Otitis media related hearing loss in Indonesian school children

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International Journal of Pediatric Otorhinolaryngology 125 (2019) 44–50

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

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ARTICLE INFO

Keywords:
Acute otitis media
Chronic suppurative otitis media
Otitis media with effusion
Hearing impairment

ABSTRACT

Objective: There are scant recent studies from low middle-income countries that investigate the impact of otitis media (OM) on hearing loss (HL) in school children.

Methods: This was a prospective epidemiological survey conducted by otorhinolaryngologists and audiologists in a sample of 7005 public school children (6–15 years) from 6 urban and rural sub-districts, in Indonesia. Children with otoscopic abnormalities or who failed a hearing-screening test conducted at school, underwent diagnostic audiometry and tympanometry.

Results: OM was detected in 172 children (2.5%), acute otitis media - AOM (17%), otitis media with effusion - OME (15%), and chronic suppurative otitis media - CSOM (67%). The overall rate of HL in the school children was 181/10,000, which was almost three-fold higher in rural (273/10,000) than urban areas 92.6/10,000. OME accounted for much of the mild HL, while CSOM accounted for most of the moderate HL. There was a significantly higher rate of OM related HL in rural areas (116.2/10,000), than in urban areas (47.4/10,000), $p = 0.002$. OM related disabling HL was found at a rate of 44.2/10,000, mostly due to CSOM (37.1/10,000).

Conclusion: Otitis media contributed to 57% of all HL in school children, and posed a significant burden on Indonesian school children. Most of the disabling HL was due to CSOM. Efforts to find these children and offer ear and hearing care are important.

1. Introduction

Hearing loss (HL) in school children has a detrimental effect on academic achievement and acquiring language skills [1]. During childhood the most common cause of HL in developing countries is inflammation of the middle ear cavity, most commonly chronic suppurative otitis media (CSOM) [2]. The HL secondary to CSOM is usually conductive in nature, caused by reduced air pressure in the middle ear, fluid retained in the middle ear cavity, stiffness of the ear drum and/or ossicles, destruction of the ossicles, or fibrosis and cholesteatoma in the middle ear, compromising the sound conduction pathway [3,4]. At later stages, the inflammation can affect the inner ear causing mixed deafness with a sensorineural component [5].

The WHO estimates in 2018 that around 486 million people worldwide have disabling HL and 34 million of these are children [6]. In children 60% are due to preventable causes. Over 90% of the burden is borne by the developing world, mainly the countries in the Southeast Asia, the Western Pacific regions, and Africa [2]. A WHO study on the epidemiology of deafness and HL in the countries of the Southeast Asian Region in 2007 reported the prevalence of HL in the population of Indonesia to be 4.2%, and the estimated number of the hearing impaired, including milder degrees to be more than 9 million across all age groups [7]. The prevalence of ear disease that potentially could lead to HL in the Indonesian population (all age groups) were: active CSOM 3.6%,

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https://doi.org/10.1016/j.ijporl.2019.06.019
Received 18 March 2019; Received in revised form 13 May 2019; Accepted 16 June 2019
Available online 19 June 2019

CSOM with a dry perforated ear drum 0.27%, congenital severe HL 0.11%, and presbycusis 4.1%. Our recent multicenter study in 7005 Indonesian school children aged 6–15 years, found a significantly higher prevalence of CSOM in rural areas (2.7%) compared to urban areas (0.7%) [8]. The objectives of the present analysis were to build upon the prevalence data presented in the previous manuscript by: 1) determining the overall prevalence of HL in the 7005 school children; 2) defining the contribution of otitis media to HL in these children; and 3) examining the prevalence of "disabling" otitis media related HL.

2. Materials and methods

The study setting, population selection and recruitment, and some study methodology have been described previously [8], briefly summarised below.

2.1. Study sites

Six study areas were chosen that were distributed over the Indonesian archipelago: Palembang City and District in South Sumatra Province (population: 7,450,394); Bandung City and District of West Java Province (population: 43,053,732); Semarang City and District of Central Java Province (population: 32,382,657); Denpasar City and Abang District in Bali Province (population: 3,890,757); Balikpapan City and adjacent Samarinda District in East Kalimantan Province (population: 3,553,143), and Makasar City and District in South Sulawesi Province (population: 8,034,776). From each study site we got approval from the Government of Indonesia and Local Ministries of Education and Health to approach schools in one urban and one rural area in each district to conduct the study. The classification of urban and rural areas followed Government of Indonesia designations.

2.2. Informed consent, questionnaire, physical examination and pneumatic otoscopy

Ethical approval was obtained for the study from Institutional Review Boards at each of the 6 Study Centers and at the University of Colorado Denver. Subjects were taken from randomly selected government elementary (grade 1 to 6) and secondary schools (grade 7–9) in urban and rural areas at each of the 6 sites as previously described [8]. At each school children participated over 3 days as follows.

