Screening programmes for the detection of otitis media with effusion and conductive hearing loss in pre-school and new entrant school children

A critical appraisal of the literature
ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

- Otitis media with effusion (OME) is common in preschool and new entrant school children, particularly in Maori and Pacific Island children.
- OME is frequently associated with conductive hearing loss.
- OME is of concern because it is thought to cause developmental problems (disability).
- OME is thought to cause disability in children largely through the associated hearing loss.
- New Zealand has various health promotion strategies in place for OME including a national screening programme of 3 and 5 year old children.
- There has been concern both internationally and within New Zealand over the effectiveness of these screening programmes.
- Using a systematic methodology, this review examined the evidence for screening programmes for OME and conductive hearing loss using Wilson and Jungner’s screening criteria.
- It was found that: OME is common, but the majority of episodes resolve spontaneously, with only a few going on to be persistent.
- Risk factors for OME include male gender, low socioeconomic status, exposure to tobacco smoke, bottle-feeding and attendance at day-care centres.
- It is not possible from the current research to either support or refute the case that OME and conductive hearing loss causes disability in children.
- Treatments such as long-course antibiotic and prophylactic antibiotic therapy may improve the rate of resolution of OME in the short-term only (< 30 days).
- Grommets and adenoidectomy all offer modest improvement in hearing, with 12 dB HL at 6 months and 6 dB HL at 12 months.
- However, it is not possible to determine whether these treatments alter disability related outcomes, as these have been inadequately documented in the research.
- Suitable screening tests are available for OME (tympanometry) and conductive hearing loss (audiometry). However, hearing testing of children under 4 years of age is more difficult.
- Screening programmes for OME and conductive hearing loss may vary greatly in the way they are constructed (algorithm) and consequently vary in their sensitivity, specificity, PPV and NPV. This makes it difficult to compare different screening programmes.
- There are only a few studies that have examined screening programmes for OME and conductive hearing loss and unfortunately, these studies were generally deficient in their design. They did not demonstrate screening programmes to be an effective strategy for OME and conductive hearing loss.
- Unfortunately, it is therefore not possible to conclude from the literature reviewed in this report, if screening programmes for OME and conductive hearing loss in preschool and school entrant children are an effective health strategy.
More specifically, conclusions cannot be drawn on specific aspects of the current screening programme for OME and conductive hearing loss. Currently no recommendation can be made on high risk targeted screening, changing the age of screening (either younger or older) and changing the screening interval.

Similarly, it must also be noted that it cannot be concluded that current screening programmes for OME and conductive hearing loss in New Zealand are ineffective.

To determine whether screening programmes for OME and conductive hearing loss in preschool and new entrant school children are an effective health strategy, more research is needed. Although research is difficult in this area, a thorough critical evaluation of New Zealand's own screening programme and its outcomes would be help in part to determine the best choice for effective health strategies for OME and conductive hearing loss.
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GLOSSARY

**Adenoids.** Lymphoid tissue in the nasopharynx of children

**Acute otitis media.** Inflammation of the middle ear characterised by rapid onset and associated with pain and fever

**Adenoidectomy.** Surgical removal of the adenoids

**Adenotonsillectomy.** Surgical removal of the adenoids and tonsils

**Cleft palate.** A congenital fissure in the palate of the upper mouth

**Cohort study.** See Appendix 6

**Conductive hearing impairment/loss.** Hearing impairment due to conditions that reduce the transmission of sound into the middle ear. Most typically it is caused by fluid in the middle ear from acute otitis media or otitis media with effusion. It is usually transient and less severe than sensorineural hearing loss.

**Cross-sectional study.** See Appendix 6

**Grommet.** A plastic tube which is inserted into the ear drum to allow ventilation between the middle and the outer ear

**Impedance audiometry.** See tympanometry

**Markov modelling.** A type of mathematical modelling technique that involves a number of states (eg, no OME, unilateral OME and bilateral OME) and estimates the probability of changing from one state to another.

**Middle ear effusion.** Fluid in the middle ear

**Myringotomy.** A surgical procedure where a hole is formed in the ear drum

**Negative predictive value (NPV).** The probability that a person having a negative result on a test does not have the condition it is designed to detect

**Numbers Needed to Screen (NNS).** The number of individuals that need to be screened to detect an individual with a particular condition

**Numbers Needed to Treat (NNT).** The number of individuals that need to be treated to improve the outcome of one individual with a particular condition

**Otitis media.** Otitis media is the most general term given to inflammation of the middle ear. It includes both acute otitis media and otitis media with effusion.

**Otitis media with effusion – OME (glue ear).** Fluid (effusion) in the middle-ear, which is characteristically not accompanied by the symptoms, associated with acute otitis media such as pain and fever. Also known as “serous otitis media” , “secretory otitis media” and “glue ear”

**Otoacoustic emissions.** Otoacoustic emissions (OAEs) are low-level sounds produced by the normal cochlear.

**Oto-admittance audiometry.** See tympanometry

**Otoscope.** An lighted instrument for inspecting the ear

**Otoscopy.** Examination of the ear by an otoscope

**Positive predictive value (PPV).** The probability that a person having a positive result on a test has the condition it is designed to detect

**Pure tone audiometry.** This is a hearing test administered by a trained tester using a calibrated instrument to produce tones of variable intensity that measures the subject’s response and hence hearing level. It requires a quiet environment to produce an accurate result.
Randomised controlled trial (RCT). See Appendix 6

Screening. Screening is a test or examination that can be applied rapidly, that is intended to identify unrecognised disease. It can either be part of formal screening programme or be on a opportunistic basis

Sensitivity. Sensitivity is a measure of the probability of correctly identifying a case of a particular disease with a screening test

Sensorineural hearing loss/ impairment. Hearing impairment that is the result of damage to the inner ear (with its sensitive receptor –0 the cochlea) or the auditory nerve (that links the ear with the brain). The more common causes of sensorineural hearing loss include congenital rubella syndrome, meningitis, birth asphyxia, hyperbilirubinaemia, congenital infection and hereditary deafness. It is usually permanent and more severe than conductive hearing loss.

Serous otitis media. See otitis media with effusion

Specificity. Specificity is a measure of the probability of correctly identifying a non-diseased person with a screening test

Tonsils. A small rounded mass of lymphoid tissue in the pharynx

Transiently evoked otoacoustic emissions (TEOAE). These are otoacoustic emissions produced by the inner ear after special equipment has produced acoustic clicks or tone bursts. TEOAEs are being increasingly used for testing the cochlear function of neonates.

Tympanometry (oto-admittance audiometry/impedance audiometry). Tympanometry is a technique for assessing middle ear function and the presence of middle ear fluid. It uses sound waves to assess the compliance of the ear drum. It is not a hearing test. Otoscopy is observation of the eardrum using an otoscope. In OME the tympanic membrane appears dull and retracted and fluid levels or bubbles may be visible. The use of pneumatic otoscopy can assess the mobility of the drum and hence assess whether fluid is present in the middle ear. Tympanometry measures the ability of the eardrum to react to sound energy and hence is an indirect measure of the presence of fluid in the middle ear. It is not a measure of hearing impairment.

Tympanosclerosis. A condition characterised by the presence of scar tissue around the auditory ossicles in the tympanic cavity

Ventilation tubes (VT). See grommet
Background

Otitis media with effusion (OME) is the commonest cause of hearing impairment in young children and is thought to have long-term adverse consequences on children’s development through associated hearing impairment (Chalmers et al 1989, Department of Health and National Audiology Centre 1992, Ministry of Health 1997).

It has been widely recognised as an important health issue for New Zealand children, particularly in Maori and Pacific Island children (Department of Health 1991, Public Health Commission 1994, Public Health Commission 1995, North Health 1995, Solomon 1995, Priest 1996, Bullen 1997, Review Team to Consider Hearing Impairment Among Maori People 1989). As a response to this, Health Outcome Targets have been set aiming “to reduce hearing loss in children at school entry to 8% or less for Maori, Pacific Island and other children by 1995 and to 5% or less by the year 2000” (Ministry of Health 1997).

DEFINITION OF OME AND CONDUCTIVE HEARING LOSS

The definition and classification of otitis media with effusion (OME) is controversial. Many terms have been used to refer to OME including “serous otitis media”, “secretory otitis media”, “non-suppurative otitis media” and as it is commonly known “glue ear”.

For the purposes of this review the definitions adopted by the “Dunedin Multidisciplinary Health and Development Study” are used (Chalmers et al 1989). They define otitis media with effusion as “middle-ear effusion as evidenced by otomicroscopic and tympanic findings and without the symptoms and signs of acute otitis media”. They distinguish this from acute otitis media, which they define as “an acutely symptomatic problem, presenting with pain and/or discharge from the ear.” However, it is widely recognised that these two conditions are part of a spectrum rather than discrete entities (Chalmers et al 1989).

OME can be associated with hearing impairment. This type of hearing impairment is referred to as conductive hearing impairment or loss and is caused by an interruption of sound vibrations to the inner ear by the effusion in the middle ear. The hearing impairment may range from 0-50 dB of HL with an average of 20 dB HL in OME (Paradise 1981, Bluestone et al 1973, Brooks 1979, Silva et al 1982). To give an appreciation of what this might mean practically, a hearing loss of 30 dB HL can mean that a normal conversation sounds like a soft whisper (Freemantle et al 1992).

Conductive hearing impairment may also be caused by a ruptured ear drum or a wax occluded ear canal, but the most common cause in preschool and school age children is OME (O’Mara et al 1992, Augustsson et al 1990).

DIAGNOSIS OF OME AND CONDUCTIVE HEARING IMPAIRMENT

The diagnosis of OME and conductive hearing impairment may be made in a number of ways, most commonly by otoscopy, tympanometry and audiometry. Definitive diagnosis of OME is by myringotomy and aspiration of the fluid from the middle ear (Maw and Tiwar 1988).

Otoscopy

Otoscopy is the observation of the eardrum using an otoscope. The eardrum characteristically appears dull and retracted in cases of OME. The pneumatic otoscope can assess the mobility of the eardrum, which is reduced in OME.

Otoscopy is not a test of hearing impairment.

Tympanometry

Tympanometry (impedance audiometry) measures the compliance of the eardrum by sending sound waves down the ear canal and recording its reflection. The recordings of this reflected sound can indicate the presence of fluid in the middle ear. A type B tympanogram is most predictive of OME. Typical readings are presented in Appendix 1.

