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A data linkage study

Su, Jiunn Yih; He, Vincent Yaofeng; Guthridge, Steven; Howard, Damien; Leach, Amanda; Silburn, Sven

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The impact of hearing impairment on Aboriginal children's school attendance in remote Northern Territory: a data linkage study

Jiunn-Yih Su,[1] Vincent Yaofeng He,[1] Steven Guthridge,[1] Damien Howard,[2] Amanda Leach,[3] Sven Silburn[1]

Abstract

Objective: To investigate the association between hearing impairment (HI) and Year 1 school attendance in Aboriginal children in the Northern Territory (NT) of Australia.

Methods: Observational cohort study (n=3,744) by analysing linked individual-level information for Aboriginal children from the NT Government school attendance records, NT Perinatal Register and Remote Hearing Assessment dataset, and community level data for relative remoteness, socioeconomic disadvantage and housing crowdedness.

Results: Children with unilateral hearing loss, mild HI and moderate or worse HI had significantly lower Year 1 attendance than those with normal hearing, attending 5.6 (95%CI, -9.10~-2.10), 4.0 (95%CI, -7.17~-0.90) and 6.1 (95%CI, -10.71~-1.49) days fewer, respectively. Other variables that yielded significant association were: male gender, having attended preschool less than 20% of available days, speaking English as second language, twin birth and average household size >5.

Conclusions: Aboriginal children with any level of HI are likely to have lower school attendance rates in Year 1 than their peers with normal hearing.

Implications for public health: In this population, where the prevalence of otitis media and accompanying HI remains extremely high, the early detection and management of hearing loss on entry into primary school should be included in the measures to improve school attendance.

Key words: hearing impairment, otitis media, school attendance, Indigenous health, child health

The high quality of contemporary Australian education systems is well recognised; however, it is also the case that the cultural orientation and requirements for students are predominantly Western in their focus.[1] Among these requirements, consistent school attendance is considered fundamental. There is clear evidence that regular attendance plays a vital role in children's learning of core knowledge and skills, such as literacy and numeracy, and that this shapes children's life trajectories, affecting longer-term socioeconomic status and opportunities.[2,3] School attendance has been problematic for some Aboriginal communities,[1,4-6] and improving school attendance was nominated as one of the key national goals of the national Aboriginal and Torres Strait Islander Education Action Plan, 2010–2014.[6] (Note: In the Northern Territory, 'Aboriginal' is respectfully used when referring to both Aboriginal and Torres Strait Islander peoples.)

School attendance is an issue of particular policy concern in the Northern Territory (NT) of Australia, where the average attendance of Aboriginal students was 71% in 2007, 68% in 2012 and 67% in 2016. These attendance rates all fall substantially below the 90% attendance target for Aboriginal students that was agreed to by the Council of Australian Governments (COAG).[7] The attendance rates among Aboriginal students in remote areas are even lower and are close to 50% for students commencing secondary school.[7,8]

According to a recent NT report, only 40% of Aboriginal students attend school 80% or more of the time.[8] The consequences of missing one day per week or more to the overall time spent in school education are serious. Students with this level of attendance would, on average, lose two years of education over a 10-year period.[9] As several studies have shown significant association between lower attendance and poorer academic achievement, this is highly likely to translate into poorer education outcomes.[3,10] Students with high rates of non-attendance are also at higher risk of early school leaving and failure to complete high school, both of which have been shown to be associated with increased risk of criminal activity.[3,11]

Several factors have been suggested as contributing to Aboriginal student's low rates of attendance, including family socioeconomic circumstance, poor child

