Decreasing Rates of Middle Ear Surgery in Western Australian Children

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Objective: To investigate temporal, social, demographic, and health care utilization factors associated with myringotomy with ventilation tube insertion (MVTI) in Western Australian (WA) children.

Design: Observational retrospective population-based cohort study using hospital administrative data.

Setting: All WA hospitals.


Main Outcome Measures: Age-specific incidence rates and incidence rate ratios.

Results: The rate of MVTI in children younger than 15 years peaked in 1997 at 6.7 per 1000 person-years and decreased to 5.6 per 1000 person-years by 2004. Based on 2004 rates, 8.4% of WA children will undergo at least 1 MVTI procedure before reaching age 15 years. The rate of MVTI was 37% lower in Indigenous children, and the procedures were performed at an older age compared with non-Indigenous children. Higher rates of MVTI were associated with areas of higher economic resources, lower education and occupation status, and living in metropolitan areas.

Conclusions: The rate of MVTI in WA is showing evidence of a decline, even among children younger than 5 years. There remains an issue regarding equity of access to care for Indigenous children. Increasing parental economic resources may be associated with higher rates of MVTI independent of educational status.

Arch Otolaryngol Head Neck Surg. 2006;132:1216-1220

Acute otitis media (AOM) and otitis media (OM) with effusion (OME) are significant causes of childhood morbidity and developmental delay. They account for a high percentage of pediatric presentations and antibiotic use and are the most common reason for surgery in children. Increasing rates of AOM, particularly in younger children, have been associated with increased use of child day care facilities. The prevalence of OME in Australian children at any one time is high, with reports of effusion in 37% of ear examinations at day care centers and middle ear fluid found in 30% of infants aged 6 to 8 weeks. Indigenous children have significantly higher rates of AOM and OME compared with non-Indigenous children and often demonstrate earlier disease, chronic suppurative OM, and perforated tympanic membranes.

Many studies have investigated the long- and short-term health and developmental effects of myringotomy and ventilation tube insertion (MVTI) in children presenting with AOM or OME because most cases resolve spontaneously with time. Current Australian guidelines recommend MVTI for persistent OME (lasting for 3 months or longer) with hearing loss, recurrent episodes of AOM, and acute complications of AOM such as retracted tympanic membrane, mastoiditis, facial nerve paralysis, or brain abscess. Rates of MVTI in developed countries vary considerably. Thirty percent of 6-year-olds in Iceland were reported as having at least 1 procedure compared with 9% of 3-year-olds in Norway and 6.4% of 4-year-olds in an Australian study. Variation of MVTI rates also occurs within countries. A Canadian study found the rate varied from 3.3 to 21.3 per 1000 person-years in children younger than 15 years within a single province.

Although underlying disease burden may account for some of this variation, other reports have shown that parental socioeconomic status and physician factors strongly affect the decision to undergo surgery, which may result in inequitable health care utilization.

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To our knowledge, no study has been conducted to examine the rate of MVTI in Western Australia (WA). Furthermore, considerations of sex, socioeconomic status, and Indigenous status have also not been addressed in previous studies. The aims of this research were first, to estimate the rate of MVTI and to compare it with rates in the published literature, and second, to investigate the influence of socioeconomic and demographic factors on the rate of this procedure in light of the unique challenge of health delivery in a geographically large but relatively sparsely populated state. Western Australia is the largest state in Australia, one quarter the size of the United States, with a population of 2 million inhabitants, most of whom live in Perth, the only major metropolitan city. The Indigenous population comprises Aboriginal and/or Torres Strait Islanders, who represent 3.5% of the state population and who disproportionately reside in rural and remote areas compared with the non-Indigenous population.

**METHODS**

Study data were obtained from the WA Data Linkage System through the WA Safety and Quality of Surgical Care Project, this is a validated record linkage system that systematically links administrative health data from core data sets that include all hospital morbidity data of Western Australians linked back to 1980. A deidentified extraction of all hospital morbidity belonging to children younger than 15 years who underwent a myringotomy with tympanostomy tube insertion between January 1, 1981, and December 31, 2004, was performed. Demographic, diagnostic, and procedural data were included in the extraction.