On day one, the parents of 80–100 students from two or more selected classes were approached with the assistance of the respective class teachers. After obtaining informed consent, a questionnaire, was administered.

On day two, ENT surgeons and assistants (ENT residents), examined all the selected students, who had consented and completed questionnaires the previous day. A Welch Allyn (Skaneateles Falls, NY, USA) pneumatic otoscope was used to visualize and check the movement of the tympanic membrane, to determine the presence of any tympanic membrane abnormality after wax removal.

Because of the levels of ambient noise in the schools, we chose a threshold sound intensity of 30 dB for the hearing screening. A semi sound proof room was set up in the most quiet area of the school with an ambient noise level < 30 dB. Hearing screening was performed using Interacoustics (Assens, Denmark) Audio Traveller AA222 audiometers with a pre-set intensity of 30 dB HL through air conduction, at 500, 1000, 2000 and 4000 kHz frequencies. If the child could not hear the 30 dB HL tone at any one or more frequencies, the child was referred for Diagnostic Audiometry.

2.3. Diagnostic audiometry

On day three, a complete diagnostic audiological examination was performed for the selected children who either did not pass the hearing screening, or had any abnormality on otoscopic examination. Experienced audiologists performed the diagnostic test in a soundproof room at a nearby ENT center or hospital. Air Conduction (AC) and Bone Conduction (BC) thresholds were determined at 500, 1000, 2000, 4000 and 8000 Hz. Average AC hearing thresholds of each ear were determined by the average of thresholds at 500, 1000, 2000 and 4000 Hz. To determine the type of HL, it was considered conductive if there was an air-bone gap of ≥15 dBHL, sensorineural (SNHL) if the air-bone gap was < 15 dBHL, and mixed HL if the air-bone gap was > 15 dB and the bone conduction was also elevated > 15 dBHL. Tympanometry was performed and the type was determined as A, As, Ad, C, or B, according to the Jerger classification [9]. From diagnostic audiometry tests, the type of HL was finally determined and noted, to be the conductive, sensorineural or mixed type. For determination of the grade of hearing impairment, we used the WHO criteria for children: slight or mild (16–30 dB HL), moderate (31–60 dB HL), severe (61–80 dB HL), profound (> 80 dB HL) [10].

The final working otologic diagnosis included acute otitis media (AOM), otitis media with effusion (OME), active and inactive chronic suppurative otitis media (CSOM) and retraction of the tympanic membrane. Dry perforations of the eardrum as well as tympanosclerosis were included in the inactive type of CSOM. The ears affected, the type of HL, and the category or grade of the HL was determined.

Any child found to have active CSOM or any other ear disease and/or unilateral HL, as well as disabling HL, was referred either to the local health center or the ENT clinic at the nearby hospital for further consultation and management.

2.4. Statistical analysis

Data were double entered into a Microsoft SQL database. Rate comparison and χ^2 analyses were used in statistical evaluations. Confidence intervals for rates were calculated with a normal approximation to the Poisson distribution [11] when $N \geq 10$, and an exact Poisson test when $N < 10$ [12]. Rates were statistically compared using a normal approximation to the binomial distribution when there were a sufficient number of cases, and an exact binomial test otherwise. $P < 0.001$ was considered to be highly significant.

3. Results

3.1. Overall rate of HL in Indonesian school children

A total of 7005 children aged 6 years–15 years were enrolled, 3563 children from urban areas and 3442 children from rural areas (Table 1). Table 2 shows the number of hearing loss (HL) cases and the rate per 10,000 subjects by HL degree, ear laterality, urban/rural residence, age, and sex. 127 total children (33 from urban areas and 94 from rural areas had HL (181/10,000 Table 2). Bilateral HL (N = 103; rate = 146/10,000) was more common than unilateral HL (N = 24; rate = 33/10,000; difference $P < 0.00001$). Overall children from rural areas had higher HL rates than those from urban areas (273.1/10,000 children vs. 92.6/10,000 children, $P < 0.0001$) and in all age subgroups. The rate of bilateral disabling HL was 94.2/10,000 overall, from 66 cases. In rural areas, the rate of moderate or greater HL was higher in boys (253/10,000 from N = 40 cases) than in girls (144/10,000 from N = 27 cases; P = 0.021).

In most of the children with HL, it was mild to moderate in severity. One boy had a profound unilateral sensorineural HL, from unknown cause and another had severe bilateral sensorineural HL, unrecognized by his teachers. After retesting and thorough questioning, we concluded that most likely this was a post-lingual genetic deafness on his father's side. Hence, the child could speak and lip-read, and the severe HL went unnoticed.

Table 1
Age and regional distribution of the school children.