Tympanometry is not a test of hearing impairment.

Audiometry

Audiometry is a hearing test that measures the level of hearing (measured in decibels, dB) in each ear individually using a calibrated instrument to produce tones of variable intensity (usually 500,
1000, 2000 and 4000 kHz). It requires a quiet environment to produce an accurate result and relies on a high level of cooperation from the child being tested.

Hearing impairment detected by audiometry in preschool children is most commonly a conductive hearing loss and most commonly caused by OME. However, sensorineural hearing impairment (inner ear or auditory nerve damage) can also be detected, although this is much less common (O'Mara et al 1992, Augustsson et al 1990).

TREATMENT OF OME

The most common first line treatment for children with OME is long-course antibiotic therapy, while the most common second line therapy is the surgical intervention of grommet insertion (Appendix 2). There are various other interventions that can also be used to treat OME and these include adenoidectomy, tonsillectomy, decongestants, steroids, nose blowing and autoinflation. The underlying rationale for all these interventions for OME is to promote the resolution of the effusion in the middle ear.

STRATEGIES FOR CHILD HEARING LOSS AND OME IN NEW ZEALAND

The Ministry of Health’s “Progress on Health Outcome Targets” (Ministry of Health 1997) outlines strategies to reduce child hearing loss. In this document these have been divided into primary prevention, health promotion and screening.

Primary prevention

Primary prevention measures to reduce the occurrence of OME in New Zealand include the promotion of breastfeeding and avoidance of tobacco smoke (Ministry of Health 1996, Ministry of Health 1997).

Health promotion

Health promotion measures in New Zealand include community awareness programmes and health education resources to help identify children with hearing loss. An example of this is the publication distributed to parents “Can your child hear?” (Anonymous 1992, Appendix 3).

Screening

Screening programmes for child hearing loss and OME are seen as an important health strategy in New Zealand (Department of Health and National Audiology Centre 1992, Ministry of Health 1997).

A screening programme for childhood hearing loss that tests new entrant school children with pure tone audiometry has been established for many years (Pellow 1998, personal communication). In the 1980’s this screening programme was extended to include the screening of 3 year old and new entrant children with tympanometry. This was first introduced as a pilot in Canterbury and Otago in the early 1980’s and was subsequently introduced nationally. By 1991, all parts of the country had included tympanometry into the screening programme (National Audiology Centre 1997). The recommended screening protocol has been set out in “Hearing in infants and children. Manual for primary health care professionals” (Department of Health and National Audiology Centre 1992, Appendix 4).

Additional opportunities for screening by general practitioners are described in the Ministry of Health’s publication “Well child Schedules” (Ministry of Health 1996, Appendix 5). It appears that opportunistic screening for OME has also been occurring with increasing frequency in the general practice setting (Greville 1995).

However, in the 1997 Ministry of Health publication Progress on Health Outcomes Targets, concern was expressed “...as to whether current screening detects cases of chronic glue ear early enough, and whether treatment is effective enough to prevent the emotional, social and educational consequences of hearing loss that occur in some children”. This is a concern that has also been expressed internationally by groups such as Canada’s “Canadian Task Force on the Periodic Health Examination” (1994), the USA’s Centre for Disease Control (Anonymous 1998) and a review group in the UK (Haggard and Hughes 1991). It is this concern that is central to this report.
Review scope

OBJECTIVE

The objective of this report was to undertake a review of research on the effectiveness of preschool and school entrant screening programmes for otitis media with effusion and conductive hearing loss.

EVALUATION CRITERIA

Criteria for assessing the validity of screening programmes have been described by a number of authors (Cuckle and Wald 1984, Gray 1997). However, Wilson and Jungner's 1968 criteria remain the benchmark for evaluation. These have been summarised by Snowdon and Stewart-Brown (1997) and were used as the basis of this report.

The condition
- The condition should be common and disabling
- The natural history of the condition should be known
- There is a recognisable latent or pre-symptomatic phase of the condition

The screening test
- There should be a reliable, valid and repeatable screening test
- The screening test should be acceptable, safe and easy to perform
- The screening test should have a high positive predictive value
- The screening test should be sensitive and specific
- The cost of the screening programme should be commensurate with the benefits of early detection

Treatment
- There should be effective and available treatment
- The service provision should be adequate to treat the children identified by the screening programme
- There should be an agreed policy on who will be treated

It is argued that a screening program’s failure to fulfil any one of these criteria calls into question its validity.

RESEARCH QUESTIONS

On the basis of these criteria, research questions for this report were formulated:

Prevalence
What is the prevalence of the OME and associated conductive hearing loss between the ages of 0 and 5 years?

Natural history
What is the natural history of OME and associated conductive hearing loss?

Disability
What are the consequences of OME and associated conductive hearing loss in terms of disability at that time or later?

Treatment
What is the effect of treatment on OME and associated conductive hearing loss on disability?

Screening
Is there a suitable screening test for OME and the associated hearing loss?

What is the evidence of effectiveness of screening programmes for OME and associated hearing loss?
Methodology

A systematic method of literature search, grading and appraising of the literature was employed in the preparation of the report.

SEARCH STRATEGY

The literature search was divided into the following sections: natural history, incidence, disability, treatment outcome and screening programmes.

The search strategies used for MEDLINE, and CINAHL are given in the Appendix 6. The MEDLINE strategies were also used to search HealthSTAR but limited to non-MEDLINE references. Current Contents was also searched using the keywords “otitis media” AND “effusion” or “serous” or “secretory” or “chronic” or “recurrent”.

The search was limited to preschool child (2-5 years) and child (6-12 years). Searches were limited to studies in English on human subjects.

The search for material on screening programmes was run as far back as possible on MEDLINE (back to 1966) HealthSTAR (back to 1975) and CINAHL (back to 1982). Other sections of the search were run from 1987 onwards. The search on all databases was undertaken until January 1998 and on Current Contents until March 1998.

SOURCES SEARCHED

The sources searched included:

- Medline
- HealthSTAR
- CINAHL
- Current Contents (combined files)
- Cochrane Library
- Database of Abstracts of Reviews of Effectiveness (DARE)
- NHS Economic Evaluation Database
- New Zealand Bibliographic Network
- New Zealand Ministry of Health publications
- United States National Institute of Health publications
- Catalogues of New Zealand medical libraries
- Publications and current projects by the International Network of Agencies for Health Technology Assessment (INAHTA)

In addition material held in the NZHTA print collection was hand scanned and the reference lists of material obtained during the course of the research were searched.

LEVELS OF EVIDENCE

For each question that was posed in this review, the most appropriate type(s) of study(ies) to examine this question were selected (refer to Table 1 and Appendix 6).

If a systematic review or a meta analysis was available in a certain area, this was used as the primary source of data. Any studies that were conducted in New Zealand were more leniently assessed in order to obtain a local context.

The level of evidence was assessed using criteria developed by the NZHTA (NZHTA 1997). Refer to Table 2.
**Table 1.** Types of studies selected

<table>
<thead>
<tr>
<th>Research question</th>
<th>Type of study</th>
</tr>
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<tr>
<td>Prevalence of OME and associated conductive hearing loss</td>
<td>Population based cross-sectional and cohort studies were selected</td>
</tr>
<tr>
<td>Natural history of OME and associated conductive hearing loss</td>
<td>Population based prospective cohort study</td>
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<tr>
<td>Disability of OME and associated conductive hearing loss</td>
<td>Prospective cohort and case-control studies</td>
</tr>
<tr>
<td>Treatment of OME and associated conductive hearing loss</td>
<td>RCTs</td>
</tr>
<tr>
<td>Screening programmes of OME and associated conductive hearing loss</td>
<td>RCTs (And also cohort studies and audits)</td>
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**Table 2.** Evidence levels used in this review

<table>
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<th>Level of evidence</th>
<th>Study design</th>
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<td>Meta analyses</td>
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<tr>
<td>Level 2</td>
<td>RCTs</td>
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<tr>
<td>Level 3</td>
<td>Comparative studies including: cohort and case control studies</td>
</tr>
<tr>
<td>Level 4</td>
<td>Descriptive studies including: cross-sectional studies and case series</td>
</tr>
<tr>
<td></td>
<td>Expert opinion, consensus statements and non systematic reviews</td>
</tr>
</tbody>
</table>
APPRAISAL METHODOLOGY

Studies were selected from the literature search that examined OME and associated hearing impairment and

- had subjects that were predominantly 0-7 years of age
- included assessment by tympanometry
- had >30 participants
- had generalisability to the New Zealand population
- had reported adequate demographic details about the study participants

Articles were formally appraised using the schedule developed by the Group Health Cooperative of Puget Sound (Group Health Cooperative of Puget Sound 1996) and adapted by the New Zealand Guidelines Group of the National Health Committee (New Zealand Guidelines Group 1997).

LIMITATIONS OF THIS REVIEW

There are some issues that are outside the scope of this review and consequently have not been addressed. These include:

1. Screening programmes specifically designed to detect sensorineural hearing loss.

2. Primary prevention strategies for OME. Only a cursory search for literature on risk factors was undertaken.

Although this review has greatly benefited from advice provided by consultants, it has not been exposed to wide peer review. In addition, the review has been limited to the published academic literature and has not appraised unpublished work.

The bulk of the studies included in the review were conducted beyond New Zealand so it is uncertain whether their conclusions can be generalised to the New Zealand population and context.

The review was conducted over a limited period of time (January – June 1998).
Prevalence, natural history and risk factors

The prevalence, natural history and risk factors for OME and associated conductive hearing loss in children have been the subject of an increasingly large number of studies.

Population based cross-sectional studies were selected as the most appropriate type of study to examine prevalence and these have a Level III rating. Population based cohort studies were selected as the most appropriate study type for natural history and these have a Level II rating.

PREVALENCE

International studies

The prevalence of OME is a measure of the proportion of children who have OME at any given time. There are now numerous studies that have examined the prevalence of OME in children. These studies have consistently found OME to be a very common (Table 3).

Zielhuis et al (1990) has reported the findings of a comprehensive review of cross-sectional studies that were designed to determine the prevalence of OME. In this review, 23 studies that were population-based, examined children aged 6 months to 10 years and that based diagnosis of OME on tympanometry were examined. The 56 age-specific prevalence rates yielded by these studies were plotted and the best fitting third-degree polynomial computed (Figure 1). The resulting curve shows steadily increasing prevalence of OME from the age of 6 months, with peaks at 2 and 5 years of age with prevalence in the order of 15-20%.

