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**Promoting diagnostic accuracy in the GP management of otitis media in children:  
findings from a multimodal, interactive workshop on tympanometry and  
pneumatic otoscopy**

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Running Title: promoting diagnostic accuracy in otitis media

## **Abstract**

**PURPOSE:** Previous research has shown that General Practitioners (GPs) rarely use pneumatic otoscopy (PO) or tympanometry (TYM) as recommended by best practice guidelines for diagnosing otitis media (OM). The purpose of this study was to determine whether a multimodal, interactive training workshop on the techniques of PO and TYM would improve the confidence of GPs for diagnosis of otitis media with effusion (OME) and acute otitis media (AOM), and for using PO and TYM. Additionally, we sought to determine whether this training could change GPs' intentions for using PO and TYM in their practices. **METHODS:** Twenty-three GPs participated in a three-hour training workshop led by an ENT surgeon, a Paediatrician, and an Audiologist. Prior to and following the workshop, GPs completed questionnaires indicating their previous use and beliefs about the usefulness of PO and TYM, confidence for diagnosing AOM and OME, confidence for using PO and TYM, and intention to use PO and TYM in the future. **RESULTS:** There were no differences ( $p > 0.05$ ) from pre- to post-workshop in GP confidence for diagnosing AOM. There were increases in GP confidence for diagnosis of OME (pre:  $4.5 \pm 0.9$ , post:  $4.9 \pm 0.4$ ,  $p < 0.01$ ) and confidence for using PO (pre:  $3.6 \pm 1.6$ , post:  $4.8 \pm 1.0$ ,  $p < 0.01$ ) and TYM (pre:  $3.3 \pm 1.5$ , post:  $5.0 \pm 0.7$ ,  $p < 0.01$ ), but no change ( $p > 0.05$ ) in intention to use PO or TYM in their practices in the future.

**CONCLUSION:** These results suggest that a multimodal, interactive workshop can significantly increase the confidence of GPs for diagnosis of OME and also for using PO and TYM. It is likely, however, that GPs will need follow-up and further practice with these techniques to implement them in their practices.

**Keywords:** otitis media, continuing medical education, General practice, evidence based medicine, clinical competence

## **Introduction**

Otitis media (OM) is a major cause of morbidity in children and is one of the most common reasons for antibiotic prescriptions within the primary care context.<sup>1</sup> OM can be defined as middle ear inflammation with effusion present and includes disorders ranging on a continuum from a single bout of acute otitis media (AOM) to otitis media with effusion (OME).<sup>2</sup> A diagnosis of AOM would require signs and symptoms of middle ear inflammation (fever, otalgia, otorrhoea, or irritability) and rapid-onset middle ear effusion.<sup>3</sup> At the other end of the continuum, OME is also middle ear effusion but with the absence of symptoms of acute infection.<sup>4</sup> Despite OM being a common reason for General Practice (GP) consultations,<sup>2,5</sup> the difficulty of otoscopic examination in young children, and the variable appearance of the tympanic membrane in OM contribute to the GP's diagnostic dilemma. GP management of OM often falls outside best practice guidelines, and may be impacted by diagnostic inaccuracy.<sup>2,6</sup>

An accurate diagnosis of OM requires detection of middle ear effusion, which best practice guidelines state can only be reliably confirmed through utilization of tympanometry (TYM) or pneumatic otoscopy (PO).<sup>7</sup> There is evidence that GPs tend to over diagnose AOM and under diagnose OME.<sup>7-12</sup> GPs and paediatricians underutilise PO and TYM in the clinical assessment of children's ears and this has an inevitable negative impact on their diagnostic accuracy.<sup>7,13-16</sup>

Australia's leading otitis media researchers have recently recommended that research aiming to improve diagnostic accuracy is needed in order to ensure appropriate treatment of otitis media.<sup>17</sup> There is a clear need for GP training in the diagnosis and management of OM given the prevalence of AOM and OME in the general practice

setting,<sup>5</sup> the diagnostic difficulties impacting on management and the demonstrated underutilization of well evidenced diagnostic tools.<sup>7,13-16</sup> Despite these clear training needs, the literature around the breadth, depth, and scope of training requirements for GPs in the use of these techniques is inconclusive.<sup>12</sup> Diagnosis by ENT surgeons using PO or otoscopy and TYM has been considered a gold standard in the diagnosis of middle ear effusion.<sup>8,12,18</sup> Compared to myringotomy, PO seems to be an acceptable technique for office diagnosis, but extensive training<sup>12,19</sup> or extended practice<sup>20</sup> may be required for proficiency to be achieved. In a study by Kaleida and Stool<sup>21</sup> a three-month otoscopic validation program for junior doctors was examined. The authors concluded that a reasonable standard of accuracy with PO was achieved, but the program required an impractical amount of time.<sup>21</sup>

