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Effectiveness and Safety of Advanced Audiology-Led Triage in Pediatric Otolaryngology Services

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Objective: Expansion of the scopes of practice of allied health practitioners has the potential to improve the efficiency and cost-effectiveness of healthcare, given the identified shortages in medical personnel. Despite numerous examples in other allied health disciplines, this has yet to be applied to pediatric Audiology. This study aimed to investigate the effectiveness and safety of using audiologists with advanced training to independently triage children referred to ORL services, and compare the subsequent use of specialist resources, and postoperative grommet care to a standard medical ORL service.

Design: One hundred and twenty children consecutively referred to a large ORL outpatient service in Queensland, Australia, for middle ear and hearing concerns were prospectively allocated to either the ORL service or Advanced Audiology-led service. Demographic and clinical data were extracted from electronic medical records and compared between the two services.

Results: Approximately half of all children referred to ORL for middle ear or hearing concerns were discharged without requiring any treatment, with the remaining half offered surgical treatment. The Advanced Audiology-led model improved increased the proportion of children assessed by ORL that proceeded to surgery surgical conversion rate from 57% to 82% compared with the standard medical traditional ORL model. Children followed up by the advanced audiologists after grommet insertion were more likely to be discharged independently and at the first postoperative review appointment compared with the traditional standard medical ORL service. There were no reports of adverse events or long term bilateral hearing loss after discharge by the Advanced Audiology-led service.

Conclusions: These findings indicate that an Advanced Audiology-led service provides a safe and effective triaging model for the independent management of children not requiring treatment and children requiring routine postoperative grommet review, and improves the effective use of specialist resource compared with the standard medical ORL service.
INTRODUCTION

Otitis media is known to be associated with a significant burden of disease, particularly in early childhood (Monasta et al., 2012), yet access to specialist otolaryngology (ORL) services is often impeded by lack of capacity, medical shortages, and high demand (Caffery, Farjian, & Smith, 2016; Hofstetter, Kokesh, Ferguson, & Hood, 2010; Patil, Meinzen-Derr, Hendricks, & Patil, 2016; Pokorny, Wilson, Thorne, & Whitfield, 2018; Yates, 2001). The expansion of the scopes of practice of some healthcare workers by the substitution of a medical specialist or surgeon with a nonmedical healthcare worker is a concept that has the potential to reduce waitlists and wait times (Belthur, Clegg, & Strange, 2003; Blackburn, Cowan, Cary, & Nall, 2009; O Mir et al., 2016; Walsh, Pilkington, Wong, Brown, & Mercer, 2014), make better use of specialist skillsets, and reduce costs of service provision, all while providing conservative and appropriate treatment with improved or equivalent clinical outcomes (Hourigan & Weatherley, 1994).

There is a growing body of evidence to support the use of allied health advanced practitioner-led services in adult services (particularly from the fields of physiotherapy and orthopedic surgical outpatient services) to manage nonsurgical patients independently through to discharge (Blackburn et al., 2009; Bonanno et al., 2014; O'Farrell, Smart, Caffrey, Daly, & Doody, 2014; O Mir et al., 2016; Pearse, Maclean, & Ricketts, 2006; Wood, Hendrick, Boszczyk, & Dunstan, 2016). These initiatives report increased proportions of patients seen by the specialist who are then booked for surgery (surgical conversion rate) compared with traditional models (Bath & Pahwa, 2012; Boissonnault, Badke, & Powers, 2010; Homeming, Kuipers, & Nihal, 2012; Napier, McCormack, Hunt, & Brooks-Hill, 2013; Wood et al., 2016). In the field of ORL, advanced physiotherapy- and audiology-led services for adults referred to ORL for the management of dizziness have resulted in approximately half of
patients treated and discharged at a single appointment (Kasbekar et al., 2014) without requiring assessment or treatment by an otolaryngologist.

