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Hearing loss in urban South African school children (grade 1 to 3)

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ABSTRACT

Objective: This study aimed to describe the prevalence and characteristics of hearing loss in school-aged children in an urban South African population.
Method: Children from grade one to three from five schools in the Gauteng Province of South Africa formed a representative sample for this study. All children underwent otoscopic examinations, tympanometry and pure tone screening (25 dB HL at 1, 2 and 4 kHz). Children who failed the screening test and 5% of those who passed the screening test underwent diagnostic audiometry.
Results: A total of 1070 children were screened. Otoscopic examinations revealed that a total of 6.6% ears had cerumen and 7.5% of ears presented with a type-B tympanogram. 24 children (12 male, 12 female) were diagnosed with hearing loss. The overall prevalence of hearing loss was 2.2% with Caucasian children being 2.9 times more (95% confidence interval, 1.2–6.9) likely to have a hearing loss than African children.
Conclusion: Hearing loss prevalence in urban South African school-aged children suggest that many children (2.2%) are in need of some form of follow-up services, most for medical intervention (1.2%) with a smaller population requiring audiological intervention (0.4%).

1. Introduction

The World Health Organization estimates that hearing loss is the most prevalent disabling condition globally [1]. In 2013 the global prevalence of disabling (>40 dB HL) hearing loss was estimated at 360 million, with 32 million of these being children (<15 years) [1]. In developing areas of the world, where more than 80% of persons with hearing loss reside, there are limited prospects of early detection for hearing loss [1] due to a number of barriers. Numerous studies from developing areas of the world report varying hearing loss prevalence rates among school children. These figures range from 1.4% in China [2] and 1.75% in Saudi Arabia [3], to as high as 11.9% in India [4]. The varying ranges in prevalence is also seen in sub-Saharan Africa with prevalence ranging between 5.6% and 13.9% across studies in rural areas of Kenya [5] and Nigeria [6], respectively.

A number of studies have been conducted across South Africa to investigate the prevalence of middle ear pathology and sensorineural hearing loss (SNHL) in Caucasian and African children. Early studies indicated that the prevalence of middle ear pathology among young children varied between 13.4% and 29.4% [7–9]. A study conducted on 2036 elementary school children (5–10 years of age) reported 5% of ears with indications of otitis media with effusion [10]. Similar findings were reported in a study of 2457 grade 1 children [11], with a prevalence of 6.5% of possible middle ear pathologies.

The prevalence of sensorineural hearing loss (SNHL) was reported to be 1.8% for children between the ages of 1 and 12 years [9], and 2% and 2.1% in two other communities [10,11]. Higher prevalence rates were reported in KwaZulu-Natal with 13% of black children and 14.3% for Indian children presenting with a sensorineural hearing loss [12]. The most recent study conducted in the Western Cape indicated a referral rate of 7.9% [13].

Although prevalence data have been previously reported [7–13], the method of determining a hearing loss varied across the studies, with most basing it on screening outcome [9,10,12] as opposed to a confirmed hearing loss with diagnostic audiometry.

Abbreviations: dB, Decibel; Hz, Hertz; NHS, newborn hearing screening; SNHL, sensorineural hearing loss; SD, standard deviation; SLM, sound level meter.

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Furthermore, the screening protocol utilized in these studies varied in terms of the frequencies and screening levels employed for pass/refer criteria. For example, van Rooy [10] used a pass/refer criteria of 25 dB HL or 30 dB HL, depending on the level of the background noise in the test environment. North-Matthiassen, Singh [13] and van Rooy [10] included 0.5 kHz in the screening protocol, which resulted in an increased referral rate since 0.5 kHz is more sensitive to noise and middle ear pathologies. In addition, many of these studies [7–11] were conducted primarily on children from rural areas whose ages varied between preschool to school-going age.

The prevalence of hearing loss in children in developed countries is typically lower than in developing countries; 1.49% has been reported for the UK [14], 2% for Sweden [15], 2.5% for Finland [16] and 3.6% for Denmark [17]. Fortnum et al. [14] suggested that the reasons for differences in prevalence between developed and developing countries include the absence of regular hearing-screening programs, the impact of poverty and malnutrition, ignorance of hearing loss and paucity of accessible health care in developing countries.

School-based hearing screening in South Africa is required as part of the 2012 Integrated School Health Policy [18]. Unfortunately it is still far from common practice and screening is only available for a small minority of South African children [19]. In order to ensure availability of referral services careful evaluation and planning of school-based screening needs to be conducted [19]. Determining the prevalence of hearing loss in this population allows for adequate planning to ensure hearing health services are made available. Therefore, this study describes the prevalence and nature of hearing loss among school-aged children from grade one to three in a representative urban South African population.