Sites:	Age	Palembang	Bandung	Balikpapan	Semarang	Makasar	Bali	Total
Location		N (%[a])	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Urban	6–9 yrs	208 (39.20)	249 39.50)	195 (32.30)	288 (50.90)	256 (36.50)	230 (43.30)	1426
	10–12 yrs	179 (33.80)	199 (31.60)	236 (39.10)	158 (27.90)	200 (28.50)	165 (31.10)	1137
	13–15 yrs	143 (27.00)	182 (28.90)	173 (28.60)	120 (21.20)	246 (35.00)	136 (25.60)	1000
Total		530 (100.00)	630 (100.00)	604 (100.00)	566 (100.00)	702 (100.00)	531 (100.00)	3563
Total Urban	**6–15 yrs**							**3563 (50.9)**
Rural	6–9 yrs	210 (40.50)	209 (35.50)	192 (35.60)	201 (37.40)	242 (34.10)	143 (26.10)	**1197**
	10–12 yrs	173 (33.40)	198 (33.70)	167 (30.90)	176 (32.70)	236 (33.20)	213 (38.90)	**1163**
	13–15 yrs	135 (26.10)	181 (30.80)	181 (33.50)	161 (29.90)	232 (32.70)	192 (35.00)	**1082**
Total		518 (100.00)	588 (100.00)	540 (100.00)	538 (100.00)	710 (100.00)	548 (100.00)	3442
Total Rural	**6–15 yrs**							**3442 (49.1)**
Grand Total		**1048**	**1218**	**1144**	**1104**	**1412**	**1079**	**7005 (100.0)**

[a] Percentages were calculated by site, location, sex and age group categories.

3.2. *Otitis media related HL*

A total of 172 children had otitis media (2.5% of all 7005 school children tested; Table 3). Thirty children had AOM (17.4%), 26 (15.2%) had OME, and 116 children (67.4%) had active or inactive CSOM. Of these, 71 children (41.3%) had mild to moderate HL. Thus, otitis media contributed to 57% of the 125 mild-to-moderate HL cases and 79% (N = 56) bilateral otitis media related HL, which was more common than unilateral otitis media related HL (21%; N = 15) (Table 3).

In children with OME and HL, 10/12 (83%) had mild HL, while in those with CSOM and HL the majority 66% (35/53) had moderate HL (Table 3; P = 0.077). Thirty-one children had bilateral HL > 30 dB. These children, who constituted about 10% of all children with otitis media, or 0.4% of all school children tested, were defined as having "disabling" HL using the WHO criteria.

3.3. *Rates of better ear hearing levels in relation to ear disease*

Looking at the better ear hearing levels of all the 172 children with ear disease (rate: 245.5/10,000), 57 children (rate: 81.4/10,000) had

Table 2
Rate of hearing impairment by age group and sex per 10,000 children[a].