We used International Classifications of Diseases codes to identify specific procedures and their associated diagnoses. In this study, a case was defined as any child residing in WA who underwent his or her first MVTI procedure before age 15 years. No differentiation between unilateral or bilateral procedures was made. The International Classifications of Diseases codes prior to 1988 did not distinguish between myringotomy alone and MVTI, and all were included in the analysis.

The primary diagnosis code, which refers to the medical condition that required the most care during each individual hospital admission, was identified for all children who underwent MVTI surgery and was classified into 4 broad diagnostic groups: OM, other or unspecified ear conditions, adenoid and/or tonsil disease, and all other conditions. Secondary diagnosis codes, which refer to any other additional medical conditions requiring treatment, were also identified, similarly categorized, and then combined with the primary diagnosis to allow the identification of patient diagnostic subsets. For example, a child admitted with a primary diagnosis code for hypertrophy of adenoids but who had a secondary diagnosis code for OM could be separated from a child who was admitted for OM alone.

Children with chromosomal abnormalities; cleft palate; and other ear, nose, and facial congenital abnormalities were also identified.

Age at first MVTI was collapsed into 3 age groups: 0 to 4 years, 5 to 9 years, and 10 to 14 years. Residential location was defined as metropolitan Perth, rural, or remote. Insurance status was obtained from the payment classification of the hospital admission and defined as public, private, and self-insured. Hospitals were identified as private or public and were assigned to 1 of 34 health service districts that covered the state. Where possible, Australian Bureau of Statistics census collector’s districts (an average of 220 households) were used to assign 3 Socio-Economic Indexes for Areas (indices of relative disadvantage, economic resources, and education and occupation); otherwise, patients’ postal codes were used. These indices are constructed from approximately 50 questions of socioeconomic interest in the population census. A low score of relative disadvantage indicates that the area has many families of low income and individuals in unskilled occupations with little training. The index of economic resources excludes any information on education or occupation, and a high score indicates that the area has a high percentage of households living in large dwellings with high incomes. A low-scoring area of education and occupation indicates many individuals with low educational attainment, high unemployment, or employment in unskilled occupations.

We estimated age-standardized rates by using population denominators obtained from the Australian Bureau of Statistics. We used the 2004 age structure as weights for comparisons over time and used multivariate Poisson regression to estimate relative rates of MVTI by various social and demographic variables. The models estimating rates of MVTI by socioeconomic status were restricted to procedures performed in 2001, the year of the last Australian population census, in order to have accurate age-specific population denominators for each census collector’s district used to assign Socio-Economic Indexes for Areas status. We performed $\chi^2$ and t tests where appropriate. All statistical analysis was performed using Stata statistical software (StataCorp LP, College Station, Tex).

**RESULTS**

A total of 53,673 children younger than 15 years underwent surgery for MVTI from 1981 to 2004. Otitis media–related diagnosis codes comprised 64% of primary diagnoses associated with first MVTI procedures. This percentage increased to 77% when secondary and subsequent diagnoses were taken into consideration. The primary diagnosis codes of the 23% of children who had no record of OM were assigned to 9587 children (18%) with an unspecified ear disorder, 2445 children (4.5%) who had adenoid or tonsil conditions, and the remaining 0.5% who had sleep apnea and other respiratory conditions.

The age-standardized rate of first MVTI increased 2.3% (95% confidence interval [CI], 2.0%-2.6%) each year from 1983 until it reached a peak of 6.7 per 1000 person-years in 1997, after which there was an average decrease of 1.6% (95% CI, 1.1%-2.1%) each successive year. By 2004, the rate of MVTI in children younger than 15 years was 5.6 (95% CI, 5.3-5.8) per 1000 children. Children aged 0 to 4 years had the highest rates, which peaked at 14.9 per 1000 in 1995 (Figure 1). The rate of MVTI in children aged 5 to 9 years decreased steadily over the study period. Assuming steady state conditions, 6.2% of children born in 2004 will have undergone at least 1 MVTI by the time they reach age 5 years compared with 7.1% of children born in 1997.