A study examining GP use of TYM, showed that a three-hour training session was adequate for detection of OME when GPs' interpretations were compared to three doctors who were experienced at TYM.<sup>22</sup> The same study included a one-year follow-up period with extended use of TYM, that revealed that prolonged experience in interpretation of TYM did not further improve the quality of the interpretation.<sup>22</sup>

Use of PO or TYM increases the accuracy of diagnosis of OM markedly over non-pneumatic otoscopy.<sup>12</sup> However, it is unclear which technique is more effective and acceptable in general practice and the extent of the training requirements.<sup>12</sup>

Tympanometry has advantages over PO as it generally requires less training and can be externally validated by subsequent review of tympanometry results.<sup>23,24</sup> Pneumatic otoscopy is much less expensive and in well trained hands has been shown to have good validity.<sup>19,21,25</sup>

One possible reason for the observed reluctance of GPs to use these gold standard diagnostic techniques may be lack of training, and therefore confidence in their ability to use them. Although this has not previously been investigated in an Australian context, the main reason cited by family practice residents in a study undertaken in the United States for not using PO and TYM was lack of training.<sup>26</sup> As adult learners and practitioners, doctors learn best through interactive workshops delivered through multiple modes of instruction with multiple opportunities to practice.<sup>27,28</sup> Multimodal training, using a mix of interactive and didactic teaching, has been shown in systematic reviews to provide the best evidence for behaviour change and learning in postgraduate continuing education.<sup>27,28</sup> It remains unclear, however, how much and what sort of training is required by GPs and other clinicians.<sup>12</sup> Providing training in PO and TYM in an abridged form to GPs may be acceptable to increase the use of these techniques in General Practice.

The aim of the current study was to evaluate the effectiveness of a 3- hour multimodal interactive training workshop on the techniques of PO and TYM in improving the GPs confidence, in ability for diagnosis of OME and AOM through the use of PO and TYM. Additionally, we sought to determine whether or not the workshop altered participants' intention to use PO and TYM in their practices in the future.

## **Methods**

### **Participants**

Twenty-three GPs participated in a 3- hour multimodal, interactive training workshop led by an ENT surgeon, a paediatrician with a special interest in ear disease, and a paediatric audiologist. GPs were recruited through newsletters sent via a local Division

of General Practice. GPs attending the workshop were included in analysis if they provided written informed consent, were currently practicing.

## **Study Design**

### ***Multimodal, Interactive Workshop Format***

The workshop included: pre-reading and access to an online training resource (ePROM),<sup>29</sup> a didactic presentation on otitis media, expert presentations and demonstrations of use of TYM and PO, hands on experience in PO and TYM and guided video examples. For those who enrolled in the subsequent study to investigate the usefulness of TYM and PO in general practice, practice with equipment in the clinical setting as well as support and visits by a GP expert in TYM and PO were offered.

Immediately before and after the training workshop, GPs completed questionnaires indicating their previous use of PO and TYM, beliefs about the usefulness of PO and TYM, confidence for diagnosing AOM and OME, and intention to use PO and TYM. Following the workshop participants were invited to join a follow-up study where they were provided with the relevant equipment for use in their practices, supported by practice visits from an experienced GP educator skilled in the use of the equipment. All research components were reviewed and approved by the University of Western Sydney Human Research Ethics Committee.

### ***Pre-Workshop Supporting Materials Provided***

Prior to the workshop, participants were given pre-reading as well as access to a series of online training videos that were available as part of a Paediatrics medical education website (ePROM resource)<sup>29</sup> demonstrating diagnosis of otitis media. These resources were an adjunct to hands-on experience provided in the workshop and were used to

assist GPs in increasing their knowledge about otitis media as well as confidence for diagnosing AOM and OME using either PO or TYM. The online training videos were also made available to participants during the course of the workshop. The format of the multimodal, interactive workshop is presented in figure 1.