Cross-sectional studies subsequent to this review confirm these findings (Møller and Tos 1990, Williamson and Bain 1994, Rushton et al 1997).

Not only is OME common, it appears that it is a near universal experience in young children. Paradise et al (1997) examined the prevalence of acute otitis edia and OME in children aged 2 months to 2 years in a large cohort study. By age 2 years 91.1% had had at least one episode of acute otitis media and/or OME.

Certain ethnic groups have been shown to have a high prevalence of OME, including American Indians (Nelson and Berry 1984). Whilst other groups appear to have a low prevalence of OME, such as ethnic Chinese (Rushton et al 1997).

Figure 1. Prevalence of OME (Zielhuis et al 1990)

New Zealand studies

There have been a limited number of studies that have examined the prevalence of OME in the New Zealand population. The Dunedin Multidisciplinary Health and Development Study is the only population-based study to have examined the prevalence of OME in New Zealand (Chalmers et al 1989). It examined children at age 5 and found that 8.8% of the children’s ears had OME diagnosed by tympanometry. As with other studies, the prevalence of OME was found to steadily fall after this age with a prevalence of 6.1% at age 7, 1.8% at age 9 and 1.3% at age 11 years.

Other studies in New Zealand of OME do not have directly comparable prevalence data, but all have shown that OME is a common condition.

Hamilton et al (1980) undertook a cross-sectional study of “chronic suppurative otitis media and middle ear effusion” in predominantly Maori children aged 1-11 years attending one school and preschool in Whangarei. They found extraordinarily
high rates of OME, with 97% of 4 years olds and 85% of 5 year olds having type B tympanograms. However, recruitment of subjects may have predisposed to those with ear problems and the numbers in this study were small.

Another study by Giles and O’Brien (1989) examined a group of Maori school age children over a period of a year and found a prevalence of acute otitis media and OME ranging between 12-22% in children aged 1-15 years.

Crampton et al (1996) in a pilot for OME screening in a ethnically mixed low socioeconomic status population found high levels of OME, with 49.7% of children having a least one episode of bilateral OME in a 13 month period.

Another valuable source of data is that collected by the National Audiology Centre of the national screening programme (National Audiology Centre 1998). Of those children that were screened at 3 years of age in 1996/7, 7.1% failed screening by serial tympanometry. Maori and Pacific Island children had a higher failure rate at 16.8% and 17.1% respectively. Of those children screened by serial tympanometry and audiology at 5 years in 1996/7, 8.4% failed. Again Maori and Pacific Island children had high rates at 13.0% and 16.1% respectively.

Conductive hearing loss

Although many studies have examined the prevalence of OME, fewer have examined the prevalence of associated conductive hearing loss. Conductive hearing loss has been demonstrated in both infants (Friel-Patti and Finitzo 1990, Werner and Ward 1997) and older children affected by OME (Paradise 1981, Bluestone et al 1973, Brooks 1979).


The most common cause of hearing impairment in children is OME. Augustsson et al (1990) screened 4 and 7 year old children with audiometry and found that by far the most commonest cause of an audiometry failure was OME at 39.6%, with a much smaller percentage of 3.7% having sensorineural hearing loss.

NATURAL HISTORY

Although the understanding of the natural history of OME is incomplete, the studies that were identified led to a number of broad conclusions.

Relationship to infection

Episodes of OME frequently follow upper respiratory tract infections and acute otitis media (Nieto et al 1983). The effusion in the middle ear in OME may contain pathogens such as Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis and Streptococcus pyogenes (Jero and Karma 1997).

Duration and frequency

An episode of OME appears to last at least several days. In a study by Möller and Tos (1990) 51 children aged 3-5 years attending a preschool were followed over a one month period and examined daily for OME with tympanometry. In this group where the point prevalence of OME per ear was 13%, all ears that were found to have a Type B tympanogram remained flat for >14 days.

It appears that there is a high rate of spontaneous resolution for the majority of episodes of OME. Zielhuis et al (1989) who followed children from the age of 2 years over 3 months, over a period of 2 years, found that the duration of OME varied. They concluded that 50% of cases of OME resolved within 3 months, but a small percentage continued for >12 months. Hogan et al (1997) followed a group of children at a monthly interval and estimated that the mean duration of unilateral OME was 5 weeks and that of bilateral was 6-10 weeks. Similarly, Fiellau-Nikolajsen (1983) found a high rate of spontaneous resolution of episodes of OME. In their cohort 9.8% of ears had type B Tympanogram. Of these, only 62% had type B at 1 month, 35% had Type B at 3 months and 20% had Type B at 6 months.

It appears that children with more severe OME have episodes more frequently, rather than for a longer duration. Hogan et al (1997), in a study of children followed from birth over three years, used the shorter screening interval of a month. The results of this study were subjected to Markov modelling and from this it was concluded that the main
variation between children was not duration of episodes, but frequency and time between episodes of OME.

Those children that have more prolonged or frequent episodes of OME early in life appear more likely to have episodes at an older age. Paradise et al (1997) found that there was a moderate correlation between the occurrence of OME in the first year of life with that in the second year of life. Similarly, Schilder et al (1995) found that children with persistent OME between the ages of 2 and 4 years were much more likely to have OME at age 7-8 years, than those who had no OME as young children.

Unilateral/bilateral OME

OME may affect one or both ears of a child. Paradise et al (1997) found that just over half (52.5%) of children from 6 weeks to 2 years experienced episodes of acute otitis media and OME bilaterally.

RISK FACTORS

Several risk factors have been associated with OME including bottle feeding, male gender, lower socioeconomic status, passive smoking and exposure to other children in day-care.

Paradise et al (1997) has reviewed the extensive literature in this area. This review concluded that studies that addressed the association between gender, socioeconomic status and passive smoking had inconsistent findings. Whereas, studies that have examined the breastfeeding and attendance day-care centres and OME have consistently reported statistically significant and strong associations.

Cleft palate has also been found to be associated with high rates of OME in children (Paradise et al 1969).

CONCLUSION

- The prevalence of OME is high in children under the age of 5 years
- OME is a near universal experience in young children
- OME is associated with a conductive hearing loss ranging from 0-50 dB HL. In approximately 50% of children this is ≥25 dB HL.
- Episodes of OME appear to last >14 days
- There is high rate of spontaneous resolution
- Children who are affected more severely by OME appear more likely to have more frequent episodes, rather than episodes of longer duration
- Children who are prone to OME at a young age appear also to be more prone to OME at an older age
- There are several risk factors for OME including male gender, low socioeconomic status, and exposure to tobacco smoke, bottle-feeding and attendance at day-care centres.
Table 3. Summary of studies examining prevalence and natural history of OME

<table>
<thead>
<tr>
<th>Study</th>
<th>Study type</th>
<th>Sample</th>
<th>Condition surveyed</th>
<th>Method of testing</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chalmers et al (1989) New Zealand</td>
<td>Cohort study (Level III)</td>
<td>N=1661 of a birth cohort of which 879 were seen at 5 years</td>
<td>CME</td>
<td>Tympanometry and otoscopy at age 5</td>
<td>Age 5 OME = 9.4% and at age 76%, 9 if was 2.4%</td>
<td>Only population based study conducted in New Zealand that has reported the prevalence of CME.</td>
</tr>
<tr>
<td>Crampton et al (1986) New Zealand</td>
<td>Audit of pilot screening (Level III)</td>
<td>N=731 children under the age of 5 years were screened in a pilot CME screening programme in an ethnically mixed low socio-economic status population in New Zealand</td>
<td>CME</td>
<td>Tympanometry screening at age 9, 15, 18 months, 2, 3, 4 years over a 13 month period</td>
<td>49.7% of children had one or more episode of bilateral OME in a 13 month period</td>
<td></td>
</tr>
<tr>
<td>Fiellau-Nikolaussen (1980) Denmark</td>
<td>Cohort study in 1976 and 1978 (Level II)</td>
<td>N=503 children aged 3 years over a 6 month period in 1976 N= 435 in 1978</td>
<td>MEE</td>
<td>Tympanometry at 0, 1, 3 and 6 months (Children with type A tympanogram were not screened again)</td>
<td>• 9.8% of ears had type B tympanogram on the first reading • Of these, 62% had Type B at 1 month • 35% had Type B at 3 months and 20% had Type B at 6 months • 3% of the total population had type B for 3 months check and only 2% at 6 months</td>
<td>Population based study.</td>
</tr>
<tr>
<td>Giles and O'Hrien (1999) New Zealand</td>
<td>Cohort (Level II)</td>
<td>N=278 children aged 1-15 years recruited from preschool and school Rangi Maori population, New Zealand</td>
<td>MEE, cholesteatoma and perforation</td>
<td>Otoscopy on 4 occasions at 3-4 month intervals</td>
<td>Prevalence of MEE ranged between 12% and 22% on the four occasions 59% never had MEE 23% had detected once 10% had twice 5% had three times and 4% had four times</td>
<td>Only 123 children seen on all 4 occasions No breakdown on age.</td>
</tr>
</tbody>
</table>

SCREENING PROGRAMMES FOR OME AND CONDUCTIVE HEARING LOSS
Table 3. Summary of studies examining prevalence and natural history of OME (continued)

<table>
<thead>
<tr>
<th>Study</th>
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<th>Method of testing</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Hamilton et al (1980) New Zealand | Cross-sectional (Level III) | N= 277 (222 school children aged 5-11 attending one school and 55 preschool children) Predominantly Maori population in North Island, New Zealand | Chronic suppurrative otitis media and middle ear effusion | Otoscopy, Tympanometry and pure tone audiometry | • Out of a total of 253 tested with tympanogram 97% type B in 4 year old ears, 85% at 5 year old ears and down to 35.7% in age 11 (57.1% overall)  
• At follow-up 3 months later, only 163 tested and overall only 10% had Type B | There were small numbers in young age groups.  
The study was not population based.  
Survey undertaken by the mobile ear clinic. |
| Hogan et al (1997) UK         | Cohort study with the application of Markov modelling (Level II)       | N= 112 full-term infants recruited at birth and followed till age 3 years | OME (included AOM)                                                                 | Tympanometry examined 1 monthly                | • First order Markov model described the data adequately  
• Predicted that episodes of unilateral OM had mean duration of 5 weeks and bilateral 6-10 weeks  
• Increased susceptibility to OM was primarily associated with more frequent episodes and less to with duration | Population based.  
95 completed one year and only 31 subjects completed the 3 years. |
| Møller and Tos (1990) Denmark  | Cohort study Tympanometry every weekday for one month (Level II)       | N= 51 preschool children ages from 3-5 years (100 ears)                     | OME                                                                                   | Tympanometry                                  | Point prevalence at first measurement was 15.7% (13% per ear)  
Cases with Type B lasted > 14 days, on the whole, but those that lasted less were at the beginning and the end of the study | 84% of potential reading occurred.  
Limited to 1 month and this was too short to estimate the average duration of and makes interpretation difficult. |
Table 3. Summary of studies examining prevalence and natural history of OME (continued)