These examples in adult services suggest similar success could be achieved in the closely aligned fields of audiology and ORL in the management of pediatric middle ear and hearing issues, a concept that has not previously been tested. It is common practice in large teaching hospital-based services for ORL outpatient clinics to be staffed by ORL consultants, trainee doctors undergoing ORL specialist training, and junior doctors with a range of experience and expertise. This structure allows a high volume of patients to be seen through the service while providing teaching opportunities for junior doctors. ORL outpatient clinics that are concerned with ear disease generally also require the support of audiology services in providing hearing assessment and diagnoses. Audiologists working independently in an expanded scope of practice to postoperatively review children receiving ventilation tubes (grommets) have been reported to reduce ORL workload by up to 54% (Davies-Husband, Harker, Davison, & Yates, 2012); however, there have been no studies to date investigating audiologists providing first point of contact services for children referred to ORL services. Recently we have reported that a first point of contact Advanced Audiology-led service has the potential to provide significant benefits to the ORL service with up to 45% of semi-urgent outpatient pediatric ORL referrals meeting eligibility criteria to be diverted to an Advanced Audiology-led service, which could potentially result in an overall increase in ORL pediatric outpatient capacity of up to 77% (Pokorny et al., 2018).

In light of these potential benefits, the present study was undertaken to determine if an Advanced Audiology-led service co-located within the existing ORL outpatient service, was able to provide a safe and effective triage service for children referred to pediatric ORL services with middle ear or hearing concerns, and to compare the postoperative grommet care provided by advanced audiologists to the traditional standard medical ORL service. The
primary aim of this study was to determine if effectiveness (as measured by the proportion of children seen by the otolaryngologist that required surgical treatment, also known as the surgical conversion rate) was improved by using an Advanced Audiology-led service in a first point of contact triaging role. Secondary aims were to compare the two services after grommet insertion and to monitor safety of the Advanced Audiology-led service only (as measured by the number of recorded adverse events).

MATERIALS AND METHODS

This study was a prospective single-site clinical study comparing the current standard of care (existing ORL service) with a new Advanced Audiology-led service (intervention). The study was conducted in the ORL outpatient department of a large secondary hospital in Queensland, Australia. Recruitment of participants occurred from 1 June 2014 to 30 March 2015 (10 months). Data were collected for all participants until 31 January 2018.

Services and Clinical Staffing

The pediatric ORL outpatient service was staffed by 1 senior otolaryngologist, 2 trainee doctors undergoing ORL surgical training, and up to 5 junior doctors. The senior otolaryngologist had over 30 years of pediatric ORL experience in Australia, South Africa and the UK. This pediatric ORL service accepts referrals only from primary care providers and other medical specialists for all children with signs and symptoms of ear, nose and throat disease and/or hearing, balance, breathing or swallowing difficulties.

The Advanced Audiology-led service was co-located and ran independently, but concurrently, with existing ORL outpatient clinics. It was staffed by 2 advanced-experienced audiologists who had completed the training described below and are subsequently referred to as “advanced audiologists”. Each held a Master’s degree in Audiology and had 5-10 years full-time clinical experience in hospital settings. Children who meet referral eligibility criteria
were accepted into this service directly from the ORL pediatric outpatient waitlist and from inpatient theatre services for postoperative grommet review. The eligibility criteria included: 1) aged from 2 years 4 months to 17 years 0 months, 2) reason for referral being middle ear, hearing, or speech concerns, and 3) routine grommet insertion (with or without adenoidectomy). Referrals for complex middle ear disease, otitis externa, diagnosed sensorineural hearing loss, or wax impaction are deemed unsuitable for the Advanced Audiology-led service and remained on the ORL waitlist to be seen by the standard medical service. Children younger than 28 months were not eligible to be seen by the Advanced Audiology-led service due to the recognition of the greater complexity of middle ear disease and differences in guidelines for treating otitis media in younger children, as well as the difficulties assessing hearing thresholds in this younger age group (normally requiring two audiologists for the assessment process).

**Advanced Audiology Training**

The advanced audiology training was a 6 to 12 month structured program provided through clinical observation, theoretical and practical assessment (involving at least 40 new and postoperative grommet review ORL patients) overseen and supervised by a senior otolaryngologist. Formal competency sign off (in the room assessment) was conducted by the senior otolaryngologist followed by application for credentialing in advanced scope of practice (pediatric ORL services) through the Metro-South Credentialing and Scope of Clinical Practice Committee within Queensland Health. Audiologists at this facility who are credentialed and practice in this field are called advanced audiologists in recognition of the higher level of expertise and training required to provide these services.