Factors associated with higher rates of MVTI were younger age, male sex, living in metropolitan areas, and being non-Indigenous (Table). Although rural and remote areas had lower overall MVTI rates, large variations by health service district were observed. For example, the rate of MVTI ranged from the lowest, 2.1, to the highest, 8.1, per 1000 person-years among rural health service districts in 2004.

Of children aged 0 to 4 years, non-Indigenous boys had the highest rates and Indigenous girls the lowest rate of pro-
Table. Relative Rate of MVTI in Children Younger Than 15 Years at Time of First Procedure

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>IRR (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age group, y</td>
<td></td>
</tr>
<tr>
<td>0-4</td>
<td>2.10 (2.07-2.14)</td>
</tr>
<tr>
<td>5-9</td>
<td>1.00</td>
</tr>
<tr>
<td>10-14</td>
<td>0.99 (0.98-1.00)</td>
</tr>
<tr>
<td>Female</td>
<td>0.73 (0.71-0.74)</td>
</tr>
<tr>
<td>Indigenous status</td>
<td>0.63 (0.60-0.66)</td>
</tr>
<tr>
<td>Residential location</td>
<td></td>
</tr>
<tr>
<td>Metropolitan Perth</td>
<td>1.00</td>
</tr>
<tr>
<td>Rural</td>
<td>0.91 (0.89-0.93)</td>
</tr>
<tr>
<td>Remote</td>
<td>0.67 (0.64-0.68)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; IRR, incidence rate ratio; MVTI, myringotomy with ventilation tube insertion.

*Multivariate Poisson regression Wald test P values associated with individual rate ratios were all less than .001.

Figure 1. Age-standardized rates of first myringotomy with ventilation tube insertion for all children (heavy black line) and age-specific rates in children aged 0 to 4 years (solid squares), 5 to 9 years (open circles), and 10 to 14 years (solid triangles) at first procedure in Western Australia from 1983 to 2004.

Figure 2. Age-specific rates for myringotomy with ventilation tube insertion in non-Indigenous boys (solid squares), non-Indigenous girls (open squares), Indigenous boys (solid circles), and Indigenous girls (open circles) younger than 5 years at first procedure.

Interpretation of these results was limited by the use of administrative data that were not collected specifically for this study. A high percentage of children identified as having undergone MVTI surgery had poorly defined diagnoses associated with their procedural admission. It was difficult to distinguish between cases of OME and recurrent AOM for many children. Another limitation of this study was that socioeconomic status could be applied only to geographical areas and not to individual children, which may lead to overinterpretation of the results or bias. The socioeconomic analysis was also restricted to the 2001 population census year and may not accurately represent earlier time periods. Despite these limitations, our study has the advantage of being large, continuous, and population based, which gives the statistical power to identify small changes in clinical outcomes and reduces bias that may be observed in single-institution studies.

There is evidence that the rate of MVTI in WA children has been slowly decreasing since 1995, perhaps in response to the release of middle ear disease management guidelines in 1993. An earlier study found only a temporary effect of the guideline release on decreasing MVTI procedure rates in another Australian state. However, the magnitude of the response to management guidelines may have been obscured by the simultaneous increased use of formal child care facilities, particularly for children younger than 5 years, which has been associated with increased rates of OME.

The decrease in the rate of MVTI observed in children younger than 5 years was particularly evident in the last 3 years of the study. The introduction of universal
pneumococcal conjugate vaccination for infants in 2001 could have perhaps influenced the decline in MVTI in this age group, although the effect of the vaccine on OM incidence and in what context remains controversial. It will be interesting to investigate this relationship further in the future when more data become available and to verify the decreasing rates.