2. Materials and methods

The investigation was conducted following approval from the Research Ethics Committee of the Faculty of Humanities, University of Pretoria and Gauteng Department of Education, South Africa.

2.1. Study populations

Five public government schools in underserved urban regions which served as a sample from the City of Tshwane, Gauteng Province, South Africa were utilized in this study. The schools were purposively selected from a list of government schools in the north western region of Tshwane. This area was selected as the population has a high unemployment rate, low incomes and poor living standards representative of the majority of South Africans [20]. All students in grade one to three within the school, who had signed consent from their parent/caregiver and who provided assent, were screened. A consecutive sample of 1070 school-aged children were screened which included Caucasian and African (Black, Coloured and Indian) individuals.

2.2. Data collection

2.2.1. Screening phase

Screening was conducted by audiology students (40) from the University of Pretoria. As part of their practical training, under direct supervision of the first author who conducted validation checks throughout, they were required to complete five days of screening. Testing was conducted in a quiet room provided by the school. Sound in the test environment was measured with a sound level meter (RION, NA-24, Japan, Tokyo) prior to data collection and twice during the data collection session. Noise levels ranged between 42.5 and 79.6 dBA (mean 65.1 SD 9.9).

Ears were examined using a handheld Welch Allyn [Welch Allyn, South Africa (Pty) Ltd.] or Heine mini 3000 (Heine, Germany) otoscope. Any abnormalities of the external ear canal and tympanic membrane were noted. Tympanometry was conducted to obtain information regarding the participant's middle ear status using one of two screening tympanometers: GSI Auto Tymp (Grayson Stadler, Eden Prairie, USA) or an Interacoustics Impedance Audiometer AT 235 (William Demant, Smørum, Denmark). Results were recorded in terms of middle ear pressure, static compliance and ear canal volume and classified based on the modified Jerger classification [21].

Each child was screened twice as part of a validation study [22], once with a conventional screening audiometer and once with a smartphone-based audiometer. For conventional screening the same screeners used for tympanometry were coupled with TDH 39P headphones (Telephonics, Huntington, N.Y.) to conduct the hearing screening. For smartphone screening, two sets of Samsung Galaxy Pocket Plus S5301 phones running the hearScreen™ Android OS application with supra-aural Sennheiser HD202 II headphones (Sennheiser, Wedemark, Germany) were used. Screening audiometry was conducted, according to recommended guidelines [23,24] using a screening level of 25 dB HL [22]. Immediately following a fail result, the child was rescreened using the same screening audiometer. All screeners were calibrated according to ISO 389-1 (1998) standards prior to data collection.

2.2.2. Diagnostic phase

Diagnostic audiometry was conducted on every child who failed one or both screenings (conventional and smartphone-based screen) and on 5% of the children who passed on both screenings [22], to determine the prevalence and nature of hearing loss. Diagnostic audiometry was performed with a KUDUwave (MoyoDotNet, Johannesburg, South Africa) Type 2 Clinical Audiometer (IEC 60645-1/2). Testing was only conducted down to 15 dB HL as hearing of children is considered normal if all thresholds are at or below 15 dB HL [25,26]. Diagnostic air- and bone-conduction was determined across 0.5, 1, 2, 4 kHz. Air-conduction pure tones were delivered via deeply inserted insert foam tips covered by circumaural earcups with forehead placement bone-conduction audiometry conducted with both ears occluded by the deep insertion of the insert earphones. Testing was conducted in a natural environment provided by the school, which constituted either a classroom, administrative or media room. Thresholds were recorded using the routine 10 dB descending and 5 dB ascending method (modified Hughson-Westlake method) commencing at 1000 Hz at 40 dB HL in the left ear. A continuous contralateral effective masking level of 20 dB HL above the air-conduction threshold of the non-test ear was used for the forehead bone-conduction audiometry [24].

The KUDUwave software actively monitored ambient noise levels across octave bands throughout both test procedures. Whenever the noise exceeded the maximum ambient noise level allowed for establishing a threshold, the audiologist waited for the transient noise to subside.

2.3. Data analysis

Diagnostic audiometry results confirming a hearing loss provided the prevalence rate for this sample population. A hearing loss was defined as having at least one threshold more than 15 dB HL at 0.5, 1, 2 and 4 kHz in either ear [25,26]. The AMCLASS® classification criteria was used to classify audiograms [27]. A hearing loss was classified as conductive when a 10 dB air-bone gap at three or more frequencies, or a 15 dB air-bone gap at any one frequency was present, whereas a sensorineural hearing loss was noted when the configuration was not normal ($\leq$15 dB HL) and