<table>
<thead>
<tr>
<th>Study</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Schilder et al (1985)</td>
<td>Continuation of the Zielhuis et al 1989 study (Level II)</td>
<td>As in Zielhuis et al (1989), N=1160 subjects that still lived in the area were followed up at 7-8 years Netherlands</td>
<td>OME</td>
<td>As above and also full audiological examination at age 7-8 years</td>
<td>Four groups identified from the preschool age group:</td>
<td>High levels of follow-up,</td>
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<td></td>
<td>1. Those with no OME</td>
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<td>2. Those with untreated OME</td>
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<td>3. Those with transient OME</td>
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<td>4. Those treated with ventilation tubes</td>
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<td></td>
<td>Found that OME at age 7-8 was much more common in those that had it between 2-4 years. If no OME in childhood, only 2.2%, if transient 7.4%, but if persistent or had VT then 12%</td>
<td></td>
</tr>
<tr>
<td>Williamson and Bain (1994) UK</td>
<td>Cross-sectional with multiple recordings (Level III)</td>
<td>N=856 school children population aged 5-8, recruited over 3 years 78% response rate</td>
<td>OME</td>
<td>Typanometry tested at 4 monthly intervals</td>
<td>At age 5 there was annual mean of 17%, at 6 - 10%, at 7 - 7% and at 8 - 6%</td>
<td>Cannot contribute to understanding natural history as it only measures 4 monthly. Confirms the reduction in point prevalence with age,</td>
</tr>
</tbody>
</table>

**SCREENING PROGRAMMES FOR OME AND CONDUCTIVE HEARING LOSS**
Table 3. Summary of studies examining prevalence and natural history of OME (continued)

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Zielhuis et al (1989) Netherlands</td>
<td>Cohort study (Level II)</td>
<td>N=1420 birth cohort followed 2-4 years of age Netherlands</td>
<td>OME</td>
<td>Tympanometry at 3 monthly intervals</td>
<td>Resolution was found in 50% of the affected ears after 3 months or less. About half of the ears that recovered had a further episode of OME (Figure Zielhuis et al 1989)</td>
<td>Population based study. Good fellow rates and frequent screening with tympanometry.</td>
</tr>
<tr>
<td>Zielhuis et al (1990) (Level III)</td>
<td>Review of cross-sectional studies</td>
<td>Collected population based studies with age range 6 months to 10 years, no sub-populations and use of tympanometry 23 studies were identified which gave a total of 56 age-specific prevalence rates</td>
<td>Otitis media with effusion</td>
<td>Tympanometry</td>
<td>Plotted and the best fitting third-degree polynomial was calculated by computer. Showed a sinusoidal curve with two modes at age 2 and 5 years. Same curves if season taken into account</td>
<td>Binodal curve confirmed by other authors. Almost all studies calculated the rates per ears, rather than children. The five studies that were prevalence per child had a 0.73 correction factor applied.</td>
</tr>
</tbody>
</table>
Disability associated with OME

OME in children has become of concern largely because it is thought to cause developmental delay and disability (Chalmers et al 1989). Various types of disabilities are attributed to OME. Chalmers et al (1989) categorises these as psychological, educational and social. Haggard and Hughes (1991) expand these categories to anatomical/physiological, perceptual, linguistic, cognitive, educational and emotional/interpersonal.

The most commonly accepted view is that disability associated with OME is mediated through associated hearing loss (Haggard and Hughes 1991). However, some authors have suggested that OME may cause disability independent of hearing loss. One postulate is that this might be mediated through an increased time in a “sick” role in children with OME that limits normal activity and social learning (Haggard and Hughes 1991).

There are now numerous studies that have examined the relationship between OME, associated hearing loss and disabilities, which date back to the 1960’s (Lous 1995) and there are several recent reviews of this literature (Haggard and Hughes 1991, Lous 1995, Friel-Patti 1990). All reviews have noted that the majority of studies are of a low quality, frequently retrospective, relying on unvalidated exposure measurements and usually involving very small sample sizes. These reviews all noted an inconsistent relationship between OME and disability.

THE STUDIES

As described previously, only prospective cohort studies using tympanometry as a screening tool have been chosen. These studies are the most appropriate as they are more likely to reduce bias in the results. Under the grading system used in this review, these are Level II studies.

There are a number of these types of studies and they are of a reasonable quality, however all involve small sample sizes (Table 4). All studies assessed the severity of OME by a measure of the persistence of OME. Studies varied as to whether they identified unilateral and/or bilateral OME as the exposure measure. No studies compared the outcomes between those children with unilateral and bilateral OME. Whilst four of the studies documented associated hearing impairment (the Dallas Cooperative study, the Nashville study, the Dunedin study and the Danish study), only one of these reported an analysis on the relationship between hearing impairment and disability.


In a group of predominantly socioeconomically disadvantaged children attending the Frank Porter Graham Development Centre of the University of North Carolina, the relationship between unilateral/bilateral OME and development was monitored closely from 6 weeks to 8 years of age. Children were examined monthly for OME and the severity of OME was estimated by the time spent with effusion before the age of 3 years.

Multiple developmental outcomes were measured including cognitive, academic, narrative skills, attention skills, phonological development, language abilities, intelligence and behavioural outcomes over ages 3 to 8 years of age. The majority of the outcome measurements showed no statistically significant association with the OME experience of the children. This was with the exception of a statistically significant association between poor attention skills at 5 and 7 years (p<0.04), poor phonological development at 4½ (F=5.51, p=0.025) and poor teachers’ ratings of behaviour at 8-9 years (F=5.95, p<0.05) and more prolonged exposure to OME.

This study extensively documented the children’s experience with OME and had multiple outcome measures. However the studies at this Centre have some shortcomings. Factors such as the preschool “hot-house” environment in this study and high levels of therapeutic intervention may have mitigated any adverse affects of OME and weakened the chance of finding a real relationship. On the other hand, the multiple analysis of the results in a post-hoc manner may have increased the chances of finding a statistically significant association between OME and disability.
This study did not document associated hearing impairment.


This population-based study is the largest reviewed in this report. The OME experience was comprehensively documented by examinations at 3 monthly intervals from 2-4 years of age in 1439 children. In a series of papers, variable numbers of subjects were selected from this larger cohort that had had different experiences with OME for use in nested case-control studies. These were divided into three groups with one group having had no OME, a second group with moderate bilateral OME (either OME for 3-6 months or Type B tympanogram for 22-50% of the time screened) and a third group with more prolonged bilateral OME (OME >6 months or Type B tympanogram for >50% of the time screened). One study (Grievink et al 1993) also had a comparison group that had had OME treated with ventilation tubes (VT).

Again, a variety of developmental outcomes were measured including language, phonological ability, reading skills, spelling skills, auditory perception at ages ranging from 31 months to 8 years. For the majority of the multiple outcome measures after the age of 4 years there was no statistically significant association with the experience of OME. This is with the exception of a small number of disparate outcomes where prolonged exposure to OME was correlated to poor writing as judged by a teacher rating, poor auditory perception tested by a speech-in-noise test and poor spelling in boys.

Although a large study, some of the sub-analysis involved only a small number of subjects. Its strength is that it was population based.

This study did not document associated hearing impairment.

**Dallas study (Friel-Patti and Finitzo 1990)**

This study examined a paediatric clinic population for unilateral/bilateral OME and followed children from 6 to 24 months of age by tympanometry at 4-6 weekly intervals and audiometry at 6 monthly intervals.

It made a limited number of outcome measures in language skills. The interval between documenta-

tion of OME and the outcomes was a short time interval (0-12 months). It found a statistically significant association between experience with OME and expressive and receptive language skills and a statistically significant association between hearing and receptive language skills.

This was one of only four studies that examined hearing impairment and the only one that reported an analysis of the relationship between hearing impairment and disability.


In the first of the two cohort studies undertaken by this group (Lous and Fiellau-Nikolajsen 1984, Lous et al 1988) enrolled 463 3 year old children and documented their OME experience by otoscopy and tympanometry on 4 occasions over a 6 month period. From this cohort, children with persistent unilateral and bilateral OME were selected as cases and matched to controls with no OME (See Table 2 for matching criteria).

Vocabulary, verbal intelligence and reading outcomes were measured at 8 years of age. No statistically significant association was found between these outcomes and experience with OME. The children with OME that also had hearing impairment were compared to their controls (only 7 pairs). There appeared to be no difference in the outcomes. However, the numbers involved were very small and this was not subjected to statistical analysis.

This study was well designed, with a population based source cohort and extensive matching in the case-control study. However, it had small numbers in the analysis.

In the second of these cohort studies (Lous 1993) 366 children were enrolled at new school entrants (7 years of age) and were monitored for OME with serial tympanometry, otoscopy and audiology over the first year of school.

The Silent Reading Word Test was the only outcome measure recorded. Post-hoc analysis revealed a statistically significant association between a reading outcome measure and those who did not have type B tympanograms (p=0.04).

Interestingly multiple regression analysis found that classroom quality, previous performance at age 7 on a phonology test (Lous 1990) and the
social group of the mother were greater contributors to the variance in test performance than having a type B tympanogram.

This study did document associated hearing impairment. It did attempt to compare cases with hearing impairment and the controls. However, numbers were so small and statistical analysis was not undertaken.


This New Zealand population based study followed a cohort of 1661 children from birth. Of these, 879 were examined for OME on a single occasion using a combination of otoscopy, tympanometry and audiometry at 5 years of age.

A wide range of outcome measurements were conducted including intelligence, language skills and auditory skills at ages 3, 5, 7 and 9 years. There was no correlation between the outcome measurements and OME experience at 7 and 9 years, with the exception that bilateral OME was positively associated with poor verbal expression at 7 years. Some developmental measures at 3 and 5 years were correlated with OME experience. However, these predate or coincide with the OME measure and cannot infer a causal link.

