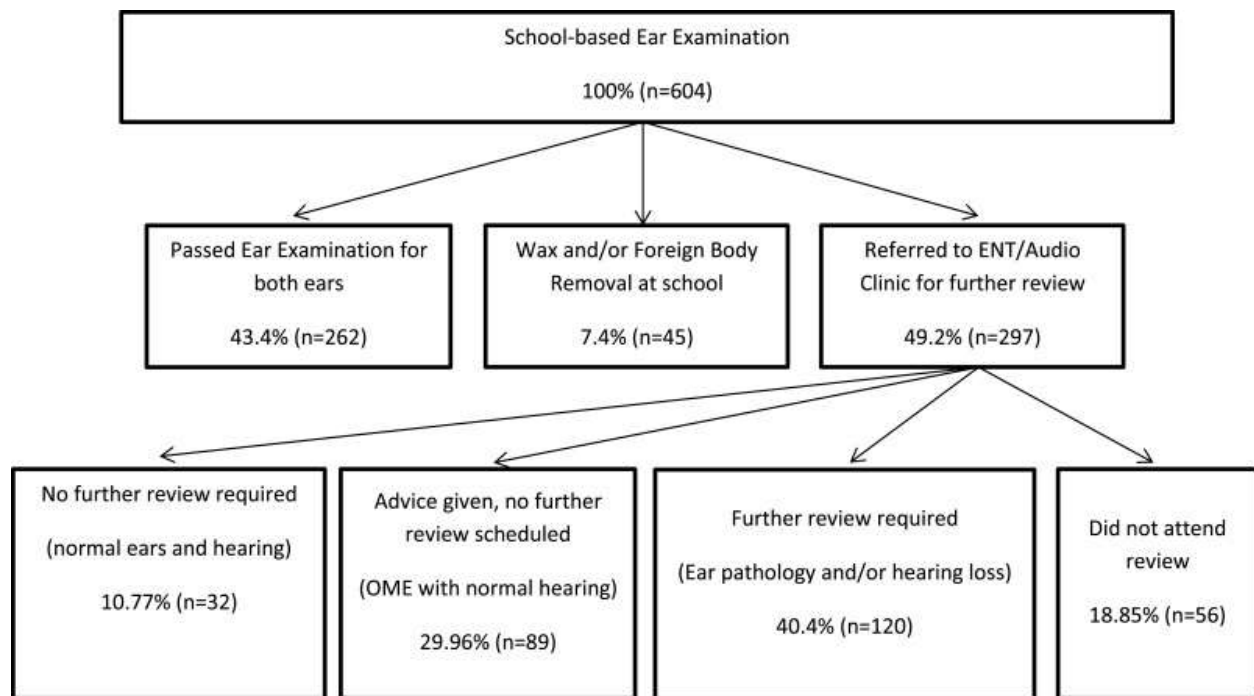
	Government Primary School	Non-Government Primary School	Total
<b>Male</b>			
4–9 years	62	48	110
10–15 years	138	32	170
Total	200	80	280
<b>Female</b>			
4–9 years	76	67	143
10–15 years	125	56	181
Total	201	123	324
All	401	203	604

## **2.2. School-based Ear Examination Procedure**

All ear examinations were performed by the senior ENT Registered Nurse-Audiometrist (ON). The school-based Ear Examination procedure followed the WHO Ear and Hearing Disorders protocol for Basic Ear Assessments. An ear examination was performed using Vorotek-O-Scope equipment for each ear of participating students, and the results were recorded on the “Basic Ear Assessment” Section of the WHO/PBD Ear and Hearing Disorders Examination Form. Results were required for ear pain (no/yes/not asked), auricle (normal/malformation/not seen), external ear canal (normal/inflammation/wax/foreign body/otorrhea/fungi), ear drum (perforation/dullness or retraction/red and bulging/normal/unsure/not examined), and middle ear (normal/otorrhea/not examined). If possible, impacted wax and foreign bodies in the



external ear canals were removed by the ENT Registered Nurse during the school-based assessment. Routine ENT Clinic practice in the Solomon Islands is to perform tuning fork tests, and in the absence of tympanometry and audiometry screening, it was decided to perform the Rinne tuning fork test for each student: Rinne positive was a “pass” result, and Rinne negative was a “fail” result [26]. Students who did not pass the ear examination and/or Rinne tuning fork test were referred to the ENT Clinic for further assessment and management as required (see Fig 2).