1. Centre for Child Development and Education, Menzies School of Health Research, Charles Darwin University, Northern Territory
2. Phoenix Consulting, Northern Territory
3. Ear Health Research Program, Child Health Division, Menzies School of Health Research, Northern Territory
Correspondence to: Dr Jiunn-Yih Su, Centre for Child Development and Education, Menzies School of Health Research, PO Box 41096, Casuarina 0811, Northern Territory; e-mail: Jiunn-yih.su2@menzies.edu.au
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health and wellbeing, high interschool mobility, poor track record of past school engagement, and family travel associated with social and cultural obligations. Further, for some Aboriginal students and families, the Western-style formal education system and curriculum can be perceived as foreign and inflexible.[1,3,8,9,12] Aboriginal children's high rates of otitis media (OM) and the accompanying hearing impairment (HI) is a frequent health condition and may also affect school attendance.[1,4] However, to date, no studies have been published that have investigated the independent impact of hearing impairment on school attendance for Aboriginal children.

Given the widely reported rates of low school attendance and the extremely high prevalence of OM in Aboriginal children in NT remote communities, this study was undertaken to address this knowledge gap. It involved investigating the association between HI and Year 1 school attendance in Aboriginal children living in remote NT communities.[13] The study was made possible by the availability of the Remote Hearing Assessment (RHA) dataset for individual-level linkage with a range of health and education datasets. The RHA dataset contains clinical and audiometric information collected, from 2007 onwards, by the NT Outreach Hearing Health Program, an Australian Government-funded program that provides outreach specialist hearing health services to Aboriginal children living in remote NT communities.[14] Specifically, this study aimed to test the hypotheses that, in the targeted population, children with HI had lower Year 1 school attendance rates than children with normal hearing.

Methods

Study design and participants

This was a retrospective observational study using linked individual-level data. The participants were NT-born Aboriginal children with records in three key datasets: the NT Perinatal Register (an administrative data collection of maternal and perinatal data for all births in the NT and available from 1994 to 2014); the NT Department of Education school attendance dataset (containing enrolment and daily attendance records of students attending NT Government schools for the period of 2005–2016); and the RHA dataset (containing hearing assessment data for the period 2007–2015). Children who underwent surgical treatment for OM before the age of four were excluded because the surgery could alter the impact of HI. This was done by searching in a fourth linked dataset, the NT Hospital Separations Dataset, and excluding 17 children admitted before age four with a diagnosis of OM and selected surgical procedure codes. The diagnosis and procedure codes (Table 1) were classified using the International Statistical Classification of Diseases and Related Health Problems, 10th edition.[15] Other exclusion criteria were living in geographic area other than remote and very remote and Aboriginal status being either non-Aboriginal or unknown.

Table 1: Admission diagnoses and surgical procedures related to otitis media and their International Classification, 10th Revision- Australian Modification codes used in the exclusion criteria.

ICD-10AM CODE	Diagnosis / Procedure
Diagnosis	
H65	Nonsuppurative otitis media
H66	Suppurative and unspecified otitis media
H72	Perforation of tympanic membrane
Procedure	
41527-00	Myringoplasty, transcanal approach
41530-00	Myringoplasty postaural or endaural approach
41533-01	Myringoplasty with atticotomy
41542-00	Myringoplasty with ossicular chain reconstruction
41551-00	Mastoidectomy by intact canal wall technique with myringoplasty
41554-00	Mastoidectomy by intact canal wall technique with myringoplasty and ossicular chain reconstruction
41560-00	Modified radical mastoidectomy with myringoplasty
41560-01	Radical mastoidectomy with myringoplasty
41563-00	Modified radical mastoidectomy with myringoplasty and ossicular chain reconstruction
41563-01	Radical mastoidectomy with myringoplasty and ossicular chain reconstruction
41626-00	Myringotomy, unilateral
41626-01	Myringotomy, bilateral
41632-00	Myringotomy with insertion of tube, unilateral
41632-01	Myringotomy with insertion of tube, bilateral
41635-01	Excision of lesion of middle ear with myringoplasty
41638-01	Excision of lesion of middle ear with myringoplasty and ossicular chain reconstruction
41789-00	Tonsillectomy without adenoidectomy
41789-01	Tonsillectomy with adenoidectomy
41801-00	Adenoidectomy without tonsillectomy
90114-00	Other procedures on eardrum or middle ear