### ***Otitis Media Overview***

An information session was provided by a paediatrician to the entire group of GPs. Information included the epidemiology of OM in children, diagnosis of OM, and a description of best practice guidelines and evidence based treatment of OM. Following the large group session, the GPs were divided into two groups with one group attending a skills session on PO and the other group attending a skills session on TYM. Each group received both sessions (PO and TYM) prior to returning to the large group.

### ***Pneumatic Otoscopy Skills Session***

The hands-on skills session for PO, led by an ENT surgeon, began with a brief presentation about PO including guided videos of normal and abnormal otoscopy. The presentation was followed by demonstration of the technique on participant volunteers. Finally, participants practiced on each other with the ENT surgeon giving feedback and answering queries.

### ***Tympanometry Skills Session***

The hands-on skills session for TYM was led by a paediatric audiologist who provided participants with an overview and practical information on operating the tympanometer and interpreting the findings. Following demonstrations given by the paediatric audiologist, participants practiced using the technique on fellow participants with the Audiologist providing feedback on technique and answering queries.



### ***Materials***

A questionnaire comprised of Likert-type items was developed for the current study and consisted of four main constructs. These constructs included: previous use of PO and TYM (baseline only; never to always) for example “I have previously used pneumatic otoscopy in my practice”; beliefs that PO and TYM are valuable diagnostic tools (disagree to agree) for example “I believe tympanometry is a valuable diagnostic tool”; confidence for diagnosing AOM and OME (disagree to agree) for example “I am confident I can diagnose acute otitis media” and confidence for using PO and TYM (disagree to agree) for example “I am confident I could successfully use pneumatic otoscopy in my practice; and intention to use PO and TYM in their practices in the future (never to with every consultation requiring standard otoscopy) for example “I plan to use tympanometry in addition to standard otoscopy in my practice in the future.

### ***Subsequent Study Enrolment and Ongoing Support***

To reinforce learning from the workshop, participants were encouraged to continue to view the online video resource (ePROM)<sup>29</sup> provided prior to the workshop. At the conclusion of the workshop, participating GPs were asked if they would like to participate in a subsequent study which included use of these two diagnostic techniques in their practice. Study participants were able to elect to have a two-week lead-in practice time with the study equipment in order to gain confidence with using the techniques prior to the commencement of the study. GPs who volunteered for the follow up study were offered the relevant equipment and one to two follow-up visit by a GP trained in PO and TYM to reinforce key messages from the workshop and assist the GPs with the diagnostic techniques in the clinical environment.

### ***Statistics***

SPSS (version 18.0; SPSS Inc., Chicago, Ill.) was used for all analyses. Data are expressed as mean  $\pm$  SD and significance was set at  $p < 0.05$  for all analyses. Parametric assumptions were not markedly violated for any variables used in analyses. Item frequencies were ascertained for questionnaire responses. Associations were determined using Pearson's correlations. Paired t-tests were used to determine pre to post-workshop differences in all questionnaire items.

### **Results**

#### ***Pre-Workshop Use of TYM and PO***

Frequencies of use of TYM and PO are presented in Table 1. At pre-workshop, 19 out of 23 GPs (83%) indicated that they never used PO and 16 out of 23 GPs (70%) indicated that they never used TYM in their practices.

#### ***Pre-Workshop Beliefs about the Usefulness of TYM and PO***

Frequencies of beliefs about the usefulness of TYM and PO in Table 2. Pre-workshop, sixteen out of 21 GPs (74%) indicated that they agreed or strongly agreed that PO was a valuable diagnostic tool and 19 out of 22 GPs (83%) agreed or strongly agreed that TYM was a valuable diagnostic tool.

#### ***Confidence Pre- and Post-Workshop***

Questionnaire responses at pre- and post-workshop are presented in Table 3. Pre-workshop, the average GP confidence for using TYM was 3.3 ( $\pm 1.5$ ) with six out of 22 GPs (27%) indicating agree or strongly agree with being confident they could use TYM in their practice. For PO, the average GP confidence was 3.6 ( $\pm 1.6$ ) with nine out of 21 GPs (43%) indicating agree or strongly agree for being confident they could use PO in their practice. The average GP confidence for accurately diagnosing OME was 4.5 ( $\pm$

0.9) with 12 out of 22 GPs (55%) indicating agree or strongly agree with being confident they could diagnose OME. The average GP confidence for accurately diagnosing AOM was 4.9 ( $\pm 0.4$ ) with 19 out of 22 GPs (86%) indicating agree or strongly agree with being confident they could diagnose AOM.

