

BMJ Open Epidemiological assessment of geographic and socioeconomic disparities in myringotomy procedures among First Nations children in South Australia

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ABSTRACT

Objective Australian First Nations children bear 8.5 times greater burden of early and recurrent ear and nasopharyngeal infections compared with non-Indigenous children. These disparities are compounded by structural inequities in access to healthcare. To better understand these patterns, we analysed the state-wide epidemiology of childhood myringotomy procedures in South Australia and conducted spatial analysis for its main metropolitan region—Adelaide—to examine the associations with socioeconomic status and distance to healthcare facilities. **Design and setting** A cross-sectional, population-wide study.

Participants All persons who had myringotomy procedures performed between 2007 and 2022.

Primary and secondary outcome measures Annual, age and sex-specific incidence was calculated at the local scale (Statistical Area level 2, SA2). We used admitted patient care data from SA Health, providing comprehensive coverage of otitis media procedures across the population, including First Nations. We applied negative binomial regression to assess associations with socioeconomic status and distance to healthcare facilities, accounting for count-based data and overdispersion.

Results Myringotomy incidence among First Nations children ranged from 2.2 to 6.1 per 1000 child-years across SA2 regions, compared with 2.4 to 3.7 among non-indigenous children. For the whole population, overall annual incidence ranged from 2.7 to 4.2 for males and 2.0 to 2.9 for females, with higher incidence observed in several suburban areas of Adelaide. Myringotomy procedures were associated with socioeconomic status, with increased socioeconomic advantage associated with a 17% reduction in cases (relative risk 0.83, 95% CI 0.76 to 0.92) among First Nations children. Distance to healthcare facilities was associated with myringotomy for non-indigenous children but not for First Nations children.

Conclusions This study found a higher incidence of myringotomy procedures among First Nations children, particularly in later childhood. Socioeconomic disadvantage was a driver, while geographic proximity to healthcare had limited influence. Future initiatives may benefit by prioritising culturally informed, community-led strategies focused on early intervention, prevention and equitable service delivery.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study utilises statewide hospital admission data (2007–2022), ensuring broad coverage of myringotomy cases and capturing temporal variations at a spatial level.
- ⇒ Analysis at the Statistical Area Level 2 (SA2) provides detailed spatial profiling of First Nations populations in metropolitan and regional areas.
- ⇒ SA2 provides meaningful spatial granularity in urban and regional settings; it may not accurately reflect population distribution in remote areas where large and diverse geographical regions are aggregated.

INTRODUCTION

Babies and young children are particularly susceptible to middle ear infections—clinically known as otitis media—due to their ongoing immune system development and anatomical structure of Eustachian tubes.^{1 2} This condition involves the accumulation of fluid behind the ear drum, causing pain and mild deafness as sound is unable to transmit to the middle ear structures.³ The ramifications of untreated ear infections include the significant impact on various facets of children's well-being, language acquisition, communication, academic engagement and social interaction.⁴ Furthermore, hearing loss negatively influences self-concept, educational attainment and social skills, consequently increasing the risk of disengagement from services and systems and increased risk of contact with the justice system.^{5 6} Furthermore, childhood otitis media has been shown to have links to hearing loss in older people,⁷ which can impact on quality of life in later life.

In Australia, ear infections are one of the leading reasons for general practitioner consultations.⁸ When conservative management and repetitive antibiotic treatments prove ineffective, children are often recommended for surgical intervention.⁹ This is



typically a myringotomy with tympanostomy tube insertion—that is, insertion of a small drainage tube into the ear drum—which is the fifth most common surgical procedure in Australia.¹⁰ Over time, the incidence of ear surgery in Australia has shown varying trends. Nationally, there was a 4% decrease in the rate of myringotomy hospitalisations per 100 000 individuals aged 17 and under, between 2012–2013 and 2017–2018. However, this varies across jurisdictions. For example, in the Australian Capital Territory (one of the smallest Australian jurisdictions), the rate increased from 600 to 725 per 100 000 persons between 2012–2013 and 2017–2018, while in Western Australia (the largest Australian jurisdiction), there was a decrease from 800 to 650 per 100 000 persons during the same period.¹¹ South Australia—a geographically dispersed Australian state—historically, has had a higher incidence of tympanostomy tube insertion, estimated to be double that of other regions.¹² Prior to 2017, myringotomy hospitalisations in South Australia ranged between 900 and 1050 per 100 000 persons aged 17 and under, with children aged 0 to 4 years in South Australia having the highest incidence of myringotomy hospitalisations in the nation.¹³

Australian First Nations children are internationally recognised as having some of the worst ear and hearing health,¹⁴ which is an inequity directly linked to the ongoing impacts of displacement, discrimination, colonisation and intergenerational trauma.^{15–18} In fact, First Nations children bear a significantly higher burden—8.5 times greater—of early, frequent, severe and persistent ear and nasopharyngeal infections compared with the rest of the paediatric population.^{11 19} National data indicate a persistently high burden of hospitalisations for middle ear procedures among First Nations children.¹¹ In some remote regions, the prevalence of recurrent or persistent otitis media remains among the highest for First Nations children internationally.²⁰ Furthermore, it is important to note there is substantial underreporting of hearing impairments within First Nations populations in Australia.²¹ These inequitable statistics are linked to a combination of biomedical factors, including bacterial pathogenicity, immunosuppression, gastroesophageal reflux and anatomical vulnerability,^{4 22} as well as social and environmental factors stemming from colonisation, racism and disempowering government policies, including economic disadvantage, challenges in accessing affordable and culturally appropriate healthcare and inadequate housing that supports good health.^{4 15 16} Untreated ear disease and hearing loss experienced by First Nations children reinforces these existing inequities by significantly impacting their overall well-being and development, affecting language acquisition, communication, academic engagement and social interaction.²³ Improving the cultural safety and responsiveness of the health system is critical to addressing inequities in ear and hearing health for First Nations children, as culturally safe services improve access, quality of care and outcomes.^{24 25}