Hearing Impairment		Urban		Rural				Grand Total		
		16–30 dB	31–60 dB	16–30 dB	31–60 dB	61–80 dB	> 80 dB	Urban	Rural	Urban v. Rural
AGE GROUP	Description	mild	moderate	mild	moderate	severe	profound	Rate (95% CI)		*p*-value
		N (Rate)	N (Rate)	N (Rate)	N (Rate)	N (Rate)	N (Rate)			
6–9 yrs	**UNILATERAL**		**2 (14.0)**	**1 (8.4)**	**5 (41.8)**		**1 (8.4)**	**14 (1.7, 50.6)**	**58.5 (23.5, 120.5)**	**0.054**
	Boys		1 (14.4)		2 (32.8)		1 (16.44)	14.4 (0.4, 80)	49.3 (10.2, 144)	0.264
	Girls		1 (13.7)	1 (17.0)	3 (56.0)			13.7 (0.3, 76.3)	68 (18.5, 174.1)	0.127
	BILATERAL	**6 (42.1)**	**6 (42.1)**	**5 (41.8)**	**18 (150.4)**			**84.2 (36.5131.8)**	**192.1 (113.6270.7)**	**0.013**
	Boys	2 (28.7)	2 (28.7)	3 (49.3)	13 (213.5)			57.5 (15.7147.1)	262.7 (134,391.5)	0.002
	Girls	4 (54.8)	4 (54.8)	2 (34.0)	5 (85.0)			109.6 (47.3215.9)	119 (47.8245.2)	0.536
10–12 yrs	**UNILATERAL**	1 (8.8)	**2 (17.5)**		**5 (43.0)**			**26.4 (5.4, 77.1)**	**43 (13.9, 100.3)**	**0.376**
	Boys	1 (16.9)	2 (36.6)		3 (59.3)			54.9 (11.3, 160.6)	59.3 (12.2, 173.3)	0.620
	Girls				2 (30.4)			0 (0,62.4)	30.4 (3.7109.9)	0.277
	BILATERAL	**6 (52.8)**	**5 (44.0)**	**9 (77.4)**	**16 (137.6)**	**1 (8.6)**		**96.7 (39.6153.9)**	**223.6 (137.6309.5)**	**0.013**
	Boys	4 (73.3)	2 (36.6)	4 (79.1)	6 (118.6)	1 (19.8)		109.9 (40.3239.2)	217.4 (88.9345.9)	0.130
	Girls	2 (33.8)	3 (50.8)	5 (76.1)	10 (152.5)			84.6 (27.4197.5)	228.3 (112.8343.9)	0.036
13–15 yrs	**UNILATERAL**			**3 (27.7)**	**4 (37.0)**			**0 (0.3,36.9)**	**64.7 (26, 133.3)**	**0.010**
	Boys			1 (21.6)	1 (21.6)			0 (0.6,82.9)	43.2 (5.2155.9)	0.260
	Girls			2 (32.3)	3 (48.5)			0 (0.5,66.5)	80.8 (26.2, 188.5)	0.041
	BILATERAL	**2 (20)**	**3 (30.0)**	**9 (83.2)**	**17 (157.1)**			**50 (16.2116.7)**	**240.3 (147.9332.7)**	**0.0004**
	Boys	2 (44.9)	2 (44.9)	4 (86.4)	13 (280.8)			89.9 (24.5230.1)	367.2 (192.6541.7)	0.006
	Girls		1 (18.0)	5 (80.8)	4 (64.6)			18 (0.5100.4)	145.4 (66.6275.9)	0.017
Total (all age groups)	**UNILATERAL**	**1 (2.8)**	**4 (11.2)**	**4 (11.6)**	**14 (40.7)**		**1 (2.9)**	**14 (4.5, 32.8)**	**55.2 (30.4, 80)**	**0.003**
	Boys	1 (5.9)	3 (19.0)	1 (6.3)	6 (38.0)		1 (6.3)	23.7 (6.5, 60.7)	50.7 (21.9, 99.9)	0.163
	Girls		1 (5.3)	3 (16.1)	8 (42.9)			5.3 (0.1, 29.7)	59 (24.1, 93.9)	0.003
	BILATERAL	**14 (39.3)**	**14 (39.3)**	**23 (66.8)**	**51 (148.2)**	**1 (2.9)**		**78.6 (49.5107.7)**	**217.9 (168.6267.2)**	**1.25E-06**
	Boys	8 (47.4)	6 (35.6)	11 (69.7)	32 (202.8)	1 (6.34)		83 (39.5126.5)	278.8 (196.4361.2)	2.4E-05
	Girls	6 (32.0)	8 (42.6)	12 (64.4)	19 (101.9)			74.6 (35.5113.7)	166.3 (107.8224.9)	0.008
Grand Total		**15 (42.1)**	**18 (50.5)**	**27 (78.4)**	**65 (188.8)**	**1 (2.9)**	**1 (2.9)**	**92.6 (54.1114.3)**	**273.1 (199.6305.9)**	**1.7E-08**

[a] Rate per 10,000 for each category of age group, urban/rural residence, sex and unilateral or bilateral ears affected.

Table 3
Unilateral and bilateral[a] distribution of hearing impairment in children by type of ear disease.

Grade	N	Unilateral Hearing Impairment			Bilateral Hearing Impairment			Total with Hearing Impairment
		16–30 dB	31–60 dB[b]	Subtotal	16–30 dB	31–60 dB[b]	Subtotal	
Type of Ear Disease		N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
AOM	30	1 (3.3)	1 (3.3)	2 (6.7)	1 (3.3)	3 (10)	4 (13.3)	6 (20)
OME	26	1 (3.8)	0 (0)	1 (3.8)	9 (34.6)	2 (7.7)	11 (42.3)	12 (46.2)
CSOM	116	3 (2.6)	9 (7.8)	12 (10.3)	15 (12.9)	26 (22.4)	41 (35.3)	53 (45.7)
Total	172	5 (2.9)	10 (5.8)	15 (8.7)	25 (14.5)	31 (18)[2]	56 (32.6)	71 (41.3)[c]

[a] In the bilateral cases, the better ear hearing level was used to determine the degree of hearing loss.
[b] Disabling hearing impairment 24% of total children with otitis media, prevalence 0.6%.
[c] Total hearing impairment 41.3% of total children with otitis media, prevalence 1.0%.

Table 4
Rate of better ear hearing levels in the children (per 10,000) by type of HL, type of ear disease, and urban/rural residence.

Type of Ear Disease	Location	Grade	0–15 dB (normal)	16–30 dB (mild)		31–60 dB (moderate)[a]	Total with Hearing Impairment	Urban v. Rural *p*-value
		Description	None	Conductive	Mixed	Conductive		
		N	N (Rate)	N (Rate)	N (Rate)	N (Rate)	Rate (95% CI)	
AOM	**Urban**	14	11 (30.9)	1 (2.8)		2 (5.61)	8.4 (1.7,24.6)	0.326
	Rural	16	15 (43.6)			1 (2.91)	2.9 (0.1,16.2)	
OME	**Urban**	13	7 (19.6)	4 (11.2)		2 (5.6)	16.8 (6.2,36.7)	0.589
	Rural	13	7 (23.2)	6 (17.4)			17.4 (3.5, 31.49)	
CSOM	**Urban**	25	17 (47.71)	2 (5.61)	1 (2.8)	5 (14.0)	22.5 (9.7,44.2)	5.7E-05
	Rural	91	58 (168.51)	12 (34.86)		21 (61.0)	95.9 (63.2128.6)	
All with Ear Disease	**Urban**	52	35 (98.2)	7 (19.6)	1 (2.8)	9 (25.3)	47.7 (25,70.4)	0.002
	Rural	120	80 (232.4)	18 (50.5)		22 (63.9)	116.2 (80..2, 151.2)	

[a] Disabling hearing impairment.