**Participants**

A total of 131 children met the above referral eligibility criteria for referral to the Advanced Audiology-led service. These children were allocated to either the standard ORL service or
the Advanced Audiology-led service. Working forward in chronological order of referral date to the ORL waitlist, alternate eligible referrals were redirected to the Advanced Audiology waitlist to form the Advanced Audiology (AA) study group with those remaining on the ORL waitlist forming the ORL study group. Other than ensuring that referrals met inclusion/exclusion criteria, there was no other screening of referrals to determine study grouping. An exact 1:1 allocation ratio was unable to be maintained due to service-level demands and the known lengthy waiting times for ORL services in this facility as previously reported (Pokorny et al., 2018). This resulted in greater numbers of eligible referrals being redirected to the AA group instead of waiting for treatment through the standard medical ORL service.

Of the 131 eligible participants, 48 were allocated to the ORL service and 83 to the Advanced Audiology-led service. Informed consent was sought for inclusion in this study and 4 participants from the ORL group and 7 participants from the AA group declined to allow their data to be included in the study. All of the participants allocated to the Advanced Audiology-led service were offered the option to decline this service and return to the ORL waitlist. No participants declined the provision of this service.

Protocols

All children were provided with normal clinical care according to the service they were attending (Fig. 1). Children attending the ORL outpatient services received audiometry and tympanometry as a separate appointment (but usually within the same clinic) by the on-site general audiologist. Postoperative grommet review appointments usually also included a second separate appointment to include audiometry and tympanometry provided by the on-site general audiologist. Requests by junior doctors for second opinions from more senior ORL staff occurring within the single medical appointment were recorded in the clinical notes and defined in this study as “second opinion requests”.
The Advanced Audiology-led service provided video-otoscopy and all clinical testing within a single appointment. These tasks were completed independently or with the advice and/or assistance from the ORL medical staff present in the clinic. Requests for advice or assistance from medical staff occurring within the single appointment were recorded in the clinical notes and defined in this study as “second opinion requests”. The tasks of prescribing medications and booking children for surgery fell outside the advanced audiologist’ scope of practice, however they were able to refer directly to the otolaryngologist to be seen with high priority in a separate second appointment. All decisions for surgery bookings were made at the discretion of the treating doctor. In both services, the number of postoperative grommet review appointments and discharge schedule was at the discretion of the treating clinician (advanced audiologist or ORL doctor).

All results and clinical diagnoses were recorded in the individual electronic medical charts.

**Blinding**

Participating clinicians were not blinded; however, the participating children formed part of the normal clinical load of both services and were not easily identifiable by those providing treatment.

**Data Collection**

Data were extracted from the individual electronic medical charts including: 1) demographics: age, gender, and Aboriginal and/or Torres Strait Islander ethnicity (ATSI status); 2) service information: dates of appointments, surgery, discharge and new referrals; and 3) clinical data: primary and additional clinician(s) seen/consulted, clinical test results, management plan, and surgery type. Clinical incidents and adverse events data were collected from the Queensland state-wide risk monitoring database (Riskman). Study data were collected and managed using REDCap (Research Electronic Data Capture) tools hosted at the University of Queensland (Harris et al., 2009).
Data Analysis

Categorical variables were described by frequency and valid percentages and analyzed inferentially using Chi square testing for differences between the two groups. Continuous variables were analyzed for normality of distribution using Shapiro-Wilks testing at the 5% level. As multiple continuous variables showed significant breaches of normality, differences between the groups on these variables were assessed using nonparametric Mann-Whitney U testing. A binary logistic regression analysis was conducted to find any association between the likelihood of children who were seen by the otolaryngologist requiring surgery, and the independent variables of group allocation (AA or ORL), gender (female or male), age at referral and season at time of referral (not winter or winter). Winter months were defined as June-August (southern hemisphere winter definition). Odds ratios were calculated with their 95% CI for each independent variable. Variables with \( p < 0.05 \) were considered significant. All statistical analysis was performed using the Statistical Package for Social Sciences, version 25.0 (SPSS Inc, an IBM Company, Chicago, Illinois).

Ethics

Ethical clearance was provided by the Metro-South Human Research Ethics Committee within Queensland Health (HREC/13/QPAH/688) and the University of Queensland Human Research Ethics Committee.

RESULTS

Of the 120 children enrolled in the study, 44 were offered initial appointments in the standard medical ORL service and 76 were offered initial appointments in the Advanced Audiology-led service. Two children from the ORL group and 3 from the AA group were subsequently removed from analysis due to diagnosis of permanent sensorineural or mixed hearing loss. Of
the total number of appointments attended through the ORL service (134), 63% were seen by junior doctors and the remainder % by the otolaryngologist or ORL trainee doctors. There were no significant differences between the two groups for gender, ATSI status \( (p=0.646 \text{ and } p=0.919 \text{ respectively}) \); median age \( (p=0.727 \text{ at referral and } p=0.297 \text{ at first appointment}) \); and proportion that were booked for surgery and discharged from the service due to nonattendance or not requiring any treatment \( (p=0.289) \) (Table 1).