There are two factors in this study that may mitigate any positive correlation between OME and developmental delay. Firstly, the documentation of OME was limited to a single assessment and had no serial component. This reduces the chances of identifying children who were more seriously affected by OME because of more persistent OME. Secondly, there were also high levels of intervention in the group of children identified with OME and again this may reduce any positive correlation.

This study documented associated hearing impairment, but did not relate it to the outcome measures.

**Pennsylvania study (Feagans et al 1994, Vernon-Feagans et al 1997)**

This study followed 46 children from 3 different preschools from the age of 12 to 24 months. The children were assessed weekly for OME. The quality of the day-care centre that they attended was also assessed on the basis of the ratio of caregivers to children.

Outcome measures were predominantly language skills. There was a positive correlation with severity of OME (unilateral and bilateral) and language skills, but this was interestingly only seen in those children attending poor quality day-care (high ratio of caregivers to children). The numbers in this study were small, with the numbers of subjects in sub-analysis ranging from 12-37.

This study did not document associated hearing impairment.

**Nashville study (Wright et al 1988)**

In this study 210 children were recruited at birth and were followed from 0 to 2 years with routine visits for OME. Hearing was also tested at 2 and 3-4 years.

Outcome measurements included speech, language and developmental outcomes at 2 and 3-4 years. No statistically significant association was found between OME and any of the outcome measurements.

Although this study documented hearing impairment, it did not attempt to relate this to outcome measures.
SUMMARY

- The majority of the numerous outcome measurements taken in these studies showed no statistically significant association between OME experience in children and disability.
- Those outcome measures that did show a statistically significant association between OME experience in children and disability were of a disparate nature.
- Only one study reported an analysis of the relationship between conductive hearing loss and disability. It found a statistically significant association between hearing loss due to OME and receptive language skills. However, this study had only a small number of subjects.
- Explanation of these conflicting findings could be due to:
  * the inadequate power of studies to detect differences due to small sample size
  * high intervention rates in the OME affected groups
  * that severity of OME was largely assessed on the basis of persistence and not on associated hearing impairment or the laterality of OME (bilaterality or uni/bilaterality).
  * disparate non-comparable outcome measures
  * failure to measure outcomes that might have revealed an association (e.g. social and emotional outcomes)

- This research does not adequately support or refute the theory that OME results in disability
- This research does not adequately support or refute the theory that conductive hearing loss associated with OME results in disability
- Further well conducted research is needed to determine the association between OME, conductive hearing loss and disability
<table>
<thead>
<tr>
<th>Study</th>
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<th>Sample</th>
<th>The exposure and its measurement</th>
<th>Outcomes measures</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Roberts et al (1986)</td>
<td>Cohort (Level II)</td>
<td>N=70</td>
<td>Followed from 3 months to 5 years</td>
<td>Cognitive and Academic Outcomes at age 3 years: 1. McCarthy Scale of Children’s Abilities (42) 2. Stanford-Binet Intelligence Scale (48) 3. McCarthy Scale of Children’s Abilities (54) 4. Wechsler Preschool and Primary Scale of Intelligence (60) 5. Peabody Individualised Achievement Test (kindergarten)</td>
<td>No correlation between time spent with CME and test performance</td>
<td>Subjects in “hot-house” environment. Subjects treated if problems persistent. Good rate of completion at 87% (61). Researchers were blinded. Tympotograms not used in first 4 years. Control for confounding with multivariate analysis and also in examining primarily children of a lower socioeconomic background.</td>
</tr>
<tr>
<td>2. Feagans et al (1987)</td>
<td>Cohort (Level II)</td>
<td>N=44</td>
<td>Otherwise as in Roberts et al 1986</td>
<td>Narrative and attention skills at 5 and 7 years: Narrative task developed by researcher that measured: 1. Mean length of utterance 2. Quality of the paraphrase</td>
<td>Subjects with 9 or more episodes of CME in the first 3 years produced significantly more involuntary/distinct ability in comparison to others (t=2.20, p &lt; 0.04). All other results non-significant</td>
<td>This significant result was found only after attempting a range of other calculations. Blinding not mentioned. No control for confounding on the “significant” result. Small numbers.</td>
</tr>
</tbody>
</table>

**Table 4.** Summary table of studies examining OME and disability

**SCREENING PROGRAMMES FOR OME AND CONDUCTIVE HEARING LOSS**
Table 4. Summary table of studies examining OME and disability (continued)

<table>
<thead>
<tr>
<th>Study</th>
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<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Roberts et al (1988)</td>
<td>Cohort</td>
<td>N = 55</td>
<td>As in Roberts et al (1986)</td>
<td><strong>Phonological development at age 2 ½ to 8 years measured annually:</strong></td>
<td>No significant correlation between total OME and CER /TTP were found during the preschool years</td>
<td>Blinding not mentioned. There were multiple calculations and authors themselves caution that the significant result may be a Type I error.</td>
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<tr>
<td></td>
<td>(Level II)</td>
<td>Otherwise as in Roberts et al 1986</td>
<td></td>
<td>Goldman-Fristoe Test of Articulation annually (when OME free and passed hearing test)</td>
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<td>Measurements</td>
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<td>1. Total phonological processes (TPP)</td>
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<td></td>
<td>2. Total number of constants in error (CER)</td>
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<tr>
<td>4. Roberts et al (1991)</td>
<td>Cohort</td>
<td>N = 63</td>
<td>As in Roberts et al 1986</td>
<td><strong>Language abilities between 4 ½ and 6 years:</strong></td>
<td>No correlation between OME (0-3) and any language outcomes in either low or middle socioeconomic status children</td>
<td>No mention of blinding.</td>
</tr>
<tr>
<td></td>
<td>(Level II)</td>
<td>(N = 23 lower socioeconomic and N = 30 were middle socioeconomic)</td>
<td></td>
<td>1. Miller-Yoder Language Comprehension Test (Comprehension of differing syntactic forms) - 4 ½</td>
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<td>2. Bankston Language screening test (vocabulary identification)</td>
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<td>3. Clinical Evaluation of Language Functions</td>
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<td>4. Peabody Individualised Achievement - 6</td>
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</table>
Table 4. Summary table of studies examining OME and disability (continued)

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<tr>
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<tbody>
<tr>
<td>5. Roberts et al (1994)</td>
<td>Cohort (Level II)</td>
<td>N = 55</td>
<td>As in Roberts et al 1986 Otherwise as in Roberts et al 1986</td>
<td>Intelligence at between 3 and 9 years: 1. Standford Binet IQ at age 3 and 4 years 2. McCarthy GCI at age 3 ½ and 4 ½ years 3. WPPSI verbal and performance IQ at 5 years 4. WISC-R verbal and performance IQ at 6 ½ and 8 years 5. Academic performance by Woodcock-Johnson Psychorelational Battery at 8-9 years 6. Classroom Behaviour Inventory Task Orientation (teacher assessed) at age 8-9 years</td>
<td>Overall OME in the first 5 years was not significantly correlated with patterns of overall intellectual development between the ages of 3 and 8 years. The only significant correlation was the frequency of episodes of OME during infancy was a negative predictor of teachers' ratings of children's task orientations (r = -0.55, p &lt; 0.05)</td>
<td>Multiple analysis in a post-hoc manner.</td>
</tr>
</tbody>
</table>
Table 4. Summary table of studies examining OME and disability (continued)

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<tbody>
<tr>
<td>1. Rach et al (1988)</td>
<td>Cohort (Level II)</td>
<td>Birth cohort of 1439 children examined for OME between 2-4 years. From this cohort, three groups selected: N= 16 with OME for 3-6 months; N = 36 with OME &gt;6 months; N = 13 without OME</td>
<td>Bilateral OME diagnosed by Type B tympanogram. Between the ages of 2 and 4 years examined 3 monthly.</td>
<td>Language test at age 31-36 months: RDLS-r language test</td>
<td>No significant difference on verbal comprehension, but those in Group 2 were poorer on Verbal expression by p &lt; 0.0001</td>
<td>Very small numbers. Not specifically matched for age, sex and maternal educational level, but same parental educational level. Language test not validated.</td>
</tr>
<tr>
<td>2. Grievesh et al (1993)</td>
<td>Cohort/recycled case-control (Level II)</td>
<td>As in Rach et al 1988, but subjects selected from 946 who were re-examined at age 7 years. Subjects selected from this were three groups: 1. N= 82 OME free children 2. N=151 OME group with bilateral OME of 2 or more occasions and consecutive 3. N=37 OME and treated with VT</td>
<td>As in Rach et al (1988)</td>
<td>General language and phonological ability at age 7-8 years: 1. Language Test for Children 2. Word Forms Production Test 3. Consonant Meaning 4. Non-verbal Intelligence test (Coloured Progressive Matrixes)</td>
<td>No significant difference between the groups and in the performance of the tests, even after stratification for number of episodes.</td>
<td>Population based study. Attempts to account for confounding (no difference in characteristics of sex, age, educational level of mothers and fathers). But OME-VT subjects lower intelligence and higher educational level of parents. Results of this study published elsewhere. The selection of the subjects not described well. Blinding present.</td>
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Table 4. Summary table of studies examining OME and disability (continued)