The independent variable

Results of hearing assessment were recorded in the RHA dataset as the average threshold of hearing (as deviation from the normal threshold, in decibels hearing level [dB HL]) for the three frequencies: 500 hertz (Hz), 1000 Hz and 2000 Hz, as assessed with pure tone audiometry. The result for each ear was classified as either normal or one of four levels of hearing loss: mild (16–30 dB HL); moderate (31–60 dB HL); severe (61–90 dB HL); and profound (≥91 dB HL), a comparatively conservative classification that was deemed more suitable for children aged under 15.[14] Only results of conductive and mixed hearing loss were included.

The independent variable of HI consisted of four ordinal categories:

- No HI: normal audiometry results in both ears
- Unilateral hearing loss (UHL): normal in one ear and any degree of hearing loss in the other
- Mild HI: mild hearing loss in the better-hearing ear
- Moderate or worse HI: moderate or worse hearing loss in the better-hearing ear.

Otitis media in NT Aboriginal children develops early in life, is persistent and often asymptomatic,[16,17] and tends to be diagnosed at an older age due to easier diagnosis and greater healthcare access. We therefore assumed that the first recorded audiometry result was representative of a child's HI level regardless of their age at time of assessment.

The outcome measure

The outcome measure was the school attendance rate for Year 1, which is expressed in terms of the number of school days per year from the total of about 200 school days per year.

Control variables and data management

Information for each individual across the three datasets was merged using person-specific, anonymised linkage keys (a 10-digit random number) produced by the linkage agency, SA NT DataLink, during the data linkage process. Each individual record in the merged dataset was also linked with relevant community-level information sourced from publicly available Census data downloaded from the website of the Australian Bureau of Statistics (ABS), including the Index of Relative Socio-Economic Disadvantage (IRSD), which represents socioeconomic disadvantage expressed as quintiles,[18] the level of relative remoteness of children's residential community as measured with the Accessibility and Remoteness Index of Australia (ARIA+, 'remote' and 'very remote' categories only),[19] and housing crowdedness indicators (including 'average household size >5 persons' and 'average persons per bedroom >2').[18] The ABS data were aggregated at the level of the Statistical Local Area (SLA), and then merged with the study dataset using the SLA for the school in which each student was enrolled in Year 1.

Control variables for the regression modelling process were selected based on previous Australian literature on school attendance.[3,7,20] The control variables selected from the Perinatal Register were those factors associated with early childhood development, which may in turn impact on school attendance. They included teenage mother at time of birth, maternal diabetes, maternal hypertension, maternal smoking or alcohol consumption during pregnancy, twin birth, low birthweight and preterm birth.[21] Variables selected from the school attendance dataset were speaking English as a second language (ESL), preschool attendance rate <20%, and demographic variables (gender and age on the first attended school day in Year 1). Other variables of interest from the school attendance and enrolment dataset were parental education level and parent employment status, but these were not included because of the high proportion of missing data.

Statistical analyses

The difference between the study cohort and the cohort of children in the school attendance dataset excluded from the study was assessed with t-test or chi-square test as appropriate. Linear regression was used in both univariate and multivariate analyses for the association between school attendance and HI. Multivariate model building followed the parsimonious model building strategy.[22] As children's records of attendance data were repeatedly recorded in the same school they attended, there might be some unobservable school factors that had affected their attendance, and we therefore adopted a school level fixed-effects model in the multivariate analysis. In reporting the estimated magnitude of an association with the outcome measure, 'change in the number of school days attended in Year 1' was used, instead of 'change in attendance rate', for easier interpretation. All analyses were conducted using Stata version 15 (Stata Corporation, College Station, TX, USA). A two-tailed p-value <0.05 or a regression coefficient (COEF) with 95% confidence interval (CI) not inclusive of the unity was considered significant.

Ethical approval

The study was approved by the Human Research Ethics Committee of the NT Department of Health and Menzies School of Health Research (HREC-2016-2708).