The increasing rates of MVTI in children younger than 5 years observed during the 1980s may have been due to an improved understanding of the OME disease process, which rises from birth and reaches its peak at around 2 years of age. We believe such rate increases were at least partly indicative of improved access to otolaryngology services and subsequent increase in pickup rate of infants and young children with hearing impairment secondary to OME. Therefore, otolaryngology service should continue to focus on this age group and schedule early outpatient appointments and put these patients on a short waiting list for MVTI when clinically required.

The rate of MVTI in WA is half of that reported for Canadian children, and the risk by age 5 or 6 years is much lower than reported in Scandinavian countries but similar to rates reported elsewhere in Australia. The lower rate of MVTI in WA children is perhaps a reflection of the generally milder winters and outdoor lifestyle that may reduce the incidence of AOM and the subsequent OME compared with those who live in cooler climates. Large variations among the 34 different health service districts within the state also suggest that there is a strong surgeon and/or primary physician influence on surgery rates as reported in a Canadian study that also found large small-area variations.

Despite efforts to improve audiological investigation and the delivery of audiological services to remote areas, we found evidence of some access inequity, with lower surgical rates observed in children residing in rural and remote areas of the state compared with those who live in metropolitan Perth. However, it is possible that the prevalence of OM is lower in some of these less-populated areas. The rate of MVTI was also significantly lower in Indigenous children despite a documented higher prevalence of OME compared with the rate in non-Indigenous children. Furthermore, Indigenous children who did undergo surgery were more likely to be older, which is also indicative of reduced access to health care services. However, the etiology of OM in Indigenous children is often different than that of non-Indigenous children because it begins at a younger age and involves different pathogens, and therefore a more detailed study looking at surgical access issues would be required to quantify the size of this problem.

We observed that more advantaged areas had higher rates of MVTI and that these increased rates were driven

![Figure 3](image1.png)

**Figure 3.** Rate of myringotomy with ventilation tube insertion (MVTI) procedures by quartiles of relative advantage for indices of overall social disadvantage, economic resources, and educational and occupational status based on residential areas for children younger than 15 years in 2001. Error bars represent 95% confidence interval of rate estimate.

![Figure 4](image2.png)

**Figure 4.** Number of myringotomy with ventilation tube insertion (MVTI) procedures performed by season and patient health insurance status as either private or self-funded health insurance (open circles) or public health insurance (solid circles) for children younger than 15 years from 1981 to 2004.
by increased economic resources and not necessarily by educational or occupational attainment. This suggests that children of parents with monetary resources have either easier access to appropriate treatments and/or higher rates of OME requiring MVTI compared with children of families with less resources. Even though all Australians are entitled to free access to public hospitals, parents with higher incomes are more likely to have private health insurance and to be able to afford private hospital care without experiencing the long waiting lists in the public hospital system. The responsiveness of the private hospital sector to meet demand is evident from the more marked seasonal fluctuation in surgery numbers.

Increased family income is also associated with increased use of formal day care facilities in Australia, and given that it has been established that repeated exposure to many children is associated with increased prevalence of OME, it is plausible that higher rates of MVTI surgery in children of more wealthy parents may be partly accounted for by higher rates of disease. However, the documented high rates of OM in the Indigenous population and lower rates of surgery outside the major urban areas indicate that further evaluation of this issue is needed to enhance equitable provision of health care across our population. Continuing improvement of our data collection and its analysis will facilitate this.

Submitted for Publication: January 31, 2006; final revision received May 9, 2006; accepted July 9, 2006.

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Author Contributions: The authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Kadhim, Semmens, and Lannigan. Analysis and interpretation of data: Spilsbury, Kadhim, and Lannigan. Drafting of the manuscript: Spilsbury and Kadhim. Critical revision of the manuscript for important intellectual content: Kadhim, Semmens, and Lannigan. Statistical analysis: Spilsbury and Kadhim. Obtained funding: Semmens. Study supervision: Kadhim, Semmens, and Lannigan.

Financial Disclosure: None reported.

Acknowledgment: We thank the WA Data Linkage Unit for supplying the data analyzed in this study and the National Health and Medical Research Council for financial support of the WA Safety and Quality of Surgical Care Project.

REFERENCES