**Fig. 2.** Summary of school ear and hearing study results.

### **2.3. Review of Referred Students at the ENT/Audio Clinic**

Follow-up assessment was performed the day after the school visit at the National Referral Hospital ENT/Audio Clinic. Previous experience showed this enabled the best attendance rate

of referred students. If a student did not attend the follow-up appointment, a letter was provided offering another appointment.

The ENT Clinic Registered Nurses (mostly second author ON) reviewed all students who required medical intervention for ear pathology such as removal of impacted cerumen, removal of foreign body, and medical treatment of CSOM. Any other ear diseases requiring medical management were also cared for by the ENT Clinic staff members (i.e., aural polyp). All treatment and management procedures were conducted as per routine ENT Clinic protocols.

The audiologist (AK) performed an audiometry assessment for all students who were referred from the school-based ear examination with a diagnosis of OME, CSOM, dry tympanic membrane perforation, or who presented with a fail result on the Rinne tuning fork test. Students were referred for audiometry from the ENT Clinic if cerumen and/or foreign body removal identified further pathology (i.e., OME diagnosed following impacted cerumen removal).

Audiometry assessment was conducted in a non-sound-treated room next to the ENT Clinic, where average ambient noise levels were 55-60 dB A. An Audio Clinic audiometer (Madsen Xeta) with audio-cup headphones (a gift from RACS PIP ENT Surgery Program), was used for testing. Given the ambient noise levels and the volume of students to be assessed, age-appropriate pure-tone screening audiometry was performed across the major speech frequencies for each ear (500, 1000, 2000, and 4000 Hz). A pass result was an air-conduction threshold of 25 dB HL at 1000-4000 Hz and 30 dB HL at 500 Hz. If the student did not pass the screening, air and bone conduction pure-tone audiometry was performed immediately to

determine the degree and nature of hearing loss for each ear (i.e., conductive, sensorineural, mixed). As per the routine clinical protocols, students with ear diseases and associated hearing loss were scheduled for follow-up audiometry after 3 months. All students with OME were given advice regarding nose-blowing.

#### **2.4. Data analysis**

The study results were entered into an Excel spreadsheet by the first author. The school-based ear examination results were assigned a numerical code based on the WHO Ear and Hearing Disorders protocol for Basic Ear Assessments. These results were then transferred into the STATA and SPSS statistical software packages, and data analysis was performed in collaboration with the Audiology Division of the University of Queensland, which included consultation with a statistician.

A multiple linear regression was performed to investigate for any significance between a student presenting with ear pathology in at least one ear, and the independent variables of gender, age, and school. The proportion of students who attended their follow-up appointment was also calculated to assess the follow-up rate. A Pearson chi-squared test was performed to determine any significant differences in percentages of students with ear pathologies and associated hearing loss between the two age groups.

### **3. Results**

#### **3.1. *Outcome of school-based ear examinations***

There were 342 students (56.6%) who presented with ear pathology in at least one ear during the school-based ear examinations. A logistic regression model was fitted to the data with ear pathology in at least one ear as the dependent variable, and school, age and gender as independent variables. The results showed that the model as a whole was statistically significant ( $p < 0.0001$ ). Furthermore, the odds of having ear pathology in at least one ear were increased by a factor of 1.79 for students in the younger than the older age group ( $p < 0.0001$ ), having controlled for other variables in the model. The effects of school ( $p = 0.092$ ) and gender ( $p = 0.069$ ) were not statistically significant.

The most common pathology in the study population was OME. There were 207 students diagnosed with OME in at least one ear, representing 34.3% of the total study population, or 60.5% of students with ear pathology in at least one ear. OME was bilateral in 162 students (78.3%), and unilateral in the remaining 45 students (21.7%). Bilateral OME was significantly more common in the 4-9 age group than the 10-15 age group (Table 2).