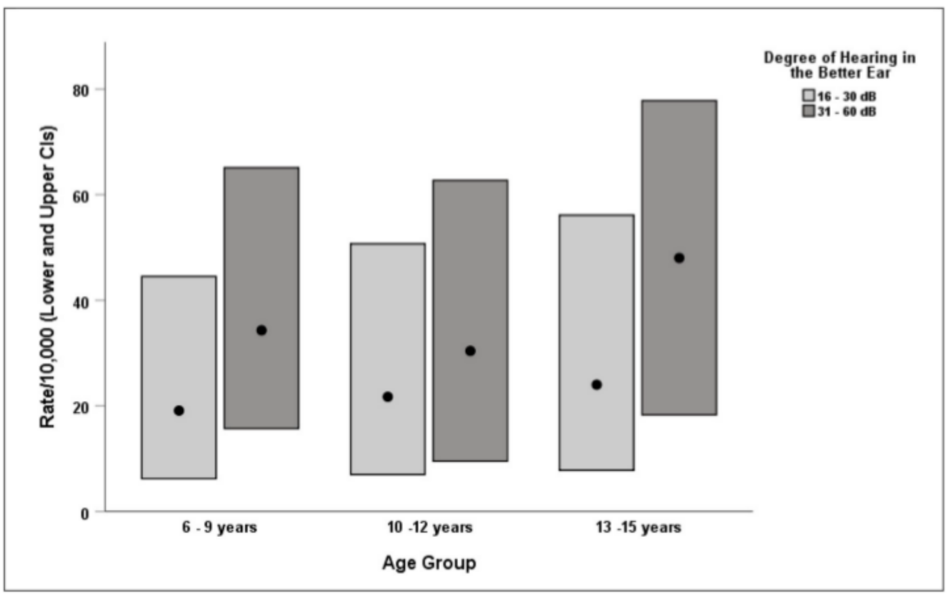

Fig. 1. Rate (95% Confidence Intervals [CI] per 10,000 subjects by age group and degree of hearing loss (HL) for subjects with CSOM.

mild or moderate conductive HL (Table 4). Moderate conductive HL was more common than mild conductive HL (18.0% and 15.1% respectively; Table 4). Only one child had mild mixed HL in one ear. The rate of otitis media related HL in rural children was 116.2/10,000 (N = 40; 95% CI: 80.2, 152.2), and was significantly higher than in urban children 47.7/10,000 (N = 17; 95% CI: 25, 70.4; P = 0.002), primarily due to differences in CSOM rates (N = 33 and 8; rates = 9/10,000 and 22.4/10,000 respectively; P < 0.001) The highest rate of otitis media related HL was in those from rural areas with CSOM (34.9/10,000), with mild conductive HL, and (61/10,000) with moderate

Table 5
Rate of worse ear hearing levels in the children (per 10,000) by type of HL, type of ear disease, and urban/rural residence.

Type of Ear Disease	Location	Grade	0-15 (normal)	16-30 (mild)	31-60 (moderate)		61-80 (severe)	Total with Hearing Impairment	Urban v. Rural *p*-value
		Description	None	Conductive	Conductive	Mixed	Conductive		
		N	N (Rate)	N (Rate)	N (Rate)	N (Rate)	N (Rate)	Rate (95% CI)	
AOM	**Urban**	14	10 (28.1)		4 (11.2)			11.2 (3.1,28.7)	0.360
	Rural	16	14 (40.7)	1 (2.91)	1 (2.9)			5.8 (0.7,21)	
OME	**urban**	13	7 (19.6)		6 (16.84)			16.8 (6.2,36.7)	0.589
	Rural	13	7 (20.3)	2 (5.81)	4 (11.62)			17.4 (6.4,37.9)	
CSOM	**Urban**	25	15 (42.1)	2 (5.6)	7 (19.7)	1 (2.8)		28.1 (10.7,45.5)	3.1E-06
	Rural	91	48 (139.5)	5 (14.5)	36 (104.6)		2 (5.8)	124.9 (87.6162.3)	
All with Ear Disease	**Urban**	52	32 (89.8)	2 (5.6)	17 (47.7)	1 (2.8)		56.1 (31.5,80.7)	1.05E-04
	Rural	120	69 (200.5)	8 (23.2)	41 (119.1)		2 (5.8)	148.2 (107.5188.8)	

conductive HL (Table 4). Interestingly there was no urban/rural differential in OME related HL. There were sufficient numbers of children with CSOM related HL to derive age related comparisons (Fig. 1). The point estimates of mild HL gradually increase by age group while the highest rate of moderate HL is in the oldest age group (13–15 years), though confidence intervals overlap for all comparisons.