**Effect of Advanced Audiology-Led Service on Proportion of Children in ORL Clinic Proceeding to Surgery**

Of the 115 children described above, 30 were discharged due to nonattendance and were removed from further analyses, leaving results from 28 children in the ORL group and 57 in the AA group. Thirty-three of the 57 (58%) AA group children were referred to the ORL clinic to be treated by the otolaryngologist. The proportion of this group who were subsequently booked for surgery (81.8%) was significantly higher \( (p=0.035) \) than the proportion of children seen by the ORL service directly from the waitlist (57.1%), with the children from the AA group being 3.6 times more likely than children in the ORL group to receive surgery (Table 2).

**Independent Management of Nontreated Children by Advanced Audiologists**

Forty-two children (49.4%) were discharged back to primary care providers without any treatment provided in any of the attended appointments. Twenty-four of these children were discharged by the advanced audiologists, 12 by junior doctors, and 6 by the otolaryngologist or ORL trainee doctors. Significantly more of these 42 nontreated children \( (p=0.006) \) were discharged without the assistance of a second medical opinion when seen by the Advanced Audiology-led service (100%) compared with the ORL service (72.2%).
All 42 nontreated children either had audiometry conducted at discharge (n=35) showing bilateral normal hearing (≤ 20dBHL thresholds at 500, 1000, 2000 and 4000Hz) and bilateral type A tympanogram variation (MEP ≤100daPa; peak admittance ≥0.1ml) and/or type C tympanograms (MEP ≥100daPa); or alternatively, audiology was not conducted but otoscopy was reported in the medical records as normal bilateral tympanic membranes (n=6), or bilateral patent and in situ grommets (n=1). None of these 42 children re-entered the service after discharge, up to 3 years later (monitored until the end of data collection, 31 January 2018).

**Postoperative Grommet Review**

Thirty children received grommets: 22 in the AA group and 8 in the ORL group. These children were reviewed postoperatively by the Advanced Audiology-led service (n=13) or the ORL service (n=17) with 2 children in the AA review group and 3 children in the ORL review group not attending any follow up appointments and subsequently being discharged. A further 3 children in the ORL review group were under ongoing ORL review at the end of study data collection period, and 4 children from this group were discharged for nonclinical reasons. In total, 45 grommets were inserted and reviewed with audiometry, on at least one occasion. Audiometry was conducted on all children who attended at least one postoperative grommet follow up. The majority (77%) of the postoperative grommet review appointments in the ORL service were conducted by junior doctors.

The median time from surgery to first postoperative grommet review (51.5 days for the ORL group and 51 days for the AA group) was not significantly different between the two groups (p=0.978), however, children in the AA group had significantly higher rates of discharge at the first review compared with children in the ORL group (91% versus 14%, p<0.001), despite the majority of both groups having normal clinical results (Table 3; 10/14 for the ORL group and 9/11 for the AA group).
Of the 18 children discharged upon completion of treatment by the end of the study data collection (11 in the AA group and 7 in the ORL review group), the advanced audiologists were more likely to discharge children without a second medical opinion (1 second opinion requested; \( p=0.002 \), Fishers exact test) compared with the ORL service (6 second opinions requested; all of whom were discharged by junior doctors). Three children were still under ongoing ORL review and 4 were discharged due to other nonclinical reasons. One child who had completed treatment re-entered the system through a new referral within 6 months of discharge by the Advanced Audiology-led service.

Follow up results at approximately 18 months after grommet insertion were obtained on 9 children in each group, either through specific recall after discharge, or as part of ongoing clinic review. Of the 35 grommets inserted and reviewed at this time period (17 bilateral and 1 unilateral), 31 had extruded (with 2 residual tympanic membrane perforations), 2 were in situ and patent, and 2 were unable to be viewed due to wax obstruction. All children had normal hearing (defined as \( \leq 20 \text{dBHL} \) threshold at all of 500, 1000, 2000 and 4000Hz) in one or both ears, except for two in the ORL review group who had bilateral conductive hearing loss (\( \geq 25 \text{dBHL} \)).