**Table 2.** Summary of ear pathology results according to age variable (\*significant at  $p < 0.05$ ).

	AGE		Pearson $\chi^2$ Test
	4–9 yrs	10–15 yrs	
<b>Ear pathology in at least one ear (n = 342)</b>	172/253 (68%)	170/351 (48.5%)	$\chi^2 = 22.8813$ $p < 0.001^*$
<b>Bilateral OME (n = 162)</b>	87/253 (34.4%)	75/351 (21.4%)	$\chi^2 = 12.6981$ $p < 0.001^*$
<b>Bilateral impacted cerumen (n = 106)</b>	62/253 (24.5%)	44/351 (12.5%)	$\chi^2 = 14.5593$ $p < 0.001^*$
<b>OME and impacted cerumen in the same ear, in at least one ear (n = 46)</b>	26/253 (10.3%)	20/351 (5.7%)	$\chi^2 = 4.3808$ $p = 0.036^*$
<b>OME-related hearing loss in at least one ear (n = 89)</b>	45/253 (17.8%)	44/307 (14.4%)	$\chi^2 = 3.2266$ $p = 0.072$

The second most common pathology was impacted cerumen in the ear canal. There were 138 students with impacted wax in at least one ear, representing 22.84% of the total study population, or 40.35% of students with ear pathology in at least one ear. Cerumen removal was performed during the school visits for 110 students (79.8%), and 28 students were referred to the ENT Clinic for cerumen removal. The impacted cerumen was bilateral in 106 students (76.8%), and unilateral in the remaining 32 students (23.2%). Again, bilateral impacted cerumen was more common in the younger than the older students (Table 2).

There were 46 students (7.61%) who presented with both impacted cerumen and OME in the same ear, in at least one ear, during the school visits. This was significantly more common among the younger students ( $p=0.036$ ). Most cases were unilateral, with 31 students (67.39%) presenting with impacted cerumen and OME in the same ear.

The third most common pathology in the study was CSOM. There were 19 students (3.1%) with CSOM in at least one ear, and 3 students presented with bilateral CSOM.

### **3.2. Outcome of review appointments for students referred to the ENT Clinic**

The total number of students referred to the ENT/Audio Clinic for a follow-up appointment was 297 (49.2%) [N.B. If school-based impacted cerumen and/or foreign body removal had not been performed, the total number of students referred to the ENT/Audio Clinic would have been 342 (56.6%)]. A total of 241 students (81.14%) attended their follow-up appointment at the ENT/Audio Clinic. Among these students, 120 students (49.79%) required a second follow-up appointment with the ENT/Audio Clinic: this included students requiring medical management of CSOM and fungal otitis externa, as well as students presenting with a hearing loss associated with ear diseases.

There were 207 students diagnosed with OME in at least one ear during the school-based ear examinations. Of these, 178 students (86%) attended the Audio Clinic for an audiometry assessment. Among the 89 students (50%) diagnosed with OME in at least one ear, pure-tone audiometry results showed hearing loss in the affected ear. However, age was not a significant factor for hearing loss among students with OME (Table 2).

There were 28 students referred to the ENT Clinic for cerumen removal. The procedure could not be performed for 2 students who were advised to soften impacted earwax with coconut oil and return after 3 days. Following cerumen removal for the remaining 26 students, 13 were discharged with normal ear examination bilaterally, 11 were diagnosed with OME and normal hearing bilaterally, and 2 were diagnosed with OME and associated hearing loss.

There were 15 students with CSOM who attended for audiometry, and 14 students presented with hearing loss in the affected ear.

#### 4. Discussion

The aims of the present study were to assess the prevalence of otitis media and associated hearing loss among primary school students in the Solomon Islands. The findings revealed that ear diseases and associated hearing loss in primary school students remain a major public health issue in the country. Over half of the students in the study sample presented with ear pathologies that required ENT Clinic intervention, similar to the results of an early paper from Micronesia [27]. Almost all the students with CSOM, and half of the students with OME, did not pass their pure-tone audiometry screening assessment. Attendance at follow-up review appointments was high, suggesting good support from parents and students for the school-based ear and hearing health service.

The most common pathology among this sample of schoolchildren was OME, which was diagnosed in approximately a third of students, half of whom also showed some hearing loss in the affected ear. This finding is similar to an early case series from Papua New Guinea where 62% of the children with OME presented with associated hearing loss [28], as well as a recent study from Fiji where 69.6% of caregivers reported hearing difficulties for children with OME [29]. Among the LMICs literature, OME was also reported to be the most common ear pathology among students in a school-based study from Nigeria [30]. The literature from other community-based studies of school-age children in LMICs reported OME prevalence rates varying between 1.32% and 19.4% [31-32].