3.4. Rates of worse ear hearing levels in relation to ear disease

These rates (Table 5) mirrored the better hearing ear levels (Table 4) with higher rural rates overall (3 times the urban rate) and especially those with CSOM (almost 5 times higher).

4. Discussion

4.1. Burden of HL related to different types of otitis media

The prevalence of middle ear disorders in school children in our study (CSOM, AOM, OME) was 2.5%, more than half (1.7%) of which was due to CSOM. Of all children with middle ear disorders, (41%) had otitis media related HL (Table 3). This would imply that about 1% of all Indonesian school children aged 6–15 years have otitis media related HL. OME accounted for much of the mild conductive HL (40%), while CSOM was associated with most of the moderate conductive HL (83%; difference P = 0.012).

The overall rates per 10,000 children of "disabling" HL of 121.3/10,000 (from 85 cases in Table 2) and of OM related disabling HL of 63.9/10,000 (from N = 22) in rural areas and 25.3/10,000 (from N = 9; Table 4) in urban areas (total rate = 44.2/10,000), suggests a that a large number of children may need amplification with hearing aids, and other measures like placement in class, visual aids, etc., to overcome learning difficulties and other consequences of disabling hearing.

There was only one child with severe mixed type otitis media related HL from a rural area. It cannot be ruled out that the severe HL was caused by concomitant other causes, such as viral causes.

The rate of HL in school children aged 6–15 years in our study (181/10,000), is about half the estimated rate of 410/10,000 in the 2007 WHO SEA study in Indonesia [7]. The differences might be related to the sampling methodology (ours was nationwide, and the WHO study was done only in Bandung) and we used a mixture of urban and rural sites, and focused on school children, whereas the WHO study covered all ages and was primarily rural.

Globally permanent otitis media related HL has been reported to have a prevalence of 30.8/10,000 population [13]. While high income countries have a prevalence of < 2/10,000, South Asia has the highest prevalence (97.0), followed by Oceania (51.2), and West, East, and Central sub Saharan Africa, (2.2, 1.95 and 1.92 respectively) [13]. In that meta-analysis, the rates for south Asian children by age 5, of 60.2 for HL for the best ear, are in between our urban (47.7) and rural rates (116.2) in our children aged 6–15, adding credence to that estimate.

Although it is difficult to make comparisons between these studies due to different age groupings, testing conditions, and criteria, it is only a confirmation of the importance of public health efforts for screening and management of ear disease and HL during the pre-school and school years.

4.2. Comparison with other asian studies

A 1991 study in 1307 Malaysian children aged 7–12 years found that 5.81% failed a hearing screening test, but diagnostic audiometry was not done [14]. In a 1997 study in a pediatric population < 16 years of age in Northern Thailand, moderate HL was identified in 4% of the children [15]. A 1996 study of 284 rural school children aged 6–10 years, conducted in Tamil Nadu, South India, found a very high rate of disabling HL (> 40 db) in 11.9%, most of which (10.9%) were otitis related (CSOM and OME) [16]. In contrast, another study also from rural South India in 855 children aged 5–7 years (albeit in a different state - Karnataka), while demonstrating a similar very high prevalence of HL among children of 16.5%, most was due to wax and only 1 child with CSOM had HL! [17] All these studies (except the one from Karnataka) presented higher rates than our study. There could be several reasons for this: different criteria for assessment of HL levels, (we used the WHO criteria), time of study (almost 20 years earlier), and most of these studies were in rural areas. Varying access to primary ear and hearing care in rural areas two decades ago might explain the variability in results, but there might be other microbiological differences as discussed later.

4.3. Rural versus urban areas

We found that the rate/10,000 children of overall HL in rural areas were significantly higher than in urban areas (273.1 versus 92.6 respectively; Table 2). This trend was reflected in the OM related HL as well (116.2 versus 47.7 respectively) almost half of which was disabling (63.9 versus 25.3 respectively; Table 4). The significantly higher rate of otitis media related HL in rural areas in this study, may be attributed to less health consciousness, worse personal hygiene, increased indoor smoke exposure (over 70% of rural Indonesian parents smoke at home) [18] and delayed health care seeking behavior among the overall poorer people living in rural areas as a whole.

However intriguing findings from studies in Israel, suggest that mixed ear infections with *S. pneumoniae* and NTHi (M-OM), tend to occur in poorer Bedouin children, with crowded conditions and colonization early in life, and who live in rural areas [19]. Conversely, single infections with *S. pneumoniae*, [S–OM] more commonly occur in urban Jewish populations. M-OM was associated with recurrence and chronicity, with pneumococcal serotypes commonly carried by healthy children, whereas S–OM was associated with pneumococcal serotypes with a higher disease potential. Could the rural/urban differential or OM sequelae seen in our study and other studies in Asia, reflect differential early life ear infections with NTHi in children in rural areas? This type of early life ear infection in poorer Bedouin children in Israel, might reflect what is happening in poorer rural children with many of the same risk factors related to poverty that are seen in other Asian countries and our study. We would speculate that early life M-OM with mixed infections in rural infants result in recurrence and chronicity leading eventually to CSOM and its sequelae in older children reported here. No ear tap studies in young infants in Indonesia have been done, but such studies are warrented.