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<tbody>
<tr>
<td>3. Peters et al</td>
<td>Cohort</td>
<td>As in Grieveik et al (1993), but</td>
<td>As in Rach et al (1988)</td>
<td>Reading and spelling at age 7-8 years:</td>
<td>No significant difference between the groups in the performance of the</td>
<td>Attempt to account for co-</td>
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<tr>
<td>(1994)</td>
<td>(Level II)</td>
<td>N= 29 in group with no CME</td>
<td></td>
<td>1. One-Minute Test</td>
<td>tests with the exception of that teachers judged that children with</td>
<td>founding with no difference in demographic factors of the sub-</td>
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<tr>
<td></td>
<td></td>
<td>N=36 in group with Type B 22-50%</td>
<td></td>
<td>2. Word Recognition Test</td>
<td>CME had poorer writing achievement (inadequate blinding)</td>
<td>ject groups. However, thos</td>
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<td></td>
<td></td>
<td>N=24 in group with Type B &gt;50%</td>
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<td>3. Sentence Verification Test</td>
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<td>e that received treatment m</td>
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<td></td>
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<td></td>
<td></td>
<td>4. Spelling test</td>
<td></td>
<td>ay well have had more severe CME.</td>
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<td></td>
<td></td>
<td>5. Grapheme test</td>
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<tr>
<td>4. Schiöd et al</td>
<td>Cohort</td>
<td>As in Grieveik et al (1993), but</td>
<td>As in Rach et al (1988)</td>
<td>Auditory perception tested at 7½ to 8 years:</td>
<td>The only significant association was seen with those with Type B &gt;</td>
<td></td>
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<tr>
<td>(1994)</td>
<td>(Level II)</td>
<td>N= 29 in group with no CME</td>
<td></td>
<td>1. Speech-in noise</td>
<td>50% had poorer results with the speech in noise test (p &lt; 0.03)</td>
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<td></td>
<td></td>
<td>N=36 in group with Type B 22-50%</td>
<td></td>
<td>2. Low-pass filtered speech</td>
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<tr>
<td></td>
<td></td>
<td>N=24 in group with Type B &gt;50%</td>
<td></td>
<td>3. Binural fusion</td>
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<td></td>
<td>4. Dichotic speech</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>5. Auditory memory</td>
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SCREENING PROGRAMMES FOR OME AND CONDUCTIVE HEARING LOSS
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<tr>
<td>5. Peters et al (1997)</td>
<td>Cohort (Level II)</td>
<td>As in Grieves et al (1993)</td>
<td>As in Rich et al (1988)</td>
<td>Language, spelling and reading at 7 years: The same outcomes measured in Grieves et al 1993 and Peters et al 1994.</td>
<td>Analysis examined the combined effect of single and then multiple risk factors (educational level of parents, sex, intelligence and low birthweight and pretreatment birth) and OME experience. Correlations were: • Boys spelling was negatively influenced by a history of OME ($F=3.34$, $P&lt;0.05$; pseudowords, $F=5.18$, $P&lt;0.05$) • OME in combination with other risk factors only affected the reading of real words only (One-minute test, $F=2.91$, $P&lt;0.05$) Otherwise no effect shown, in particular parental background</td>
<td>Reanalysis of two other papers (Grieves et al 1993 and Peters et al 1994). Accounted for confounding with parental educational level and nonverbal intelligence.</td>
</tr>
<tr>
<td>Dallas Cooperative Project</td>
<td>(Fried-Patt and Finizio 1990)</td>
<td>Cohort (Level II)</td>
<td>N=483 Recruited from private pedi atric clinics at 6 months of age</td>
<td>Unilateral or bilateral OME diagnosed by otoscopy and tympanometry, examined 4-6 weekly from 6 to 24 months and at other constitutions</td>
<td>Language skills at 12, 18 and 24 months: 1. Sequenced Inventory of Communication Development - receptive (SCID-R) 2. Sequenced Inventory of Communication Development - expressive (SCID-E) 3. Hearing tested with audiometry from 6 months, on a monthly basis by ABR and visual reinforcement audiometry</td>
<td>Days with OME was significantly correlated with average hearing in 6-18 months ($r=0.44$, $p&lt;0.0002$, $N=68$) SCID-R at 12 months was significantly but weakly negatively correlated with days with effusion between 6-12 months ($r=-0.20$, $p=0.06$, $N=181$) and SCID-E at 18 months was significantly but weakly negatively correlated with days with effusion between 6-12 months and 6-18 months ($r=-0.22$, $p=0.007$, $N=140$) Average hearing between 6-12 months was weakly negatively correlated to receptive language at 12 months ($r=-0.17$, $p=0.01$, $N=246$), at 18 months ($r=-0.17$, $p=0.05$, $N=155$) and at 24 months ($r=-0.17$, $p=0.05$, $N=155$)</td>
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<tr>
<td>Danish study</td>
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<tr>
<td>1. Louis and Feilmark-Niklasson (1986) &amp; Louis et al (1988)</td>
<td>Cohort with nested case-control study (Level II)</td>
<td>N= 463 of 3 year old children (94% of the population) • Cases of PCM N= 28 (Type B/C/L/C2 tympanograms unilateral or bilateral on all 4 occasions) • Controls with no PCM N= 28 Matched for sex, age and family income at birth and same class at school</td>
<td>Unilateral or bilateral OME diagnosed by tympanometry and otoscopy on 4 occasions over a 6 month period</td>
<td>Vocabulary, verbal intelligence and reading: 1. CS-400 for silent reading word test at 8 years 2. 6 months later Wechsler Intelligence Test (WISC) at 8 1/2 years 3. Revised Peabody Picture Vocabulary Test (PPVT-R) for receptive language at 8 1/2 years</td>
<td>No difference in the cases and controls on the performance of the tests any of the tests</td>
<td>This study was population based (97.3% of the population). Cases matched for sex, social group, and classroom. The numbers were small in cases and control small numbers.</td>
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<tr>
<td>2. Louis (1993) &amp; Louis (1995)</td>
<td>Cohort (Level II)</td>
<td>N=366, 7 year old school children followed over 1 year</td>
<td>CME assessed by 10 tympanometry assessments and 5 audiological assessments from age 7-8 years and otoscopy</td>
<td>Reading: Silent reading Word Test (CS-400) at age 8 years</td>
<td>No correlation between number of type B tympanograms, otoscopy and audiometry results. Only positive correlation was those children with no type B tympanogram with others there was better reading score in boys in those unaffected (p&lt;0.04) Stepwise multiple regression model, 37% of variance was explained as follows: 17% was classroom quality, 6% was phonology, 4% was social group of mother, 2% was type B tympanogram, 2% was absence from school and 1% was allergy</td>
<td>Engaged in post-hoc analysis before a correlation was found. Only one validated outcome measure.</td>
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<tr>
<td>Chalmers et al (1984), Silva, 1992 #13, Silva et al (1996)</td>
<td>Cohort (Level II)</td>
<td>N=1661 of a birth cohort of which 879 were seen at 5 years  N=47 who had bilateral OME at 5 years (includes those who were treated with ventilation tubes)  N= 357 who had no OME at 5 years</td>
<td>Bilateral OME tested by tympanometry and otoscopy at age 5</td>
<td>A wide range of outcomes measures including:  1. Picture Vocabulary Test for intelligence at 3 years  2. Stanford-Binet Intelligence Scale at 5 years  3. Wechsler Intelligence Scale for Children-Revised (WISC) at 7, 9 years  4. Reynell Developmental Language Scales for verbal expression and comprehension at age 3 and 5 years  5. Auditory Reception and Verbal Expression scales of the Illinois Test of Psycholinguistic Abilities  6. Dunedin Articulation Screening Scale at age 5 years  7. Dunedin Articulation Check at age 7 and 9 years  8. Burt Word Reading Test (Reading) at 7 and 9 years  9. Rutter Child Scale (Behavioural problems) 5, 7 and 9 years  10. Hearing loss tested by pure tone audiometry at 5.7 and 9 years of age</td>
<td>Significant results are as follows:  • At age 3 years, the verbal comprehension (p &lt; 0.01) and verbal expression (p &lt; 0.05) poorer in those with bilateral OME  • At age 5 years, Intelligence (p &lt; 0.01), Verbal comprehension (p &lt; 0.01), Verbal expression (p &lt; 0.05) and Behavioural problems as reported by teachers were poorer in those with bilateral OME  • At age 7 years only verbal expression (p &lt; 0.05) was poorer in those with bilateral OME  • No differences at age 9 years  • Hearing was significantly lower at all ages in those in the bilateral OME group (p &lt; 0.001), but this was largest at age 5 years (difference 15.6dB HTL) and dropping off at age 7 years to 2.8dB HTL, 9 years to 2.9dB HTL, and 11 years to 3.6dB HTL</td>
<td>A strength of this study is that it is population based. However, it is under-representative of Maori and Pacific Island children. It should be noted that out of the 47 children in the OME group, 22 had ventilation tubes. Confounding cannot be excluded as there was no multi-variate analysis or matching. However, there was no difference in socioeconomic status between the two groups. Outcomes measures at age 3 and 5 are before and simultaneous with the outcomes and therefore cannot indicate a causal relationship. Therefore the only measure of note is the one significant result at age 7 years.</td>
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<tr>
<td>Pennsylvania 1. (Feagans et al 1994)</td>
<td>Cohort (Level II)</td>
<td>N=46 Children followed from 12 and 24 months of age Children recruited from 3 pre-schools All attended &gt;30 hours per week</td>
<td>Two exposures measured: 1. OM measured by otoscopy and tympanometry. Children assessed weekly. Divided into those that had unilateral or bilateral OM &gt;20% (23) of the time chronic. Those that had CM &lt;20% (12) “non-chronic” 2. Day-care quality, rated as low quality (ratio of 1:8 for workers to adults) (n=17) high quality (ratio of 1:2-3) (n=18)</td>
<td>Language skills: 1. Attention to language task developed by researchers at 12-18 months 2. Sequenced Inventory of Communication Development (SICD) – of receptive and expressive language at 24 months Children were examined on two occasions, when they had an episode of OM and when they were well</td>
<td>Attention to language: No statistically significant difference in those with chronic OM and non-chronic OM when examined well No difference between those with chronic OM and those without in those attending “High Quality” day-care, but difference in those attending low quality day-care SICD: No difference in those with chronic and non-chronic OM in outcomes</td>
<td>Only 35 used in analysis and numbers very small with the sub-analyses. Blinding was present. Children at different pre-schools of similar socioeconomic background.</td>
</tr>
<tr>
<td>2. Vernon-Feagans et al (1997)</td>
<td>Cohort (Level II)</td>
<td>N=67 Children followed from 12 and 24 months Children recruited from 3 pre-schools All attended &gt;30 hours per week</td>
<td>As in Feagans et al (1994) Two exposures measured: 1. OM measured by otoscopy and tympanometry. Children assessed weekly. Divided into those that had unilateral or bilateral OM &gt;20% (30) of the time chronic. Those that had OM &lt;20% (37) “non-chronic” 2. Day-care quality, rated as low quality (ratio of 1:8 for workers to adults) (n=35) high quality (ratio of 1:2-3) (n=32)</td>
<td>Language skills: Sequenced Inventory of Communication Development (SICD) – of receptive and expressive language at 24 months Only those with chronic OM that attended low quality day-care had a significant difference in expressive language, but this was small F=3.58, p&lt;0.02 No difference in the groups for receptive language development</td>
<td>Only 46 children contributed to analysis due to incomplete data sets. Small numbers. Very inadequate reporting of the data. No acknowledgment of Feagans et al 1994 which looks to have some of the same subjects. Children at different pre-schools of similar socioeconomic background.</td>
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<tr>
<td>Nashville</td>
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<td>Speech, language and development outcomes evaluated at 2 years and 3-4:</td>
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<td>Of the original 210 there were only 156 evaluated at 2 years and 36 tested at 3-4 years. More concentrated on ACM, rather than OME.</td>
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<tr>
<td>Wright et al (1988)</td>
<td>Cohort</td>
<td>N=210</td>
<td>Two exposures measured:</td>
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<td>(Level II)</td>
<td>Normal babies recruited at birth</td>
<td>1. OM (acute OM and OME) - Diagnosed by otoscopy and tympanometry at 7 routine visits in the first year and 4 in the 2nd year. Divided into number of episodes and age of first episode. Examinations unilateral and bilateral. 2. Hearing tested by sound field examination at 2 years and 3-4 years</td>
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Screening Programmes for OME and Conductive Hearing Loss
The treatment of OME

There are a variety of interventions available for OME, all of which are intended to accelerate the resolution of the effusion in the middle ear. The most common first line treatment is long-course antibiotic therapy. Grommets (ventilation tubes) are the most common second line treatment for persistent OME (Appendix 2).