Otitis media arises from multiple interacting factors; in this study, we examined two key structural determinants—socioeconomic status and geographic access to healthcare—which are critical for timely diagnosis, treatment and preventive care, regardless of Indigenous status.^{26 27} Socioeconomic disadvantage has been consistently linked to higher burden of otitis media and poorer surgical outcomes,^{28–31} while greater distance from healthcare facilities is associated with delayed access to specialist services.³² However, evidence suggests First Nations people in urban areas also experience considerable health disparities, although research on their access to health services remains limited.^{18 33} Access to healthcare is essential for improving ear health outcomes because it directly affects the timeliness and quality of diagnosis, treatment and follow-up care for conditions like otitis media.³²

A substantial body of literature highlights the role of social determinants in shaping ear and hearing health outcomes among the First Nations populations in Australia^{26 27 34–36}; however, there remains a notable gap in empirical evidence derived from population-based spatial analysis examining socioeconomic disparities and access to surgical care for otitis media, particularly in First Nations populations. Addressing this empirical evidence gap is crucial to enhance our understanding of access to ear and hearing health services and to support the development of intervention studies aimed at mitigating the impact of social determinants on ear and hearing health outcomes for First Nations children. Furthermore, while most of the relevant studies have focused on rural and remote regions, most First Nations children live in urban areas. This has resulted in a persistent gap in the representation of urban populations in the research.^{18 37–39} To address these gaps, we described the epidemiology of childhood myringotomy procedures across South Australia (2007–2022), estimating incidence by Indigenous status and by sex, and further examining age-specific patterns within these groups. We evaluated the spatial distribution of these procedures within nationally defined administrative boundaries—Statistical Area level 2 (SA2) in ‘Greater Adelaide’. Finally, we assessed how structural factors—socioeconomic status and distance to healthcare facilities—shape the distribution of myringotomy surgeries, with particular emphasis on access equity for First Nations communities.

MATERIALS AND METHODS

We performed a cross-sectional study of hospital admissions for myringotomy in South Australia between 2007 and 2022. As most cases (76%) occurred in metropolitan areas, the spatial analysis was limited to the major metropolitan region—Adelaide—to assess within-city disparities by socioeconomic status and geographic access to care. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.⁴⁰ Ethical approval

was obtained from the South Australian Department of Health and Wellbeing (Ref: 2021/HRE00343) and the Aboriginal Health Research Ethics Committee (Ref: 04-21-946).

Study setting

This study was conducted in South Australia, the fourth-largest jurisdiction in Australia with a population of 1.78 million people.⁴¹ Most of the population resides in the metropolitan Adelaide region, which serves as the primary study area and is located on the traditional lands of the Kurna People. Around 20% of the population lives across the rest of South Australia's 9 81 061 km² land area.⁴¹ Much of this area is classified as 'outback', with limited access to services and infrastructure.⁴² An estimated 18 000 First Nations children reside in South Australia, with 71% living in 'Greater Adelaide'.⁴¹ The First Nations population in South Australia is culturally diverse, comprising over 30 language groups, each with distinct beliefs, cultural practices and languages.

Researcher positionality

The authorship team includes non-Indigenous and First Nations researchers. The first author (SHF) is a non-Indigenous data scientist, while the senior author (JHS) is a non-Indigenous epidemiologist. Two First Nations researchers (SA, PS) provided leadership on interpretation and reporting of findings.

Patient involvement

Patients were not involved in the design or conduct of the study. However, the authors have lived experience as parents of children who have had otitis media and/or myringotomy with tympanostomy tube insertion.

Study population

The study population comprised residents of South Australia admitted to any public or private hospital between 1 January 2007 and 31 December 2022 and who underwent a surgical intervention to treat otitis media. For this study, children were defined as individuals aged 0 to 18 years, representing the primary population of interest. Children accounted for approximately 95.5% of all myringotomy-related hospital admissions in the datasets. Eligible cases were identified through Australian Classification of Health Interventions procedure codes, which are routinely used to record surgical procedures in the admitted patient care (APC) dataset.⁴³ Specifically, we included any hospital admission involving at least one of the following procedures: unilateral myringotomy (41626-00), bilateral myringotomy (41626-01), unilateral myringotomy with insertion of tympanostomy tube (41632-02) or bilateral myringotomy with insertion of tympanostomy tube (41632-03). The study population's usual place of residence, recorded as SA2, had to be located within South Australia at the time of the surgery.

Data variables

Patient-level demographic data included in the analyses were age, sex (assigned at birth; male, female), First Nations identity, hospital type (public, private), insurance status (public, private) and residential location (SA2 code).⁴⁴ Hospitalisation data were length of stay, admission date, discharge date, and procedural and diagnostic codes (ICD-10-AM, 11 edition).⁴³ Population-level data used in the analyses were age, year and First Nations identity for census years 2006, 2011, 2016 and 2021 at SA2 level. Socioeconomic status was measured using Australian Bureau of Statistics (ABS) provided Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) expressed in deciles.⁴⁵

Data sources

Non-identifiable hospital admission data were provided to the researchers by the South Australian Department of Health and Wellbeing. In accordance with National Ethics guidelines,⁴⁶ individual participant consent was not required for the release of the non-identifiable hospital admission data.