Results

Descriptive statistics

After merging the attendance dataset and the RHA datasets, we found that, of the 12,112 Aboriginal children from remote and very remote areas of the NT who had Year 1 attendance records, 4,299 had hearing assessment data (see Figure 1). The processes of merging with the NT Perinatal Registry dataset and applying the study definition of HI excluded 6,379 children without hearing assessment data, who either were not born in the NT or could not be classified into any of the four categories of HI, leaving a total of 3,744 children in the study cohort (1,769 girls, 47.2%; 1,975 boys, 52.8%). The results of comparison on the descriptive statistics between the study and excluded cohorts are presented in Table 2. The two cohorts were significantly different on all but three variables compared (male gender, antenatal care visits <7 and twin birth). In particular, the study cohort had lower attendance (122.6 mean attended days compared with 126.3 days in the excluded cohort, p<0.001).

Table 2: Comparison of demographic characteristics and selected control factors

Characteristics	Excluded cohort (n=6,379)		Study cohort (n=3,744)		p value
	Number, mean or %	95% CI	Number, mean or %	95% CI	
Attended days in Year 1, mean	126.3	125.1–127.5	122.6	121.2–124.0	<0.001
Demographic factors					
Age at start of Year 1 (years), mean	6.25	6.24–6.27	6.21	6.19–6.23	<0.001
Male gender	51.2%	50.0–52.4%	52.8%	51.2–54.4%	0.128
Speaking English as second language	74.6%	73.5–75.6%	91.8%	90.9–92.7%	<0.001
Attended preschool	98.1%	97–8–98.4%	41.5%	39.9–43.1%	<0.001
Maternal factors					
Antenatal care visit <7	35.0%	33.8–36.2%	35.3%	33.8–36.9%	0.715
Teenage pregnancy	27.2%	26.2–28.3%	31.9%	30.4–33.4%	<0.001
Perinatal factors					
Low birthweight (<2500 gram)	11.8%	11.0–12.6%	13.4%	12.3–14.5%	0.016
Preterm birth	11.9%	11.1–12.7%	15.0%	13.9–16.2%	<0.001
Twin birth	1.7%	1.3–2.0%	2.0%	1.5–2.4%	0.247
Community factors					
IRSD					<0.001
Quintile 1 (least disadvantaged)	2.1%		0.7%		
Quintile 2	4.1%		1.0%		
Quintile 3	14.0%		4.2%		
Quintile 4	0.3%		0.2%		
Quintile 5 (most disadvantaged)	79.5%		93.9%		
Living in very remote areas	68.7%	67.6–69.9%	92.1%	91.2–92.9%	<0.001
Household size >5	24.2%	23.2–25.3%	30.2%	28.8–31.7%	<0.001
Average person per bedroom >2	9.5%	8.8–10.3%	11.8%	10.7–12.8%	<0.001

Results of univariate and multivariate analyses

In the univariate analysis, compared with children in the normal-hearing category, all three HI categories showed evidence for an association with lower Year 1 attendance, with a coefficient ranging from -4.1 days for the UHL category to -7.3 days for the moderate or worse HI category (Table 3). Among the control variables, male gender, preschool attendance rate<20%, ESL, maternal smoking during pregnancy, maternal alcohol consumption during pregnancy, average household size >5 persons and average persons per bedroom >2, and living in very remote regions showed a significant association.

While building the multivariate fixed-effects model, the following variables were retained in the final model to control for confounding: male gender, preschool attendance rate<20%, ESL, low birthweight, IRSD, and average household size >5 persons.[23] In the multivariate model, all three categories of HI continued to show evidence of significant association with lower Year 1 attendance, with adjusted coefficients of -5.6 (95%CI, -9.10~-2.10) for UHL, -4.0 days (95%CI, -7.17~-0.90) for mild HI and -6.1 (95%CI, -10.71~-1.49) for moderate or worse HI. Other variables that yielded evidence of an association were: male gender, preschool attendance rate<20%, ESL and twin birth. Notably, household size >5 persons yielded the greatest effect size and was associated with 24.7 (95%CI, -38.08~-11.34) fewer days attended. In the final model the adjusted R-squared was 0.270.