Although OME is not considered as medically urgent as CSOM, it has been noted that children with OME have a higher incidence of abnormalities such as cholesteatoma, adhesive otitis,

retraction pockets, and atrophy of the tympanic membrane [33]. Asymptomatic OME may persist in children for several weeks (63%) or months (26% after 3 months) following an episode of acute OM [34], and the hearing loss associated with persistent OME is likely to adversely impact on the speech and language development, and academic achievement of the affected child. Routine school-based ear examinations in the Solomon Islands should facilitate the early identification and intervention for children with OME to minimise the impact of these well-known adverse consequences. This is especially important for optimizing learning outcomes in a country where schooling is not generally provided in the child's first language.

The second most common ear pathology in our study sample was impacted cerumen, which was present in approximately a fifth of students. This prevalence rate is similar to that of an early study of school-age village children in Guam (19.7%) [35]. More recently, impacted wax was reported in 38.9% of ears (129/332 ears) of urban primary schoolchildren in Western Samoa [36], and 77 ears among 170 children with ear disease in Fiji [29]. Neither paper described the relationship between impacted cerumen and hearing loss, and neither did the current study as cerumen was removed prior to audiometry assessment. Previous school-based studies from LMICs have generally reported impacted cerumen to cause a mild hearing impairment in students [5-6]. Removal of impacted cerumen in the present study also enabled the diagnosis of other concomitant ear pathologies, especially in the younger age group.

The prevalence of CSOM in the present study was 3.1%. The WHO considers a CSOM prevalence rate of 2-4% as an avoidable burden of disease that must be addressed [37]. Our results further support the need for school-based ear health programs in the Solomon Islands



to ensure timely intervention by the ENT Clinic for children with CSOM. The results of the early landmark paper from the Solomon Islands suggests that the prevalence rate of CSOM outside the capital city Honiara is greater than 4%, which would classify CSOM as a significant public health problem for the country requiring urgent attention [18]. For children with restricted access to health care, CSOM is significantly more likely to progress to potentially fatal complications, as described in two recent reports from Papua New Guinea [21-22].

Almost all the students with CSOM who attended for audiometry screening failed the assessment in the affected ear (14 out of 15 students). This is higher than the results from other LMICs, and may have been influenced by our study sample size, and the greater motivation of students with hearing loss to attend for a review assessment. In contrast, an Indian study found that among 14 schoolchildren with CSOM, only 4 students also failed their audiometry screening [38]. A Malaysian study found that 24 out of 57 students with CSOM failed their screening audiometry assessment [7]. A cross-sectional study of 1500 Nigerian schoolchildren found that 35 students (2.3%) presented with CSOM, and reported a mild conductive hearing loss in 20 ears (38.5%), and a moderate conductive hearing loss in 14 ears (26.9%) [39]. A larger population-based study should provide greater evidence for the relationship between CSOM and hearing loss in the Solomon Islands.

The high follow-up attendance rate among students referred from the school-based ear examination suggests excellent support for the program among students and their caregivers. Community engagement with the school program is essential to reducing the prevalence of treatable ear diseases and associated hearing loss in this population.

## ***Limitations***

As previously described, the present study was conducted in the capital city of Honiara and it is difficult to generalise findings to the whole country. The LMICs literature suggests that the prevalence of ear disease could be expected to be higher in rural/remote areas [40-42].

Another limitation to generalising the results is that the UNICEF currently reports primary school net attendance for the Solomon Islands to be 62.5% for boys and 68.7% for girls.

Although a minimum of two staff members was planned for data collection to minimize intra-tester bias, only one ENT registered nurse (ON) was available to perform the ear examinations for the present study. He is one of the senior ENT Clinic staff members, and as the only one with audiometry qualifications, was the best candidate to take part in the research project.

Time and resource restrictions prevented collection of school achievement data for our sample of students. Such data may be beneficial for future studies to investigate the relationship between ear disease and school attainment, as this may be a significant obstacle to achieving universal primary school education in the country. Previous investigations from LMICs have documented poorer academic outcomes for students with ear disease and hearing loss [39, 43-44].

## **5. Conclusion**

Ear diseases and associated hearing loss are a significant public health problem among primary school students in the Solomon Islands. There is evidence of high follow-up return rates for referred students indicative of positive support and community engagement with school-based

ear and hearing health services. The implementation of routine ear assessment services could be beneficial to reduce the burden of ear diseases in the Solomon Islands.

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