Data were extracted from the APC data asset, formerly known as Integrated South Australian Activity Collection (ISAAC).⁴⁷ The APC dataset compiles comprehensive statewide information on patients admitted to, and discharged from, both public and private hospitals. This includes all procedures requiring general anaesthesia, covering both same-day and overnight admissions. As such, the dataset captures the full population of hospital-based myringotomy procedures performed across South Australia. Importantly, the APC dataset records the patient's place of usual residence, coded at the Australian Statistical Geography Standard (ASGS) SA2. The main purpose of this data asset is for South Australian hospital administration management, including supporting efficient allocation of funds, organisation of services, performance assessment and healthcare service planning. Population-level data were extracted from the publicly available ABS Table Builder.⁴⁸

Hospital data were available from November 2006 to June 2023. However, to ensure consistent annual coverage across full calendar years and to align with the implementation of the ASGS in 2006—when SA2 boundaries were first introduced—we restricted our analysis to data from January 2007 to December 2022.

Data analysis

The annual incidence per 1000 child-years of myringotomy procedures in children aged 0 to 18 in South Australia was calculated using APC data and census population data. This analysis considered age, sex, First Nations identity and place of residence. Since 2006 was the census year immediately preceding the start of our study period, population data from that year were required to estimate the SA2-level population for the subsequent 5 years. For 2006, population data were only available at the census district (CD) level and were therefore transformed to SA2



level using correspondence files provided by ABS. Given that ABS geographical boundaries change over time, we transformed both health data and census datasets to align with 2021 SA2 boundaries using the respective ABS correspondence files.⁴⁴ To estimate population counts between census years, linear interpolation was applied for 2007 to 2021, and extrapolation was used to project values for 2022.

We assessed the association between myringotomy procedures, socioeconomic status and geographic access to healthcare facilities at the SA2 level within 'Greater Adelaide'. To ensure the analysis reflected city-level patterns, we excluded individuals whose usual place of residence fell outside the 'Greater Adelaide' area, defined according to the SA2 boundaries defined in the Greater Capital City Statistical Area (GCCSA) classification.⁴⁹ To minimise high collinearity and potential confounding effects, we excluded certain socioeconomic indicators, such as the Index of Economic Resources and Index of Education and Occupation. We used the IRSAD index only, which was available for each SA2.⁴⁵ Additionally, we calculated the distance from healthcare facilities at the SA2 level, defined as the shortest road network distance between SA2 centroid and the nearest tertiary care hospital with otolaryngology services. Hospitals were identified using SA health hospital services data⁵⁰ and the South Australian Government Data Directory.⁵¹ Myringotomy procedures reported in the APC dataset are performed in these private and public hospitals. Distances generated using the network analyst tool in ArcMap (V. 10.8).⁵²

To examine the relationship between myringotomy cases and socioeconomic factors like IRSAD and access to healthcare facilities, we used negative binomial regression models. This modelling approach was selected to account for overdispersion in the count data. We chose to use total cases (counts) of myringotomy procedures in the statistical analysis (as opposed to incidence) and included total population as an additional covariate. This approach provided greater granularity and resulted in more robust findings. We conducted stratified analyses based on demographic variables, such as gender and First Nations identity.

Our initial exploratory steps involved correlation analysis and scatterplot to identify potential predictors, outcomes and their associations. Given the over-dispersed nature of the count data, we opted for negative binomial regression as the appropriate modelling technique. The regression model incorporated relevant categorical predictors including deciles of IRSAD and distance to healthcare facilities. The formulated regression model is expressed as follows:

$$\text{Log (E(Y))} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

where β_0 is the intercept term and β_1 , β_2 and β_3 are the coefficient for the covariates: IRSAD deciles (X_1), distance to healthcare facilities (X_2) and total population (X_3).

The fitted negative binomial regression model underwent assessment for goodness-of-fit, examining the significance of coefficients and addressing multicollinearity concerns. Relative risks (RRs) and their corresponding 95% CIs were calculated based on the model coefficients. The results were interpreted, taking into consideration the direction and magnitude of associations and the statistical significance of findings. Visualisations, including *visreg* plots, were employed to illustrate the partial effects of predictors on the response variable.

RESULTS

Between January 2007 and December 2022, there were 80 899 hospital admissions in South Australia that included nasopharyngeal surgery. Of these, 19 409 (24.0%) involved at least one myringotomy procedure, with the majority (n=19 113; 98.5%) performed on South Australian residents. Most cases occurred in children (n=18 225), with only 4.6% cases involving individuals over 18 years of age, who were excluded from the paediatric-specific analyses. First Nations children accounted for a small proportion of the study population (n=737; 3.9%) (table 1).

Summary statistics for both the full paediatric cohort and First Nations subgroup revealed similar trends in terms of gender. Male children were consistently the majority in both groups (60.1% overall vs 59.6% among First Nations). The infants/preschooler group (0–6 years of age) was dominant in both populations (81.7% vs 69.5%), though a higher proportion of First Nations children were in the school-age category (7–13 years), compared with overall cohort (20.9% vs 12.4%). Overall, most hospital admissions occurred in private hospitals (63.9%), while 36.1% were in public hospitals. However, most First Nation children (81.8%) received care in public hospitals, with only 18.2% receiving surgery in private hospitals. A similar pattern was reflected in the distribution of funding sources: 80.2% of First Nations children's myringotomies were funded through Medicare, with only 10.9% funded by private health insurance (table 1).