Discussion

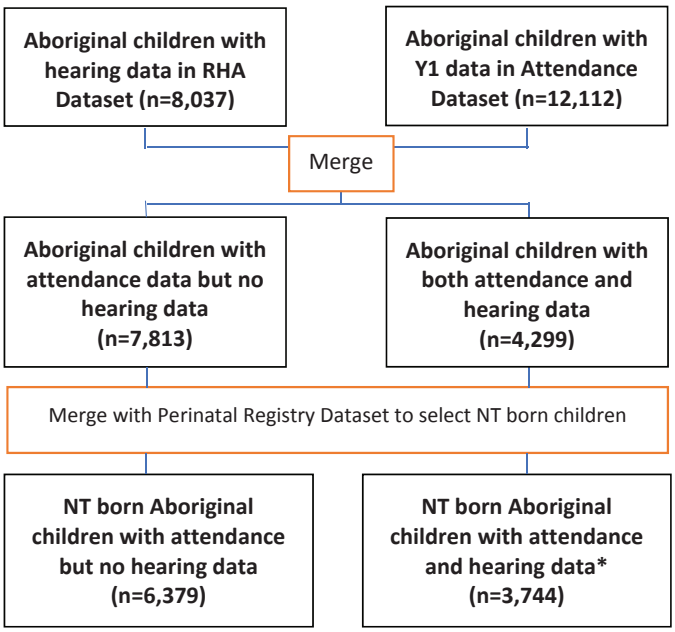
Our study found that HI was negatively associated with Year 1 school attendance in Aboriginal children living in remote and very remote communities in the NT. At univariate analysis, HI, regardless of its level of severity, was found to be negatively correlated with Year 1 attendance rates. After controlling for a range of demographic, maternal, perinatal and community factors as well as school fixed effects, the negative correlation remained for all three categories of HI. These findings provide strong evidence that Aboriginal children with HI, including mild and unilateral hearing loss, are likely to attend school less frequently than their counterparts with normal hearing.

An important result of our study is that UHL has a similar impact on school attendance to mild and moderate HI. Hearing impairment is usually defined by the level of hearing loss in the better hearing ear, and children with UHL are generally not considered to have HI, due to the better ear being normal-hearing. Because of the presence of a normal hearing ear, detection and management of UHL can often be delayed or even neglected.[24] Literature has shown that compared to peers with bilateral normal hearing (BNH), children with UHL were at higher risk of having delayed language development[25] and experiencing grade failures.[26,27] Children with UHL often required additional educational support and assistance and were more likely to develop behavioural problems at school.[28,29] On the other hand, early diagnosis and treatment of UHL can positively impact on verbal-cognitive, linguistic, communicative and socio-emotional development.[24] Our study has demonstrated that Aboriginal children with UHL on average attended 5.6 fewer days than their normal hearing peers. This indicates the need to actively detect such hearing loss and provide necessary support in learning.

In the multivariate analysis, four control variables yielded significant associations with the outcome measure, which is consistent with the findings of our previous studies. In particular, the community level variable representing housing crowdedness, 'average household size >5' was associated with 24.7 fewer school days attended (about 12.4% of the usual 200 school days in a year). This means that, although HI was independently associated with lower school attendance, its impact was considerably less than that caused by community-level factors, such as housing crowdedness. The association with housing crowdedness is consistent with an increased risk of upper respiratory tract carriage of OM-related bacteria in Aboriginal children.[30] Therefore, part of the increased risk associated with crowded housing may have been due to increased incidence of OM and, in turn, increased incidence and severity of HI. However, the overall crowded housing condition in the community can also have a separate impact on school attendance.[3,31]