#### ***Pre- and Post-Workshop Relationships***

Pre-workshop, previous use of TYM was associated negatively with confidence for diagnosing OME ( $r = -0.45, p < 0.05$ ) indicating that those who had used TYM more frequently, were less confident they could diagnose OME. Confidence for diagnosing OME was positively associated with planning to use TYM in the future ( $r = 0.69, p < 0.01$ ). Confidence for diagnosing AOM was significantly greater than confidence for diagnosing OME ( $t(21) = -2.89, p < 0.01$ ; AOM:  $4.91 \pm 0.43$ ; OME:  $4.45 \pm 0.86, p < 0.01$ ).

At post-test, confidence for using TYM was positively associated with confidence for diagnosing OME ( $r = 0.52, p < 0.05$ ) and also for diagnosing AOM ( $r = 0.43, p < 0.05$ ). Intentions to use PO in the future were also positively associated with confidence for using PO at post-test ( $r = 0.63, p < 0.01$ ), but intentions for using TYM were not associated with confidence for using TYM ( $p > 0.05$ ). Confidence for diagnosing AOM remained greater than confidence for diagnosing OME ( $t(22) = -2.47, p < 0.05$ ; AOM:  $5.13 \pm 0.63$ ; OME:  $4.91 \pm 0.73, p < 0.05$ ).

#### ***Pre- to Post-Workshop Differences***

Post-workshop, responses were not significantly different from pre-workshop for most questions, however, confidence for using TYM ( $t(21) = -5.53, p < 0.001$ ; pre:  $3.3 \pm 1.5$ ; post:  $5.0 \pm 0.7, p < 0.001$ ) and PO ( $t(20) = -3.40, p < 0.01$ ; pre:  $3.6 \pm 1.6$ ; post:  $4.8 \pm 1.0$ ,

$p < 0.01$ ) and confidence for diagnosing OME ( $t(21) = -2.89$ ,  $p < 0.01$ ; pre:  $4.5 \pm 0.9$ ; post:  $4.9 \pm 0.4$ ,  $p < 0.01$ ) were significantly higher than pre-workshop.

## **Discussion**

The results of the current study indicate that following a 3-hour multimodal, interactive training workshop led by an ENT surgeon, paediatric audiologist, and paediatrician; GPs' confidence for using PO and TYM as well as confidence for diagnosing OME was significantly higher than pre-workshop levels. Although confidence for use of these diagnostic techniques improved, there was no increase in GPs intention to use these techniques in their practices in the future.

In support of previous research, prior to the workshop, our data indicated that although GPs view PO and TYM as valuable diagnostic tools, they do not use them in their practices.<sup>7,13-16</sup> Though guidelines indicate that either TYM or PO is necessary for an accurate diagnosis of OME or AOM, most GPs were fairly confident they could accurately diagnose OME or AOM, despite not using these techniques. This confidence for appropriate diagnosis without use of these techniques could at least partially explain the disconnect between confidence in using the techniques and GPs use of them in their practices. Given that increases in confidence to use TYM and PO were seen, but intentions to use these techniques were not, it appears that there are other factors involved in uptake of use of these techniques. The GP context is complex and multifactorial and not every consultation requiring standard otoscopy can be viewed in the same way. While not comprehensive by any means, some potential barriers to translating confidence in use of these techniques to intention to use them or actual use in practice would include things like length of the consultation, patient acceptability, cost

of equipment, and access to equipment. The complexity of the GP consultation and the barriers to implementation are reflected by the fact that none of the GPs indicated at post-workshop that they would use these techniques with every consultation requiring standard otoscopy. Prior to the workshop, previous use of TYM was negatively associated with confidence for diagnosing OME, suggesting that previous use of TYM may have elucidated the diagnostic difficulties of OM. At post-workshop, confidence for using TYM was associated positively with both confidence for diagnosing OME and also AOM, potentially explaining the aforementioned relationship between previous use of TYM and confidence for diagnosing OME.