Annual incidence

Amongst First Nations children, the annual incidence of myringotomy procedures fluctuated between 2.2 and 6.1 per 1000 child-years over the study period, with a mean incidence of 3.5 (95% CI 2.9 to 4.2) per 1000 child-years. Despite year-to-year variability, an upward trend was observed (slope = +0.17 per 1000 per year, p=0.007; figure 1A). In contrast, the annual incidence among non-Indigenous children ranged from 2.4 to 3.7 per 1000 child-years, with a mean incidence of 3.1 (95% CI 2.9 to 3.3) per 1000 child-years and no temporal trend (slope = +0.03 per 1000 per year, p=0.19). Although the total number of cases among First Nations children was lower than in non-Indigenous children due to their smaller population size, the incidence rate was comparatively high (figure 1B). Furthermore, the overall incidence was higher among male children, varying from 2.7 to 4.2

Table 1 Demographic profile of South Australians who underwent ear surgery between 2007 and 2022 (N=19 113)

Study characteristics	Cases (N, %)	Children only (n, %)	First Nations children only (n, %)
Total	19 113	18 225	737
Gender			
Female	7765 (40.6)	7274 (39.9)	298 (40.4%)
Male	11 348 (59.4)	10 951 (60.1)	439 (59.6%)
Age category*			
Infants/preschoolers (0–6 years)	15 609 (81.7)	15 609 (81.7)	512 (69.5%)
School-age children (7–13 years)	2378 (12.4)	2378 (12.4)	154 (20.9%)
Adolescents (14–18 years)	238 (1.2)	238 (1.2)	9 (1.2%)
Young adults (19–25 years)	136 (0.7)	--	--
Adults (26–45 years)	238 (1.2)	--	--
Older adults (46 and above)	514 (2.7)	--	--
First Nations identity			
First Nations (Aboriginal or Torres Strait Islanders)	749 (3.9)	737 (4.0)	--
Non-Indigenous	17 546 (91.8)	16 715 (91.7)	--
Not stated/inadequately described	818 (4.3)	773 (4.2)	--
Admission election			
Public	6894 (36.1)	6568 (36.0)	603 (81.8)
Private	12 219 (63.9)	11 657 (64.0)	134 (18.2)
Funding source			
Medicare	6749 (35.3)	6429 (35.3)	591 (80.2)
Private health insurance	9708 (50.8)	9205 (50.5)	80 (10.9)
Self-Funded	2457 (12.9)	2422 (13.3)	51 (6.9%)
Miscellaneous†	199 (1.0)	169 (0.9)	15 (2.0%)

*For First Nations, 62 children (8.4%) had invalid or missing age data.

†Includes healthcare funded under the following Australian mechanisms: compensable-motor vehicle accident claims, compensable-workers compensation claims, correctional, defence, non-medicare, other hospital or public authority and veterans. For First Nations, 62 children (8.4%) had invalid or missing values for their ages.

per 1000 child-years, compared with 2.0 to 2.9 per 1000 child-years for female children. Across the study period, the mean annual incidence was 3.7 (95% CI 3.4 to 3.9) per 1000 for males vs 2.5 (95% CI 2.4 to 2.7) per 1000 for females. An upward trend was observed among males (slope = +0.05 per 1000 per year, $p=0.019$), whereas no trend was detected among females (slope = +0.01 per 1000 per year, $p=0.40$).

Age and sex-specific incidence

Incidence of myringotomy procedures varied by age and Indigenous status. Among First Nations children, incidence was highest between the ages of 2 and 5 years, ranging between 159.5 and 181.2 per 1000 child-years (figure 2A). Among non-Indigenous children, incidence peaked earlier, between ages 2 and 3 years, ranging from 196.6 to 205.6 per 1000 child-years. After the age of 4 years, rates for non-indigenous children remained consistently lower than those in First Nations children (figure 2A). The AUC was larger for First Nations children (1122) than for non-indigenous children (1003),

corresponding to a 12% higher incidence. The mean incidence across ages was likewise higher in First Nations children (62.4 vs 55.7 per 1000 child-years). However, this difference did not reach statistical significance (*permutation* $p=0.21$, 95% CI for difference: -188 to +183), consistent with similar overall shape of the two curves. By sex (figure 2B), male children had higher incidence rates of myringotomy procedures compared with female children throughout early childhood, with rates converging at around age 9 years (figure 2B). Across ages 0–18 years, the cumulative incidence was higher in males (AUC=1105) than in females (AUC=768; difference=336, ratio=1.44, $p=0.007$). The average annual incidence across ages was 61.4 per 1000 child-years for males vs 42.7 per 1000 for females.