There are multiple ways that ear disease and the associated hearing loss may affect school attendance. Firstly, ill health related to ear disease may affect children's physical health, either in isolation or in combination with other health conditions, in a way that contributes to children not attending school.[2,13,32] Secondly, it has been proposed that hearing loss may directly affect a child's capacity to engage in the 'talk-focused' type of learning of Western-style classrooms.[33] A common response for children with hearing loss, when faced with unfamiliar social processes, is to avoid engagement.[34] Disengagement can range from not participating in classroom conversations to not attending school. To improve the attendance of hearing impaired students in

Figure 1: Processes of dataset merging and study cohort* selection.



this population, teachers should be aware of the high prevalence of OM and the associated HI. This awareness, together with the implementation of routine hearing screening tests, may aid in the early and active detection of students with HI, and in turn facilitate the provision of appropriate educational support to those affected at the earliest possible time. Educational supports for such children may include installing suitable sound amplification hardware in classrooms, improving classroom acoustics, and training teachers to improve their expertise in supporting hearing impaired students.[1,3,35,36] Teachers' training in this respect should be provided routinely to all teachers newly employed to remote Aboriginal schools, especially given the high teacher turnover.[37] Where possible, teachers should communicate and collaborate with both parents and health professionals to ensure the affected children receive timely and appropriate care and support in terms of both health and education, which may be conducive to children's school attendance.

One of the strengths of our study is that it used population-level data for hearing assessment and school attendance to investigate the impact of HI. The comparatively large sample and the comprehensive coverage of administrative datasets provided ample statistical power and good representativeness of the targeted population to make useful inferences. A related benefit was that the linked datasets provided a range of other information that allowed investigation of the independent effect of HI by adjustment for a range of potential confounding and moderating factors. Another strength is the use of audiometry results that provided a clear definition across a spectrum of hearing ability, from normal hearing, UHL, mild HI to moderate or worse HI. The availability of audiometric results avoided the alternative of clinical diagnosis of OM as a proxy for HI.

This study has several limitations. The results from the RHA dataset may not be representative of all NT Aboriginal children.[14] Although the NT ear health outreach services were delivered to remote communities, access required a referral by the local clinic. From 2013, services were prioritised based on children's need for services. Therefore, the children represented in the RHA dataset may be biased towards those with worse ear health and hearing impairment. This bias does not alter the results within the study cohort, but it does suggest caution

Table 3: Results of univariate and multivariate analyses of the association between Year 1 attendance and hearing impairment and control variables.