Four (16%) of the 25 children reviewed after initial booked grommet surgery went on to require a second operation booked within the study data collection period (Table 4). The elapsed time from grommet surgery to end of data collection ranged from 224 days to 1092 days with a mean of 826 days (approximately 2 years 3 months).

**Safety**

There were no adverse events or serious clinical incidents recorded for any children in the AA group at least 2 months and up to 3 years after discharge from this service.
DISCUSSION

This is the first study in the field of pediatric ORL service delivery to investigate an audiology expanded scope of practice providing care to children referred to ORL outpatient services with middle ear disease or hearing concerns. The majority of ORL outpatient consultations in this facility were provided by junior doctors under the supervision of more senior ORL consultants and trainee doctors, as is common in many teaching hospital facilities. Compared with the traditional standard medical ORL service, the Advanced Audiology-led service functioned as an effective triaging service with higher rates of independent discharge of nontreated children and appropriate referrals to ORL of children requiring surgery.

Surgical Conversion Rate

The surgical conversion rate can be used to measure the effective use of surgical resources. In ORL practice (as in most surgical specializations) surgeons divide their time between outpatient and inpatient settings. In pediatric ORL, the majority of common procedures are conducted in an inpatient or short-stay surgical theatre under general anesthesia (to ensure child safety) by ORL surgeons, ORL trainee doctors and junior doctors under supervision. It is important for health services to maximize the use of this specialized ORL skillset. The Advanced Audiology-led service described in this study was able to significantly improve the proportion of children seen for surgery by otolaryngologists from 57% to 82%, with children from the AA group being 3.6 times more likely than children in the ORL group to receive surgery. This effect was independent of age, season and gender and the large confidence interval for the odds ratio for participant group was thought to reflect the lower sample size and the large proportion of all children receiving surgery. The predicted flow-on effect is an improved utilization of surgeon time in the outpatient setting. Similar improvements in the
surgical conversion rates have been reported in orthopedic adult outpatient services using advanced physiotherapy-led triage (Napier et al., 2013).

Management of Normal Children

A large proportion (49%) of children referred to the ORL service with middle ear disease or hearing concerns were assessed and discharged back to primary care with no requirement for medical treatment, suggesting that these children were able to be managed conservatively and/or were no longer symptomatic at the point of presentation. The present study demonstrated that advanced audiologists were able to independently discharge normal children without the assistance of a second medical opinion, whereas the junior doctors were more likely to request a second opinion at the discharge appointment. All children who were discharged without treatment had normal audiometry and normal tympanometry and/or otoscopy, and none of these children were re-referred to the service up to 3 years later, suggesting that they were correctly identified as not requiring ORL treatment. The impact of removing normal children in the older age range (over 28 months old) from the ORL outpatient workload by using an advanced audiology triage service would likely increase the capacity of the ORL service to provide more timely medical and surgical treatment for the more complex younger children, as well as the medically complex cases, and subsequently this would improve learning opportunities for the junior doctors under supervision.

Postoperative Grommet Review

A secondary aim of the present study was to compare the services provided by the Advanced Audiology-led service versus the ORL service after grommet insertion, particularly given previous reports of the successful use of audiologists to reduce ORL workload for postoperative grommet review (Davies-Husband et al., 2012). Overall, the Advanced Audiology-led service provided an effective means of reviewing children who receive
grommets and independently managing noncomplex cases appropriately. These conclusions were drawn from several findings.

In the present study’s small cohort of 25 children who were followed up after grommet insertion, much of the workload was noncomplex with normal clinical results. In addition, a large proportion of the ORL service postoperative grommet review workload was managed by junior doctors rather than senior otolaryngologists or ORL trainee doctors. The advanced audiologists were significantly more likely to independently discharge children after grommet insertion with bilateral normal hearing and patent grommets, compared with the junior doctors who mostly sought a second medical opinion. In addition, almost all the children reviewed by the Advanced Audiology-led service were discharged at the first review appointment, compared with only 14% of those reviewed by the ORL service. This was despite the majority of both groups having bilateral normal hearing and grommets in situ and patent at this first review. Before the implementation of the Advanced Audiology-led service at the facility that hosted the present study, all postoperative grommet review appointments were conducted by the ORL service and while the review schedule is at the discretion of the treating doctor, it would have been uncommon for discharge at the first review to occur.