Geospatial distribution

For First Nations, the incidence of myringotomy procedures showed significant spatial variability across the regions compared with non-Indigenous children (figure 3A,B), with higher occurrences in several

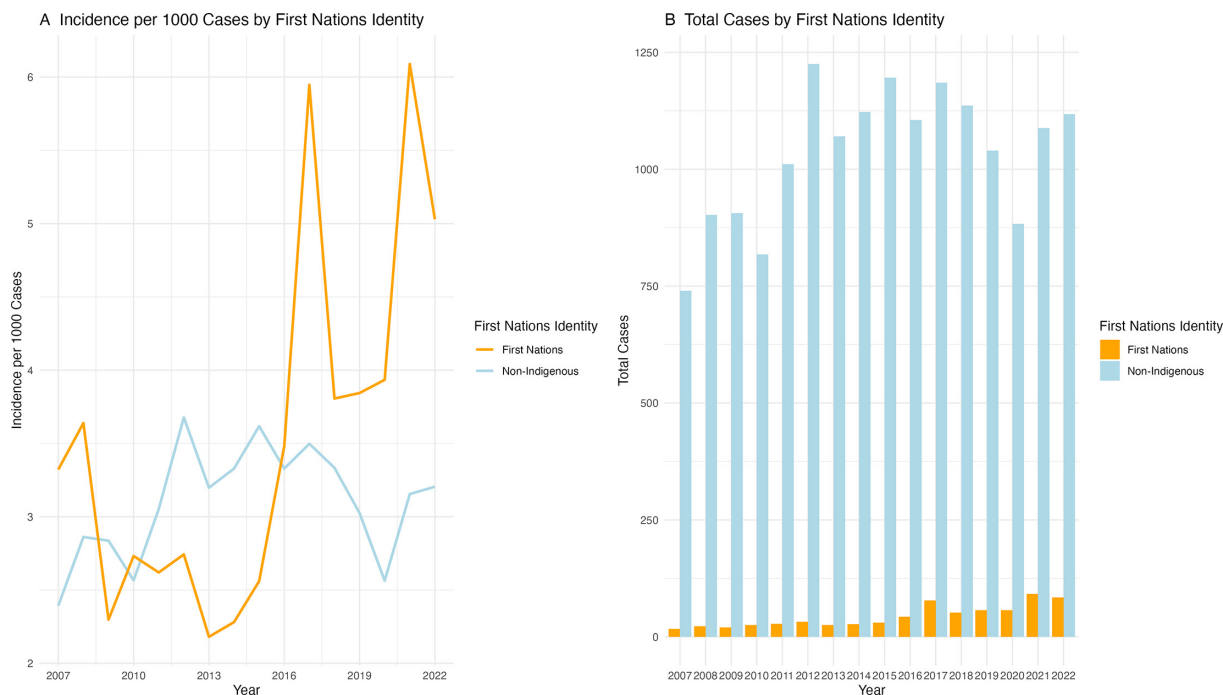


Figure 1 Myringotomy for children residing in South Australia, 2007 to 2022, by First Nations identity: (A) Annual incidence per 1000 child-years and (B) Total case numbers.

eastern, northern and southern SA2 regions of 'Greater Adelaide'. **Figure 4** presents the spatial patterns of overall myringotomy cases in relation to IRSAD and distance from healthcare facilities across different SA2 in 'Greater Adelaide' region. The number of myringotomy cases was generally higher in peri-urban SA2 regions on the city's peripheries, characterised by lower IRSAD and greater distance from healthcare facilities.

Table 2 provides the risk estimates for myringotomy cases with respect to IRSAD and distance from healthcare facilities. Our findings consistently showed a negative association of higher IRSAD on myringotomy procedures. Among First Nations, statistically significant protective effects were observed, with approximately a 17%

reduction in risk with one-unit increase in IRSAD (RR 0.83, 95% CI 0.76 to 0.92) (**table 2**). In the overall cohort, we observed that the risk of myringotomy increased by 3% (RR 1.03, 95% CI 1.01 to 1.05), for each one-kilometre increase in distance from healthcare facilities. However, this association with healthcare facilities was not statistically significant among First Nations communities in 'Greater Adelaide'.

DISCUSSIONS

Given the limited number of studies that have directly investigated the impacts of social determinants on the ear health of First Nations people,²⁷ our study is the first to

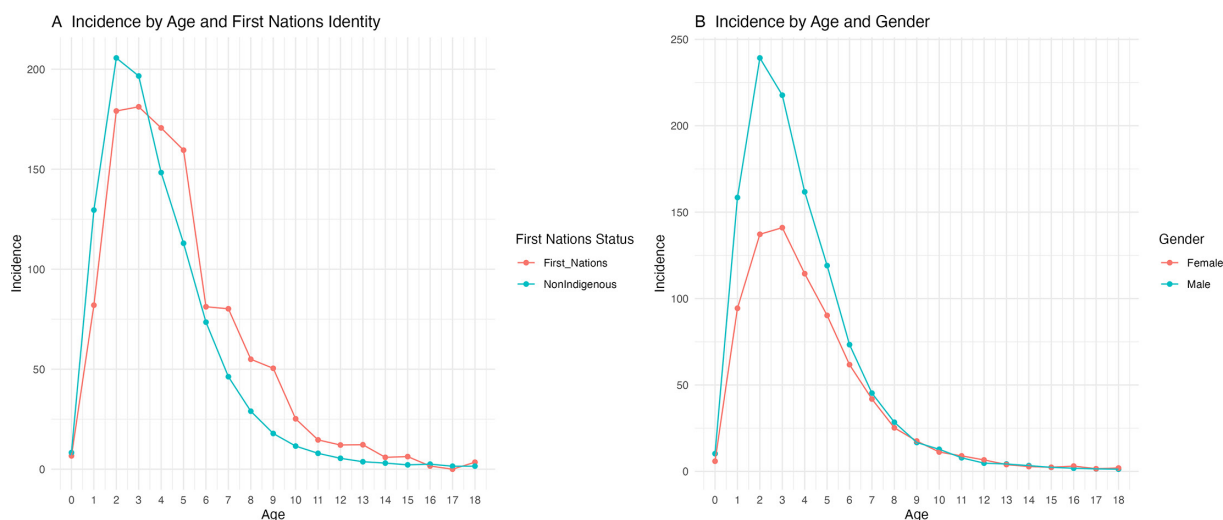
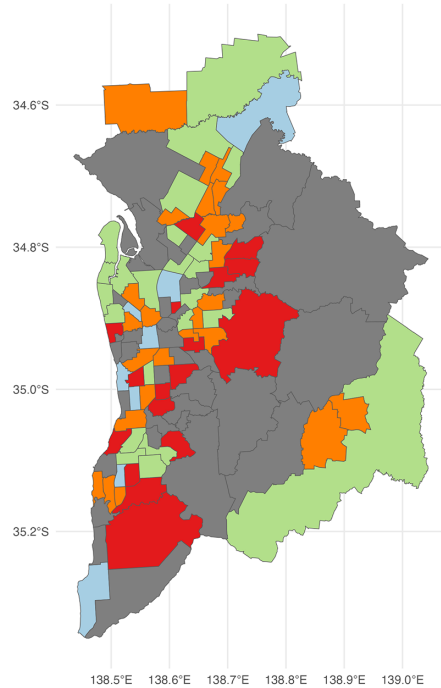