While it is been shown, that introduction of either the 10, or 13 valent pneumococcal vaccines([20–23]) reduce the burden of acute otitis media and recurrent otitis media in industrialized countries, there are no data from LMIC.

4.4. *Limitations*

There are several limitations to our study. The diagnoses of middle ear disease in detail in the field, using otoscopy and pneumatic otoscopy, was not always clear-cut and needed expertise. Training of the field investigators was an important factor in the study so that all investigators in this multicenter study used consistent diagnostic criteria. Since it was not possible to have microscopic diagnoses of the tympanic membrane as examinations were conducted in schools, we were limited to the major common diagnoses of CSOM, AOM and OME. Each audiometer and tympanometer was also well maintained and calibrated, and noise-cancelling headphones were used for screening audiometery.

In performing hearing screening, the ambient noise in schools varied and could influence the hearing screening results. To compensate for this, ambient noise was measured and had to be less than 30 dB after a pilot study showed a difference of 10–20 dB thresholds between the screening room in the field and a sound proof room at the audiology center. This was done to reduce false positives; but conversely, we might have missed some of the mild HL cases.

Otitis media related HL could vary, depending on the stage of middle ear infection and therapy given, which we could not control. Finally the division of “rural” and “urban” was not always clear-cut, although we used an Indonesian Governmental Classification of Rural/urban areas and we conducted preliminary visits to all schools to confirm the classification.

5. Conclusions

A major finding of our study is that otitis media related HL causes a significant burden of illness in Indonesian children, about half of which was disabling, conductive, and mostly bilateral. There is a significantly higher rate in rural than in urban areas. However given the current significant burden of HL in school children in LMIC as illustrated by our study, effective public health policies for the early detection and management of hearing loss should be advocated.

Potential conflicts of interest

W.W.H., B.D., R.A., T.M., K.M., and C.B.K.: This work was supported by a research grant from GlaxoSmithKline (GSK) Biologicals SA to the author's institution (Faculty of Medicine Padjadjaran University).

E.P.S.: This work was supported by a research grant from GSK Biologicals SA to the author's institution (Faculty of Medicine Udayana University).

A.G. and D.S.U.: This work was supported by a research grant from GSK Biologicals SA to the author's institution (Faculty of Medicine Sriwijaya University).

E.L.: This work was supported by a research grant from GSK Biologicals SA to the author's institution (Kanujoso Djatiwibowo Hospital).

S.W. and A.M.K.D.: This work was supported by a research grant from GSK Biologicals SA to the author's institution (Faculty of Medicine Diponegoro University).

S.P.R. and R.D.: This work was supported by a research grant from GSK Biologicals SA to the author's institution (Faculty of Medicine Hasanuddin University).

P.C. L.: This work was supported by a research grant from GSK Biologicals SA to the author's institution at the time the work was completed (Children’s Hospital Colorado, Aurora, CO).

E.A.F.S.: This work was supported by a research grant from GSK Biologicals SA to the author's institution (University of Colorado Denver, Aurora, CO).

Acknowledgements

We would like to thank Tri Hanggono Achmad, MD, Dr. Med, Dean of the Medical Faculty of Universitas Padjadjaran for his support and guidance. Special thanks to all the teachers, parents and school children that gave us all the assistance we needed to do all the necessary examinations. This work was supported by a grant from GlaxoSmithKline Biologicals SA. Data analysis and writing of the manuscript was supported in part by USAID through the Sustainable Higher Education Research Alliances (SHERA) Program. [USAID contract no:AID-497-A-16-00004 and CCR-ARI Contract no:IIE00000078-UNPAD-1].