Concerns regarding postoperative complications generally include the risks of granuloma formation, persistent otorrhea, early extrusion, and recurrent OME after extrusion requiring repeat set of grommets. The findings from this study demonstrated 4/45 (9%) grommets were blocked or extruded early at a median follow up time of 51 days. There were no cases of otorrhea at the first review appointment. These concerns were appropriately managed by the Advanced Audiology-led service by inspecting the ears of the children, providing counselling, written information, and instructions to the primary care provider for treatment of otorrhea, and providing an open access service for up to 12 months after discharge.
whereby the child could be scheduled into the next available appointment upon request from the caregiver or any concerned doctor.

Of the children who attended a review at 18 months after surgery, the majority of grommets had extruded, with only 2 out of 35 remaining in situ. Two children who saw ORL and no children who saw an advanced audiologist had bilateral mild conductive hearing loss at this 18 month review. Due to the episodic nature of otitis media throughout childhood, a certain proportion of the population is expected to develop recurrence after grommet extrusion. Of the 25 children reviewed after grommet surgery in this study, there were only 3 cases where a second ear-related surgery was booked within the study period with the period of time from initial surgery to the end of the study ranging up to almost 3 years.

The ability of the Advanced Audiology-led service to effectively review and monitor children who received grommets could reduce the number of normal clinical cases on the otolaryngologists’ workload. This would allow those otolaryngologists to focus on more complex cases requiring their specialized skillset.

Safety

The Advanced Audiology-led service was safe with no clinical incident or adverse events reported for any of its participants. The risk of misdiagnosis or inappropriate discharge was minimal with only 1 repeat referral from a primary care provider (with this child having normal hearing and bilateral in situ and patent grommets at the time of discharge), and no presentations to the Emergency Department for children managed by the advanced audiologists. Providing an Advanced Audiology-led service at the same time and location as ORL outpatient services (with a mutual understanding that ORL expertise is able to be sought as required) helps mitigate the concerns that ORL may have regarding safety. This study demonstrated that nontreated children and children with normal clinical results after grommet insertion were safely discharged without affecting ORL resources as medical opinions were
generally not required. In addition, children suspected of requiring ORL treatment were appropriately referred with only small numbers assessed by the ORL as not requiring surgical treatment. Multiple studies in other health science fields have reported similar findings demonstrating that advanced practitioners are able to discharge patients independently and appropriately (Chang, Gavaghan, O'Leary, McBride, & Raymer, 2017; Samsson & Larsson, 2014; Wood et al., 2016) without adverse events in relation to the advanced scope services (Seabrook, Schwarz, Ward, & Whitfield, 2017).

**Implications**

Audiology testing is an integral part of the assessment process for children referred with middle ear or hearing concerns, with the American Academy of Otolaryngology- Head and Neck Surgery recommending that hearing testing is performed by an audiologist for children who have persistent otitis media with effusion (> 3 months) and for all children at risk of developmental or educational delays (Rosenfeld et al., 2016). A significant proportion of children referred for ORL services may in fact be asymptomatic at the time of assessment due to the transient nature of otitis media and the difficulties diagnosing hearing deficits in the primary care setting, particularly in young children. As best practice involves an audiologist in the assessment of these children, there is the opportunity to improve the utilization of the ORL skillset by extending the scope of audiologists with advanced training to assess and manage children not requiring treatment and children requiring routine post-operative grommet review. This study has shown that audiologists with this type of training are able to work effectively and can independently manage a substantial proportion of ORL outpatient referrals for hearing and middle ear disorders.

In more global terms, the shortages of ear and hearing specialists are most severe in low and lower-middle income countries (WHO report) despite the incidence of middle ear disease
being higher in these regions (Monasta). Task-sharing is now being highlighted as a concept that may be beneficial in counteracting these service gaps (Mahmood, Mulwafa). Although there may be anecdotal reports to support the use of community health providers to improve access to ear and hearing care, the ability of non-specialist health providers to independently assess and manage ear and hearing disorders has not been reported (Mahmood). This study provides the first evidence that specifically addresses this research gap and demonstrates the successful outcomes from using audiologists in a task-sharing role, albeit in a high income population.

This study had a relatively small sample size with restricted participant follow-up which limits the generalizability of its results. Further investigation into the acceptability of the Advanced Audiology-led service to patients and stakeholders should include evaluation of patient satisfaction levels and long-term patient health outcomes.