Little is known about the patterns of antibiotic use for OME in New Zealand. However, one study in New Zealand found that 77.6% of cases of OME were treated with antibiotics (Tilyard et al 1997).

Grommets, which were introduced into surgical practice in 1954 (Armstrong 1954), have become the most widely used surgical treatment. It is known that the rate of grommet operations has been increasing dramatically over the past decade (Solomon 1995).

Other treatments that have been used to a much lesser extent include decongestants, S-carboxymethylcysteine (SCMC) and its monohydrate salt (SCMC-LYS), steroids, autoinflation and instruction in nose-blowing techniques.

RCTs with appropriate outcomes measurements are the ideal study type designed to examine the effectiveness of therapeutic interventions and are assessed as Level I for the purposes of this review. There are a considerable number of RCTs that have examined these interventions. However, the majority of the RCTs have two shortcomings. Firstly, with the exception of one study (Rach et al 1991), all studies have only used intermediate outcome measures such as OME resolution and hearing improvement and not developmental outcomes measures. Secondly, most RCTs have inadequately short follow-up periods of only a matter of days.

LONG COURSE ANTIBIOTICS THERAPY

Long course antibiotics are thought to increase the speed of middle ear effusion by treating any bacterial infection present.

There have been two recently published meta-analysis that have examined RCTs of antibiotics in the treatment of OME (Table 5).

(Rosenfeld and Post 1992)

This meta-analysis examined 10 RCTs that trialed a 10-30 day course of antibiotics for OME. The methodology of the meta-analysis was explicitly stated and thorough. Quality criteria were applied to the RCTs and selection was based on these criteria. The short-term outcome measure; OME resolution within 20 days of the completion of treatment was chosen.

The results favoured treatment in all trials but one (Møller and Dingsor 1990). The pooled results showed that children in treatment groups were 22.8% (95% CI, 10.5-35.1) more likely to clear the OME than controls. Numbers needed to treat (NNT) to have one child with an improved outcome can be calculated from the data presented in this study at 4.4.

Unfortunately this meta-analysis chose only a short follow-up period (20 days) for analysis.

(Williams et al 1993)

Williams et al (1993) identified 14 trials for their meta-analysis. Again, the methodology was described and quality criteria were applied to the RCTs before selection.

This meta-analysis employed short-term outcomes of OME resolution within 1 month and longer-term outcomes of greater than one month. As with Rosenfeld and Post (1992) they found that treatment groups were more 16% more likely to resolve the OME compared to the controls in the short-term (95% CI, 3-29%). However, this meta-analysis found that there was no statistically significant difference in the treatment and control group in longer-term outcome measures of greater than one month.

Other RCTs

One RCT was identified since these two reviews were undertaken (Van Balen et al 1996). It examined 433 children aged 6 months to 6 years with persistent OME and randomised them to either treatment with co-amoxiclav or placebo. It found similar results to those in the meta-analysis above with statistically significant higher resolution rates in the treatment group at 2 weeks follow-up.

ANTIBIOTIC PROPHYLAXIS

One RCT was identified that trialed amoxicillin prophylaxis for recurrent middle ear effusion (Mandel et al 1996). One hundred and eleven children between the age of 7 months and 12 years who had a history of
OME or recurrent AOM were randomised to either treatment with amoxicillin (20mg/kg once daily) or to placebo for the duration of one year. Follow-up consisted of monthly otoscopy and tympanometry and 4 monthly audiometry.

The rates of OME recurrence in the treatment group were significantly lower at 1.53 compared to 2.15 in the control group (p=0.016). However, there was no documentation about adverse affects in the treatment group.

**SURGICAL TREATMENT**

Surgical treatments for OME include myringotomy, insertion of grommets (ventilation tubes), adenoidectomy and tonsillectomy.

Myringotomy is a surgical procedure that makes a hole in the eardrum to drain the effusion from the middle ear. This is most usually followed by the insertion of a grommet, a small plastic tube that remains in the eardrum for a variable length of time and continues to drain the effusion. This procedure is most usually performed as day surgery.

Adenoidectomy and tonsillectomy both involve the removal of lymphoid tissues from the nasopharynx. These procedures are thought to work in the treatment of OME by improving the functioning of the eustachian tubes and therefore aid in the draining of middle ear effusion.

There have been 19 RCTs that have examined surgical interventions in the treatment of OME (Refer to Table 6).

There is one recent systematic review on surgical interventions for OME, which has been produced by the UK’s NHS Centre for Reviews and Dissemination (Freemantle et al 1992).

*(Freemantle et al 1992)*

This systematic review examined RCTs of all types of surgical interventions, including grommets, adenoidectomy, tonsillectomy and myringotomy.

The study designs varied so greatly with regard to subject selection, intervention combinations, outcome measures and follow-up length, that meta-analysis was not possible, as noted by other authors (Bodner et al 1991).

Surgical interventions examined OME resolution as judged by otoscopy and audiometry were the most common outcome measures. The length of follow-up varied from 1 month to 7 years post intervention, with the majority being within 12 months. Only one study (Rach et al 1991) also used a developmental outcomes measure (Reynell Developmental Language Scale – RDLS-r).

It was found that both grommets (Black et al 1990, Dempster et al 1993, Maw and Herod 1986) and adenoidectomy (Black et al 1990, Bulman et al 1984, Dempster et al 1993, Maw and Herod 1986) reduce the mean hearing impairment in children with OME, but this reduction is small. The mean reduction is estimated to be less than 12 dB HL at 6 months and under 6 dB HL at 12 months for both grommets and adenoidectomy.

The one study that used a developmental outcome measure, Reynell Developmental Language Scale – RDLS-r (Rach et al 1991) did not show any difference in those treated with grommets and the controls.

The added benefit of combining grommet insertion and adenoidectomy treatments compared to either treatment alone is very small. Myringotomy alone was shown to be an ineffective treatment and there was no demonstrable additional benefit with tonsillectomy in conjunction with adenoidectomy.

The sequelae of surgical intervention include tympanosclerosis, chronic perforation and cholesteatoma. In the review grommet insertion was found to lead to tympanosclerosis (Bonding and Tos 1985, Brown et al 1978, Dempster et al 1993, Mandel et al 1989, Skinner et al 1988). Only one study (Skinner et al 1988) examined the long-term consequences of tympanosclerosis and it failed to show any effect on hearing impairment. However, the numbers in this study were small and the long-term consequences of tympanosclerosis are still unclear.

Grommet insertion also led to a slightly increased incidence of chronic perforation and possibly cholesteatoma (Bonding and Tos 1985, Brown et al 1978, Dempster et al 1993, Mandel et al 1989, Skinner et al 1988). Other risks are the slight risks of undergoing an anaesthetic and haemorrhage from adenoidectomy.

The only published report of RCTs following this review are from the continuation of a study reported in that review (Maw and Bawden 1993).

The clinical significance of these small improvements in hearing with adenoidectomy and grommet insertion is unclear. Because the studies were too small and not designed for subgroup analysis there is no reliable evidence about which factors may help predict which chil-
dren with glue ear will benefit most. It has been suggested that adenoidectomy may result in longer benefit and therefore reduce the need for re-insertion of grommets (Maw and Herod 1986), however, this would require further long-term studies to confirm this.

**TREATMENT OF OME WITH S-CARBOXYMETHYL-CYSTEINE (SCMC) AND ITS MONOHYDRATE SALT (SCMC-LYS)**

This is treatment thought to work as a muco-active substance and increase the clearance of middle ear secretions (Pignataro et al. 1996).

In a systematic review of RCTs it was found that current studies do not confirm the treatment’s effectiveness (Table 7).

**NOSE BLOWING**

Nose blowing has been promoted as an intervention to reduce OME. Its rationale is that nose blowing will improve the functioning of the eustachian tube and therefore promote the clearing of middle ear effusion.

A small RCT (Heaf et al. 1991) failed to show any benefit in teaching the technique of nose blowing in resolving OME of 84 children with OME. The 3½ to 4½ year old children were randomised to those receiving instructions of nose blowing and a control group. On testing at a 2-month interval no difference was found in the two groups with respect to pure tone audiometry.

**AUTOINFLATION**

Methods of forcing air under pressure through the Eustachian tube such as the Valsalva manoeuvre and Politzerization have been used since the 18th century to allow draining fluid from the middle ear (Blanshard et al. 1993).

Two RCTs were identified that examined the effectiveness of this technique using a recently introduced device consisting of a rounded plastic nosepiece to which a balloon is attached. These studies reported increased OME resolution in the treatment group, but this was confined to subjects that were compliant (only 45% of children). Only short-term outcomes were reported (Standerup et al. 1992, Blanshard et al. 1993).

**STERIODS**

Steroids have been thought to hasten the resolution of OME by reducing the effusion in the middle ear. Steroids are not commonly used in the treatment of OME in New Zealand.

RCTs that have examined steroid use have shown either no effect (Macknin and Jones 1985) or reported some improvement, but have only examined children at the completion of treatment (Rosenfeld et al. 1991).

**DECONGESTANTS**

Decongestants are thought to be active in reducing middle ear effusion by reducing the congestion of the mucosa in the eustachian tube.

Two RCTs were identified. Both reported no difference in resolution of effusion in children with OME treated with decongestants than controls, but a higher rate of side effects (O’Shea et al. 1982, Cantekin et al. 1983).