Variable	n=	Univariate analysis			Multivariate analysis[a]		
		$Coef_{unadj}$	95% CI	P_{unadj}	$Coef_{adj}$	95% CI	P_{adj}
Hearing impairment							
No	1,680	Ref.					
Unilateral	706	-4.1	-8.00~-0.17	0.041	-5.6	-9.10~-2.10	0.002
Mild	1,015	-4.3	-7.79~-0.85	0.015	-4.0	-7.17~-0.90	0.012
Moderate or worse	343	-7.3	-12.420~-2.09	0.006	-6.1	-10.71~-1.49	0.01
Age at start of Y1	-	2.5	-0.08~5.08	0.058			
Male gender							
No	1,769	Ref.			Ref.		
Yes	1,975	-3.3	-6.14~-0.42	0.024	-5.0	-7.48~-2.48	<0.0005
Preschool attendance rate<20%							
No	2,190	Ref.			Ref.		
Yes	1,554	-10.9	-13.82~-8.07	<0.0005	-10.2	-13.01~-7.42	<0.0005
Speaking English as second language							
No	308	Ref.			Ref.		
Yes	3,436	-7.2	-12.42~-2.04	0.006	-6.5	-12.98~0.08	0.047
Maternal factors							
Antenatal care visit>=7							
No	2,333	Ref.					
Yes	1,275	-0.18	-3.22~2.87	0.91			
Teenage pregnancy							
No	2,549	Ref.					
Yes	1,195	-2	-5.09~1.03	0.194			
Smoking[b]							
No	1,625	Ref.					
Yes	1,371	-7.6	-10.82~-4.44	<0.0005			
Alcohol drinking[b]							
No	2,575	Ref.					
Yes	373	5.3	0.48~10.09	0.031			
Perinatal factors							
Low birthweight (<2500 gram)							
No	3,235	Ref.			Ref.		
Yes	202	-3.3	-7.49~0.89	0.122	-2.6	-6.43~1.25	0.186
Preterm birth							
No	3,174	Ref.					
Yes	562	-1.1	-5.06~2.93	0.601			
Twin birth							
No	3,670	Ref.			Ref.		
Yes	74	10.8	0.55~21.05	0.039	19.9	11.63~28.07	<0.0005
Community factors							
IRSD							
Quintile 1 (least disadvantaged)	27	Ref.			Ref.		
Quintile 2	37	-9.2	-31.22~12.88	0.415	2.2	-28.27~32.68	0.887
Quintile 3	155	-2.8	-20.96~15.37	0.763	10.8	-15.20~36.82	0.415
Quintile 4	7	8.3	-28.62~45.27	0.659	-8.4	-36.49~19.65	0.556
Quintile 5 (most disadvantaged)	3,488	-4.7	-21.53~12.13	0.584	7.7	-17.60~32.92	0.552
Remoteness category							
Remote	297	Ref.					
Very remote	3,447	-16.3	-21.54~-11.03	<0.001			
Household size>5							
No	2,612	Ref.			Ref.		
Yes	1,132	-28	-30.95~-25.00	<0.001	-24.7	-38.08~-11.34	<0.0005
Average person per bedroom>2							
No	3,304	Ref.					
Yes	440	-19.1	-23.52~-14.74	<0.001			

Notes:

a: with school fixed effects; adjusted R-squared=0.270; other factors included in the analysis, but not listed because they did not yield a significant association, include maternal (diabetes, hypertension) and perinatal (emergency Caesarean section, resuscitation at birth and APGAR Score<7) factors

b: Missing data for these variables >=20%

in generalising some findings, such as prevalence of HI, to the wider population of Aboriginal children living in remote and very remote areas. Further, a high proportion of the children in the RHA dataset received their first hearing assessment after the age of seven (the usual age of Year 1 students) and 57.6% of children received two or more assessments (data not shown). The availability and timing of hearing assessment made it necessary to use each child's first audiometry result for analysis, under the assumption that the result was indicative of the long-term HI status of a child. As the severity of HI may change with time, this approach may lead to some misclassification; however, if this was the case then our results underestimate the strength of association of HI with school attendance. Lastly, the results suggest that there are other unmeasured factors that influenced school attendance in the study cohort, as suggested by the moderate scale of the final multivariate model in explaining the variation in school attendance. Future research should incorporate a more comprehensive range of confounding and moderating factors, which might include influences such as parental education and employment status, adverse early life experiences such as child maltreatment,[3,38] and cultural and language factors.[35]

Conclusions

Our study provides clear evidence that HI has a negative, independent impact on school attendance for Year 1 Aboriginal students living in remote NT communities. To improve Aboriginal students' school attendance, it is important to detect HI early, including UHL, and to provide the necessary support to those affected. This can include referring students for clinical management to improve their hearing and ensuring the classroom and teaching staff are equipped with suitable awareness, skills and facilities to support those students' learning. The silent way in which HI presents in young Aboriginal students can make it difficult to detect, especially for teachers who may be unfamiliar with the children. This, together with the high prevalence of OM from first months of life, supports regular surveillance of OM and hearing for all Aboriginal children living in remote communities. This should be provided during early childhood, when they are entering pre-school, and/or their first year of compulsory full-time education.[39]

At the same time, clinical and public health prevention and intervention programs that reduce the prevalence of OM in Aboriginal children can be expected to contribute to improved school attendance.

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