Figure 2 Age-specific incidence (per 1000, child-years) of myringotomy for children residing in South Australia, 2007 to 2022 by (A) First Nations identity and (B) sex at birth.

A Incidence for First Nations population at SA2 Level



B Incidence for non-Indigenous population at SA2 Level

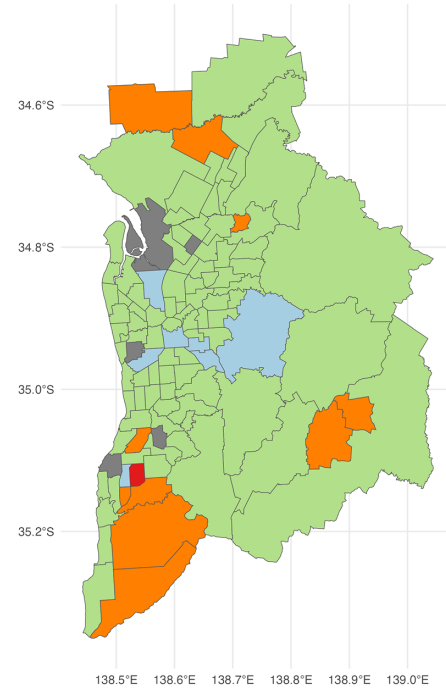


Figure 3 Mean incidence per 1000 children for children residing in statistical local areas across Greater Adelaide, South Australia, 2007 to 2022 by First Nations identity. SA2, Statistical Area Level 2.

provide a spatial epidemiological profile of myringotomy procedures and to quantify associations with socioeconomic determinants in a cohort from Adelaide, Australia. We observed an increase in procedure rates among First Nations children after 2016, with annual fluctuations between 2018 and 2022. The incidence was consistently higher among males and First Nations children. Among First Nations children, an elevated incidence persisted into later childhood (ages 4–15 years). Our findings also showed an association between myringotomy procedures

and socioeconomic status among First Nations children, whereas geographic distance to healthcare facilities was not an associated factor.

We observed an overall increase in the incidence of myringotomy procedures among First Nations children from 2.2 to 6.1 per 1000 child-years, with a mean incidence of 3.5 (95%CI 2.9 to 4.2) per 1000 child-years and a significant upward slope of +0.17 per 1000 per year. This trend is consistent with national reports indicating a 30% increase in ear-related hospitalisations for First Nations