**Conclusions**

An Advanced Audiology-led pediatric ORL service is a novel service delivery model that has been shown to improve the effectiveness of outpatient pediatric ORL services without compromising patient safety.
Acknowledgements

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Portions of this dataset were presented at the 2018 Audiology Australia meeting in Melbourne, Australia, and at the 2018 meeting of the New Zealand Audiological Society in Auckland, New Zealand.

M.A.P designed the study, collected and analyzed data and wrote the paper. M.A.P was one of the advanced audiologists in this study. W.J.W assisted in the design of the study, analyzed data and provided critical revision. P.R.T assisted in the design of the study and provided critical revision. W.J.W and P.R.T discussed the results and implications and commented on the manuscript at all stages. B.C.S.W. was the senior ORL consultant in this study and provided critical revision.
References


Table 1: Demographics and Outcomes

<table>
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<th>ORL group (n=42)</th>
<th>AA group (n=73)</th>
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<tr>
<td>Median age (years) at referral</td>
<td>5.86/7.06</td>
<td>5.5/5.89</td>
</tr>
<tr>
<td>(p=0.727) first appointment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>offer (p=0.297)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender M:F (%) (p=0.646)</td>
<td>24:18 (57%)</td>
<td>41:32 (56%)</td>
</tr>
<tr>
<td>Identify as ATSI (%) (p=0.919)</td>
<td>5/40* (12.5%)</td>
<td>11/70* (15.7%)</td>
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<tr>
<td>Discharged from service due to</td>
<td>14 (33.3%)</td>
<td>16 (21.9%)</td>
</tr>
<tr>
<td>nonattendance (%) (p=0.289)</td>
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<tr>
<td>Booked for surgery (p=0.289)</td>
<td>16 (38.1%)</td>
<td>27 (37%)</td>
</tr>
<tr>
<td>Discharged from service without</td>
<td>12 (28.6%)</td>
<td>30 (41.1%)</td>
</tr>
<tr>
<td>any treatment (p=0.289)</td>
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* a small number of the sample did not state whether they identify with ATSI status
Table 2: Logistic Regression Analysis for Likelihood of Surgery

<table>
<thead>
<tr>
<th>Included in model</th>
<th>B (SE)</th>
<th>Lower</th>
<th>Odds ratio</th>
<th>Upper</th>
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<tr>
<td>Constant</td>
<td>.39 (.78)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Group (Adv. Aud. Vs ORL)</td>
<td>1.29* (.66)</td>
<td>1.09</td>
<td>3.63</td>
<td>12.04</td>
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<td>Age at referral</td>
<td>-.007 (.11)</td>
<td>.82</td>
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<tr>
<td>Season at referral (not winter vs winter)</td>
<td>-1.412 (.72)</td>
<td>.08</td>
<td>.33</td>
<td>1.34</td>
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<tr>
<td>Gender (F vs M)</td>
<td>.27 (.66)</td>
<td>.34</td>
<td>1.30</td>
<td>4.71</td>
</tr>
</tbody>
</table>

Note: Hosmer & Lemeshow test $\chi^2(8) = 4.47, p = 0.81$; * $p < 0.05$
Table 3: Clinical Decision Making at 1st Postoperative Grommet Review

<table>
<thead>
<tr>
<th>Clinical outcome</th>
<th>ORL group (n=14)</th>
<th>AA group (n=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Discharged</td>
<td>Review</td>
</tr>
<tr>
<td>Normal*</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Bilateral GISAP and residual USMCHL</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Unilateral blocked grommet with USMCHL</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unilateral extruded grommet and USMCHL</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>2 (14.3%)</td>
<td>12</td>
</tr>
</tbody>
</table>

*Defined as normal bilateral hearing thresholds (≤ 20dBHL at 500Hz, 1000Hz, 2000Hz and 4000Hz); and bilateral grommets in situ and patent (GISAP, confirmed by otoscopy) or bilateral normal middle ear function (confirmed by otoscopy and type A tympanograms) if grommets were not inserted.

USMCHL = unilateral slight or mild conductive hearing loss
Table 4: Number of Children Requiring Additional Surgery

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No additional surgery booked</td>
<td>21 (84%)</td>
</tr>
<tr>
<td>Second set of grommets required</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>Removal of grommet(s)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>Myringoplasty</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>Other surgery booked (non-ear-related)</td>
<td>1 (4%)</td>
</tr>
</tbody>
</table>