Despite the questionnaire responses indicating that confidence for using TYM and PO increased following the workshop, the effectiveness of this training alone is likely to be limited without further opportunities to practice these techniques. This proposition is supported by observations of recruitment of workshop participants into a subsequent study which used TYM and PO in GPs practices (unpublished data). GP participants in this subsequent study were provided with ongoing support from a GP expert in TYM and PO, including one or two practice visits and phone support. Additionally, several of the participants required a trial period with the equipment in their practice prior to the beginning of data collection. In this group of GPs, for implementation of these diagnostic techniques to occur in practice, even just in the context of a research study, further training and practice for both diagnostic techniques was required. A 3-hour workshop such as the one used in this study appears to be a good starting point for improving confidence in the use of TYM and PO, but further research needs to examine how best to provide ongoing support and training to best increase uptake of these techniques.

### ***Limitations***

Participant numbers were small, as was necessary for the hands on nature of the training workshop. Despite these small numbers, we were able to detect differences in confidence for using PO and TYM as well as confidence for diagnosing OME from pre- to post-workshop. Due to time limitations it was not possible to include an assessment of clinical skills in use of PO and TYM. While these outcomes were not the primary aims of the workshop, it would have been useful to determine whether or not confidence and intention for use of these techniques reflected the GPs skill in using them.

GPs indicated an improvement in their confidence for using PO and TYM from pre- to post-workshop, however there was no change in their plans to use these techniques in the future. Because of the nature of the workshop, we were not able to further explore the barriers to use of PO or TYM. A qualitative study examining these barriers should be undertaken to elucidate the numerous potential reasons for the disconnect between confidence and intentions for future use. There were no differences between GPs who enrolled in the subsequent study and those who did not for any of the factors (data not shown), indicating that confidence for use of TYM and PO were not barriers for those who did not enrol in the study as compared to those who did enrol.

### ***Public Health Implications***

There is a clear public health impact related to up skilling GPs in the use of these diagnostic techniques. Despite best practice guidelines indicating that PO and TYM are necessary for an accurate diagnosis of effusion, previous research has clearly shown that GPs do not typically use TYM or PO,<sup>7,13-16</sup> and there is potential for improvement in diagnosis of AOM or OME with the addition of these techniques.<sup>6</sup> While the multimodal, interactive workshop described in the current paper appears to have had an

impact on participant confidence in use of PO and TYM, as well as diagnosis of OME, , further opportunities to reinforce learning appear to be required to effect the intention to change practice.

### ***Conclusions***

These findings provide information regarding the importance of training for GPs in the techniques of PO and TYM. Brief training workshops in these diagnostic techniques can significantly improve confidence for use of the techniques and for diagnosing OME. General practitioners are likely to require further information and more extensive training to increase intention for future use as well as to change actual practice. Future studies should examine the barriers to use of TYM and PO as well as the appropriate level of ongoing support necessary for successful translation of training in these techniques to successful use in practice.

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***Competing interests*** None.

### ***Ethics approval***

Ethics approval was provided by the University of Western Sydney Human Research Ethics Committee.

**How this fits with quality in primary care:**

Otitis media (OM) is a common condition managed in general practice, yet accurate clinical diagnosis can be challenging, potentially impacting management decisions. Current evidence indicates pneumatic otoscopy (PO) and tympanometry (TYM) are necessary for the reliable diagnosis of OM yet are underutilised in the primary care setting. One of the reasons GPs do not use PO and TYM may be a lack of training. There is little evidence regarding training adequacy for either diagnostic tool. This paper reports on a multimodal, interactive workshop developed to provide GP training in the diagnosis of OM in children and the use of PO and TYM as diagnostic aids.

**What do we know?**

The diagnostic techniques of PO and TYM are underutilised in a primary care setting. There is insufficient evidence regarding training requirements for increasing the confidence and intention for using either of these techniques in practice.

**What does this paper add?**

The primary finding reported in this paper is that a multimodal, interactive workshop significantly increased the confidence of GPs for using PO and TYM as well as for diagnosing OME, but did not increase their intention to use these techniques in the future. Based on observations from the current study as well as recruitment of workshop participants to a subsequent study, GPs are likely to need extra support to uptake TYM and PO as diagnostic aids in practice. A secondary finding of this paper is that despite participating GPs believing PO and TYM were important in the diagnosis of OM, they did not use these diagnostic techniques in their practices, yet most GPs still felt confident they could reliably diagnose OME and AOM.

**Figure Legend**

*Multimodal, Interactive Training Workshop Outline.* The outline of the multimodal, interactive workshop is shown in Fig. 1. The figure includes all components of the multimodal, interactive training which took place during the three-hour workshop. Elements which took place prior to or following the workshop, are not included here.



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