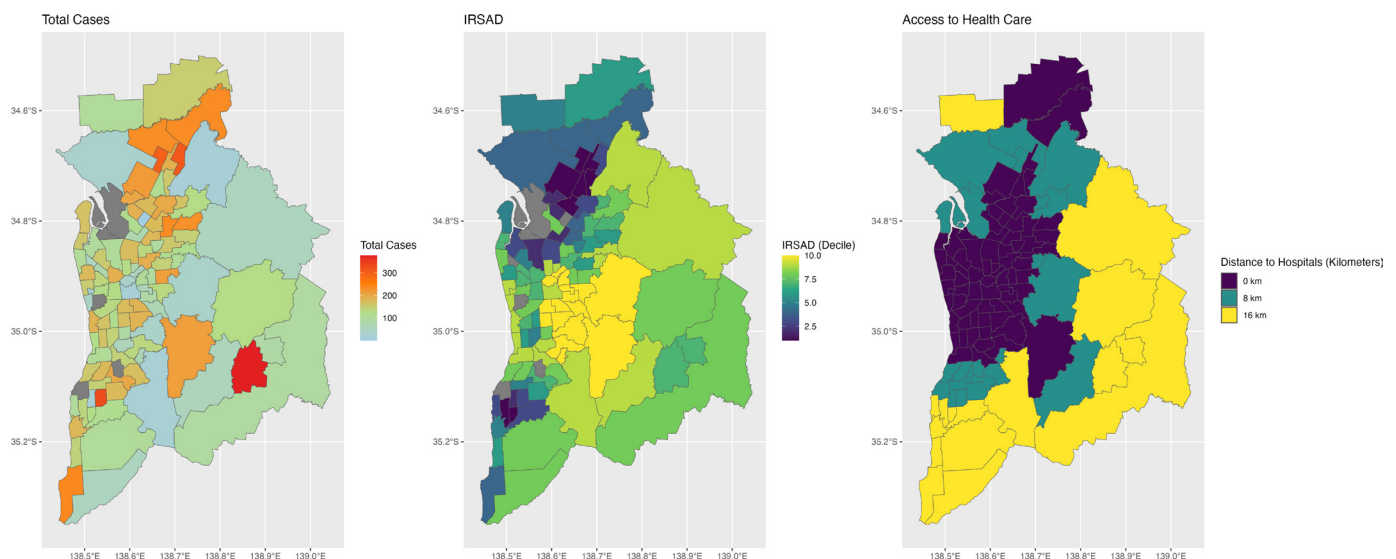


Figure 4 Spatial patterns of myringotomy cases with respect to various socioeconomic indicators for children in Adelaide, Australia. IRSAD, Index of Relative Socio-economic Advantage and Disadvantage.

**Table 2** Risk estimates (95% CI) and AIC values for IRSAD and distance to healthcare facilities by First Nations identity and gender, Adelaide, Australia, 2007–2022

Variables	IRSAD Risk Estimates (95% CI)	Distance to healthcare Facilities Risk Estimates (95% CI)	AIC
Total cases	0.99 (0.97 to 1.01)	1.03 (1.01 to 1.05)	1043.8
Female	0.99 (0.97 to 1.02)	1.04 (1.02 to 1.06)	877.0
Male	0.99 (0.97 to 1.02)	1.03 (1.01 to 1.04)	937.6
Non-Indigenous population	0.99 (0.97 to 1.01)	1.03 (1.01 to 1.05)	1023.0
First Nations populations	0.83 (0.76 to 0.92)	0.97 (0.93 to 1.02)	428.9

AIC, Akaike information criterion for the overall model fit for the respective subgroup model; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage.

children between 2009–2010 and 2018–2019.⁵³ However, the same report also noted a decline in the overall prevalence of reported ear problems, suggesting that the rise in procedures likely reflects improved access to surgical and specialist services rather than worsening disease burden. Enhancements in outreach and service programmes particularly for First Nations children—such as the U8 Aboriginal Ear Health Programme,⁵⁴ the “Healthy Ears – Better Hearing, Better Listening” programme⁵⁵ and the Deadly Sounds Programme⁵⁶—along with the expanded audiology services and reduced surgical wait times, may have contributed to this rise. While these improvements indicate better hospital access, continued efforts are required to address broader systemic barriers that are widely acknowledged as contributing to the persistent burden of ear disease in First Nations communities.^{57 58}

Further, we observed greater variability in procedure rates during the later years (2019–2022), with an increase among First Nations children in 2021, consistent with national reports.⁵⁹ The decline in First Nations incidence during 2018–2019 (52–57 cases and ~13% increase in population) reflects denominator changes and modestly fewer cases as compared with 2017. In contrast, rates among non-Indigenous children declined, particularly in 2020, coinciding with the COVID-19 pandemic, during which extensive public health measures—including restrictions on movement and non-urgent medical care—significantly impacted the delivery of hospital services and elective surgical procedures across Australia. According to national reports,⁵⁹ such fluctuations in service utilisation, including audiology and elective surgery, may reflect both reduced access to care and temporary reductions in disease transmission due to social distancing.⁵⁹ These shifts in service delivery likely contributed to the observed variability in procedure rates during the pandemic period. As such, changes in myringotomy rates during this period should be interpreted within the broader context of pandemic-related disruptions to healthcare services and community behaviours.

The overall incidence was notably higher in males, and the age-specific incidence peaked in children aged 2 to 3 years old. These trends have been previously identified in several studies.^{1 4 60 61} This sex-based disparity may be

attributed to anatomical and immunological differences, such as a shorter and more horizontal Eustachian tube and slower immune maturation in males, both of which can predispose them to recurrent otitis media.^{1 2}

While myringotomy incidence typically peaks at ages 2 to 3 years in the general paediatric population, our findings show First Nations children who underwent myringotomy were more often older, with persistently higher surgical rates, than non-Indigenous children from ages 4 to 15 years old. Previous evidence suggests that this age pattern may be indicative of reduced access to healthcare services⁶²; however, differences in the aetiology of otitis media among First Nations children—such as earlier onset and different pathogens—may also contribute.^{4 62} There is substantial evidence that the social determinants of health influence the prevalence of otitis media among First Nations children,^{32 57} which in turn may also influence access to surgery. Barriers such as mistrust of services, fear of judgement or surveillance, lack of transport and poor service coordination have also been shown to contribute to delayed or inconsistent engagement with healthcare systems^{32 57} and may also play a role in access to myringotomy for First Nations children. Further research is needed to clarify the extent to which this myriad of factors influences surgical access and outcomes.