References

[1] J.L. Culbertson, L.E. Gilbert, Children with unilateral sensorineural hearing loss: cognitive, academic, and social development, Ear Hear. 7 (1) (1986) 38–42.
[2] J. Acuin, World Health Organization. Dept. Of Child and Adolescent Health and Development., WHO Programme for the Prevention of Blindness and Deafness. Chronic Suppurative Otitis Media : Burden of Illness and Management Options, World Health Organization, Geneve, 2004 83 pp. p.
[3] C.D. Bluestone, Epidemiology and pathogenesis of chronic suppurative otitis media: implications for prevention and treatment, Int. J. Pediatr. Otorhinolaryngol. 42 (3) (1998) 207–223.
[4] A. Vergison, R. Dagan, A. Arguedas, J. Bonhoeffer, R. Cohen, I. Dhooge, et al., Otitis media and its consequences: beyond the earache, Lancet Infect. Dis. 10 (3) (2010) 195–203.
[5] A.G. Schilder, T. Chonmaitree, A.W. Cripps, R.M. Rosenfeld, M.L. Casselbrant, M.P. Haggard, et al., Otitis media, Nature reviews Disease primers 2 (2016) 16063.
[6] WHO. Deafness and Hearing Loss Geneva, WHO, 2018 [Available from: http://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss.
[7] WHO. Situation Review and Update on Deafness, Hearing Loss and Intervention Programmes: Proposed Plans of Actions for Prevention and Alleviation of Hearing Impairment in Countries of the South-East Asia Region Geneva, World Health Organization, 2007 [Available from: http://apps.searo.who.int/pds_docs/B3177.pdf.
[8] R. Anggraeni, W.W. Hartanto, B. Djelantik, A. Ghanie, D.S. Utama, E.P. Setiawan, et al., Otitis media in Indonesian urban and rural school children, Pediatr. Infect. Dis. J. 33 (10) (2014) 1010–1015.
[9] J. Jerger, Clinical experience with impedance audiometry, Arch. Otolaryngol. 92 (4) (1970) 311–324.
[10] WHO. Grades of Hearing Impairment: World Health Organization, (2018) [Available from: http://www.who.int/deafness/hearing_impairment_grades/en/.
[11] B.A. Rosner, Fundamentals of Biostatistics, fifth ed., Duxbury Thompson Learning, Pacific Grove, CA, USA, 2000.
[12] E. Pearson, Biometrika Tables for Statisticians, Cambridge University Press, Cambridge, Mass USA, 1956.
[13] L. Monasta, L. Ronfani, F. Marchetti, M. Montico, L. Vecchi Brumatti, A. Bavcar, et al., Burden of disease caused by otitis media: systematic review and global estimates, PLoS One 7 (4) (2012) e36226.
[14] S. Elango, G.N. Purohit, M. Hashim, R. Hilmi, Hearing loss and ear disorders in Malaysian school children, Int. J. Pediatr. Otorhinolaryngol. 22 (1) (1991) 75–80.
[15] S. Prasansuk, A. Na Nakorn, C. Siriyananda, An Ear and Hearing Survey in Northeast Thailand by the Bangkok Otological Center, Siriraj Hospital, vol. 51, Mahidol University. Adv Otorhinolaryngol, 1997, pp. 12–28.
[16] A. Jacob, V. Rupa, A. Job, A. Joseph, Hearing impairment and otitis media in a rural primary school in south India, Int. J. Pediatr. Otorhinolaryngol. 39 (2) (1997)

133–138.
[17] R.S. Rao, M.A. Subramanyam, N.S. Nair, B. Rajashekhar, Hearing impairment and ear diseases among children of school entry age in rural South India, Int. J. Pediatr. Otorhinolaryngol. 64 (2) (2002) 105–110.
[18] E.A. Simoes, K. Mutyara, S. Soh, D. Agustian, M.L. Hibberd, C.B. Kartasasmita, The epidemiology of respiratory syncytial virus lower respiratory tract infections in children less than 5 years of age in Indonesia, Pediatr. Infect. Dis. J. 30 (9) (2011) 778–784.
[19] R. Dagan, E. Leibovitz, D. Greenberg, L. Bakaletz, N. Givon-Lavi, Mixed pneumococcal-nontypeable Haemophilus influenzae otitis media is a distinct clinical entity with unique epidemiologic characteristics and pneumococcal serotype distribution, J. Infect. Dis. 208 (7) (2013) 1152–1160.
[20] R. Dagan, S. Pelton, L. Bakaletz, R. Cohen, Prevention of early episodes of otitis media by pneumococcal vaccines might reduce progression to complex disease, Lancet Infect. Dis. 16 (4) (2016) 480–492.
[21] A.J. Leach, C. Wigger, K. Hare, V. Hampton, J. Beissbarth, R. Andrews, et al., Reduced middle ear infection with non-typeable Haemophilus influenzae, but not Streptococcus pneumoniae, after transition to 10-valent pneumococcal non-typeable H. influenzae protein D conjugate vaccine, BMC Pediatr. 15 (2015) 162.
[22] A.L. Sartori, R. Minamisava, A.L. Bierrenbach, C.M. Toscano, E.T. Afonso, O.L. Morais-Neto, et al., Reduction in all-cause otitis media-related outpatient visits in children after PCV10 introduction in Brazil, PLoS One 12 (6) (2017) e0179222.
[23] S. Sigurdsson, E. Eythorsson, B. Hrafnkelsson, H. Erlendsdottir, K.G. Kristinsson, A. Haraldsson, Reduction in all-cause acute otitis media in children < 3 Years of age in primary care following vaccination with 10-valent pneumococcal Haemophilus influenzae protein-D conjugate vaccine: a whole-population study, Clin. Infect. Dis. 67 (8) (2018) 1213–1219.

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