Delayed interventions can lead to long-term developmental consequences including impaired language acquisition, communication difficulties and educational challenges.⁴ These challenges may reinforce the cumulative impacts of colonisation, intergenerational trauma and marginalisation,¹⁶ particularly when services are not culturally appropriate or easily accessible. In turn, this can increase the risk of adverse life outcomes, including disengagement from education and society, incarceration and difficulties in social integration.¹⁵ Addressing these disparities requires culturally safe, community-driven interventions that prioritise early access to ear and hearing healthcare and prevention, ensuring First Nations children are supported in achieving their full potential.⁶³ Review of First Nations ear health and hearing services further emphasises that strengthening timely access to treatment is critical to reducing the persistent burden of ear disease in First Nation communities.¹⁵

Noteworthy regional disparities were confirmed, with the incidence being higher among people living in the southern and north-eastern peripheries of 'Greater Adelaide'. Our analysis did not reveal any significant association between socioeconomic status (as measured with IRSAD) and the overall incidence of myringotomy cases for both males and females, or for the non-Indigenous population. However, in the First Nations population, socioeconomic status was a strong predictor of myringotomy risk. The analysis indicated that the risk of undergoing myringotomy in the First Nations population decreased by 17% for each unit increase in socioeconomic status.

A study using the Australian Early Development Census (AEDC) found a strong association between socioeconomic status and hearing loss among First Nations children, but not among non-Indigenous children.⁶⁴ Another study found a statistically significant association between socioeconomic status and chronic otitis media, with the condition being significantly less common among individuals from medium- to high-socioeconomic backgrounds (PR: 0.54; 95% CI 0.39 to 0.72).⁶⁵ These findings align with other studies showing that ear disease and hearing loss are more prevalent among children experiencing socioeconomic disadvantage.^{15 20} For First Nations children, contributing risk factors include overcrowded housing, limited breastfeeding, nutritional deficiencies and exposure to cigarette smoke—all of which are linked to lower socioeconomic status.^{4 15 66} These conditions are often shaped by the enduring impacts of colonisation and land dispossession, which have led to intergenerational poverty and inadequate housing. In addition, cultural differences and experiences of discrimination may further hinder access to appropriate and timely ear healthcare.

In our findings, access to healthcare facilities emerged as a significant factor for the non-indigenous population, with myringotomy incidence increasing with greater distance from services—suggesting a potential distance decay effect.⁶⁷ However, no such association was observed among the First Nations communities. This may be explained by the spatial clustering of First Nations communities in specific SA2 regions, where proximity to health facilities is relatively consistent. These findings support the idea that physical distance alone does not explain disparities in service utilisation. Rather, factors such as cultural safety, quality of care and delays in prevention and early intervention are likely to play a more influential role. Evidence supports this view: even within urban Aboriginal Medical Services, approximately one in nine First Nations children wait longer than recommended for ENT care, highlighting persistent barriers to timely access despite geographic proximity.³² Additionally, the disproportionately high burden of otitis media observed in socioeconomically disadvantaged SA2 regions suggests that systemic barriers to care compound the effects of underlying disease prevalence in these communities.¹⁵

Limitations

We report a secondary analysis of hospital admission data, which can be assumed to be representative of the most severe cases of otitis media requiring admission to hospital for surgical intervention. As such, while this analysis may reflect the geographic distribution of underlying otitis media cases, it cannot fully reflect the true prevalence of otitis media, especially among First Nations children.⁶⁸

Importantly, otitis media is a multifactorial condition influenced by biomedical (e.g., anatomical abnormalities, gastro-oesophageal reflux, immunosuppression), environmental (e.g., overcrowded housing, exposure to tobacco smoke), and systemic factors (e.g., delayed preventive care, culturally unsafe services). These variables were not included in our model due to data limitations and were beyond the scope of our population-level analysis.

Approximately the same number of children had 'not stated' First Nations identity as those identified as First Nations. Although these cases were excluded to maintain group comparability, this exclusion may introduce bias if children with missing identity differ systematically from those with known status. This limitation should be considered when interpreting group-based comparisons.

Additionally, our study did not intend to infer causality; rather, we aimed to describe spatial patterns and associations using structural determinants such as socioeconomic status and geographic access to healthcare. Broader contextual issues were discussed with reference to existing empirical evidence to provide a more nuanced interpretation of the findings.

Assessing access to healthcare facilities is complex and cannot be fully captured by measuring geographic distance to tertiary care hospitals alone. Moreover, the spatial variations in myringotomy hospitalisations in outer peripheries of the city might not be adequately captured by the SA2 level classification, leading to a potential underestimation of the association between myringotomy cases and distance from healthcare facilities. Future investigations should consider additional contextual factors, such as community-specific healthcare access challenges or cultural influences on health care-seeking behaviour, to better understand the observed patterns.

CONCLUSION

Improving ear health among First Nations populations in South Australia remains a complex challenge. Our findings indicate higher rates of myringotomy procedures among First Nations children, likely reflecting increased clinical need due to greater burden of otitis media. Socioeconomic disadvantage emerged as an important risk factor in this population, consistent with broader evidence that links social and structural inequities to disparities in health outcomes.

We found that geographic distance to healthcare facilities was not a significant predictor of myringotomy incidence among First Nations children. Further research is

warranted to examine how other factors, including structural and systemic barriers identified in previous studies, may influence patterns of care and health outcomes for this population of children. Further work is needed to explore culturally safe, community-led strategies that prioritise early intervention, prevention and equitable service delivery. Future initiatives may need to include the development of tailored interventions targeting high-risk areas, alongside investment in accessible, culturally competent and coordinated models of care, essential for improving long-term outcomes. Moreover, strengthening research and comprehensive data systems to better capture underlying causes and evaluate intervention effectiveness will also be critical for guiding evidence-based, community-specific strategies.

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