**CONCLUSION**

- Long-course antibiotics increases the resolution rate of OME in the short-term (<1 month), but not in the longer-term (> 1 month).
- Antibiotic prophylaxis has been shown in one RCT to decrease the rate of OME recurrence
- Grommets and adenoidectomy offer modest improvements in hearing
- Myringotomy, tonsillectomy, SCMC, nose-blowing, steroids and decongestants are not effective in OME resolution
- Autoinflation may offer short-term OME resolution, but has very poor compliance
- The clinical significance of the short-lived and modest improvements in OME resolution and improvement in hearing shown by long-course antibiotics, antibiotic prophylaxis, grommets and adenoidectomy is yet to be determined, as studies that have examined disability related outcomes are not available.
- More RCTs that measure developmental outcomes and have longer follow-up periods are required to determine whether the therapeutic interventions discussed here are valuable in the treatment of OME.
Table 5. Summary table of reviews examining antibiotic treatment of OME

<table>
<thead>
<tr>
<th>Systematic Review</th>
<th>Intervention and outcome measures</th>
<th>Subjects</th>
<th>Literature search strategy and criteria for inclusion</th>
<th>Studies included</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
</table>
Table 5. Summary table of reviews examining antibiotic treatment of OME (continued)

<table>
<thead>
<tr>
<th>Systematic Review</th>
<th>Intervention and outcome measures</th>
<th>Subjects</th>
<th>Literature search strategy and criteria for inclusion</th>
<th>Studies included</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Williams et al (1993) | Antibiotic treatment of OME | N—? Children - no age range stated | Studies of antibiotic use for the treatment of OME were identified through a MEDLINE search from 1966 to April 1993. Bibliographies of articles were searched. Only published RCTs of the use of antibiotics in OME were selected (also looked at AOM) (Level I) | **14 trials** | **Short-term effects of OME treatment using the patient as the outcome (12 studies):**  
- 10 out of the 12 studies showed an effect with treatment  
- The pooled risk reduction of OME resolution between the treatment and control group was 0.16 (95% CI, 0.03-0.29)  
**Short-term effects of OME treatment using the ear as the outcome (8 studies):**  
- 7 out of the 8 studies showed an effect with treatment  
- The pooled risk reduction for OME resolution between the treatment and control groups was 0.25 (95% CI, 0.11-0.46)  
**Intermediate and long-term effects of OME treatment (8 studies):**  
- Only 5 of the studies showed an effect with treatment  
- The pooled risk reduction was 0.06 (95% CI, -0.03-0.14) | This meta-analysis considered both the short-term and longer-term effectiveness of antibiotics. This included several studies not found in Rosenfield and Post 1992. |
Table 6.  Summary table of reviews examining surgical treatment of OME

<table>
<thead>
<tr>
<th>Systematic review</th>
<th>Intervention and outcome measures</th>
<th>Subjects</th>
<th>Literature search strategy and criteria for inclusion</th>
<th>Studies included</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
</table>
Table 7. S-Carboxymethylcysteine (SCMS) and its Monohydrate Salt (SCMC-LYS)

<table>
<thead>
<tr>
<th>Systematic review</th>
<th>Intervention and outcome measures</th>
<th>Subjects</th>
<th>Literature search strategy and criteria for inclusion</th>
<th>Studies included</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pignataro et al (1996)</td>
<td>Treatment of OME with S-carboxymethylcysteine (SCMC) and its monohydrate salt (SCMC-LYS)</td>
<td>N=413 Children aged 1-12 years</td>
<td>RCTs of this treatment were identified on EMBASE, BIOSIS, MEDLINE databases from 1972. (Level I)</td>
<td>6 trials included: 1. Form and et al (1991) 2. Hughes (1984) 3. Kumaizawa and et al (1988) 4. Ramsden et al (1977) 5. Spigioo and et al (1981) 6. Taylor and Daneeshni (1975)</td>
<td>• There was no statistically significant difference between the treatment group and controls with regard to improvement in tympanography CR 2.25, CI 0.975-3.22, P&lt;0.058  • The children were more likely to avoid operation CR= 2.31 (CI 1.2-4.20, P&lt;0.01)</td>
<td>The result of avoiding operation is open to bias because of possible problems with blinding</td>
</tr>
</tbody>
</table>
Screening techniques and programmes for OME and conductive hearing loss

INTRODUCTION

The evaluation of screening techniques and programmes for OME is vital in establishing the effectiveness of the programme. There have been numerous studies that have examined screening techniques for OME and conductive hearing loss, but very few that have examined screening programmes.

SCREENING TECHNIQUES

There are a variety of different screening techniques used for the detection of OME and conductive hearing loss. These include otoscopy, tympanometry, audiometry, otoacoustic emissions and parental reporting.

Otoscopy

Otoscopy appears to be widely used in primary health care practice as a screening and diagnostic technique, but has not seen wide adoption in mass screening programmes.

The accuracy of otoscopy in detecting OME is largely dependent on the skill of the user. In those that are highly skilled in its use, a sensitivity of around 90% and a specificity of 75% have been described (Maw 1979, Cantekin et al 1980, Paradise et al 1976, Vaughan-Jones and Mills 1992). However, this may be very much lower in those less skilled, making it an impractical screening technique.

Tympanometry

Tympanometry is now the most widely used screening technique for the detection of OME in mass screening programmes, but like otoscopy; it is not a test for hearing impairment. It has also been used increasingly in the primary care practice setting, as more affordable micro-tympanometry machines have become available (Greville 1995).

Tympanometry has been shown to have high sensitivity and specificity in the detection of OME. It has most usually been validated against the findings at the time of surgery in children diagnosed as having persistent OME. The finding of a type B tympanogram (Appendix 1) has a sensitivity of 91% and a specificity of between 79 and 90% (Orchik et al 1978, Watters et al 1997). The specificity is lower if both type B/C2 tympanograms are considered with a sensitivity of between 88%-94.4% and specificity 52.9%-71% (Vaughan-Jones and Mills 1992, Fields et al 1993, Ovesen et al 1993).

Microtympanometers have somewhat similar results to other tympanometers. Studies have shown a more variable range of sensitivity and specificity. If type B/C2 tympanograms are considered, then a sensitivity of 100% and specificity of 75% has been demonstrated. If only type B, sensitivity of 78%-90% and specificity of 63%-94% have been reported (de Melker 1992, Vaughan-Jones and Mills 1992, Koivunen et al 1997). They have the advantage of being more easily affordable for the use in general practice.

Tympanometry has many of the other qualities of a screening test that is suitable for a screening programme. It is rapid, painless and convenient to use and has a high level of compliance from young children (Paradise et al 1976). It can also be used in children from as early as seven months of age (Paradise et al 1976).

Although tympanometry is not a hearing test, it is a predictor of conductive hearing loss. A type B tympanogram is associated with hearing impairment ≥ 25 dB in only 49% - 66.4% of children (Dempster and Mackenzie 1991, Kazanas and Maw 1994). Whereas, the proportion of children without a type B tympanogram who have a hearing loss of ≥25 dB is only in the order of 2% to 13% (Dempster and Mackenzie 1991, Kazanas and Maw 1994).
**Audiometry**

Audiometry is a test for hearing impairment. It is not a direct test for OME; however, it does detect the conductive hearing impairment associated with OME. It can also detect sensorineural hearing impairment.

It is a less straightforward screening technique than tympanometry. It requires quite specific conditions including, skilled staff to administer the test, audiometry equipment and quiet conditions in which to undertake the test.

As the test requires considerable cooperation, it is difficult to administer before to children younger than 4 years. However, this age may be reduced by the use aids such as Visual Reinforced Audiometry (Hamill 1988) and behavioural audiometry (Baart de la Faille 1991, Fria et al 1985).

**Transiently evoked otoacoustic emissions**

Otoacoustic emissions (OAEs) are low-level sounds produced by the normal cochlear. Instrumentation that produces acoustic clicks or tone bursts can evoke these emissions and these are called “transiently evoked otoacoustic emissions” and will only be produced by a normal cochlear (TEOAEs) (Richardson 1995). TEOAEs are being increasingly used for testing the cochlear function of neonates.

More recently, TEOAEs have been proposed as a test for hearing in children to detect conductive hearing loss. However, this is still in the early stages of development, but are mentioned here, as they may have a place in hearing assessment of younger children in the future (Amedee 1995).

**Parental reporting**

Leaflets such as “Can your child hear” have been used in New Zealand to promote parental awareness and reporting of children’s hearing impairment (Anonymous 1992, Appendix 3). However, the value of parental reporting as a predictor of OME and conductive hearing loss has not been fully evaluated. It appears likely that is an inaccurate method of identification of OME affected children (Haggard and Hughes 1991).

**SCREENING PROGRAMMES**

Screening for OME and conductive hearing loss may be in the form of opportunistic screening in the primary care setting or formal mass screening programmes, both of which occur in New Zealand (Greville 1995).

The ideal type of study to evaluate the effectiveness of such screening programmes is a RCT. However, there were no RCTs identified in the literature. Five cohort studies of OME and conductive hearing loss formal screening programmes were identified. Of these, 2 examined health outcomes of screening programmes and 3 examined confirmation of diagnosis as the outcome. Two audits of New Zealand OME screening programmes were identified. No studies, either in New Zealand or internationally, were identified that examined opportunistic screening of OME and conductive hearing loss in primary care.

Research in the area of screening for OME and conductive hearing loss is difficult. Firstly, research is logistically challenging and costly because of the need to recruit a large number of subjects and to follow them up over long time periods that may involve months to years. Secondly, screening is now so widespread, that research may now be seen as unethical.

A further difficulty in the research on OME screening programmes is that studies may lack generalisability. This is because there is a near limitless number of ways in which a screening programme may be constructed (referred to as algorithms). Some of the parameters that may vary in a screening algorithm include:

- age at testing
- choice and combination of screening tools
- the type and training of the tester
- the setting in which the screening takes place
- the failure criteria
- the retest frequency and interval

The implication of this is that results of studies examining one type of screening programme with a particular algorithm may not be able to be generalised to other screening programmes.

There have been many different algorithms that have been developed and examples of these include:

- The ASHA algorithm (American Speech Language Hearing Association) – a two step algorithm using tympanometry as the only screening tool. Children with abnormal tympanograms at either the 1st (C2/B) or 2nd (A-/C1-/C2-/B) screen are recommended for referral (Lous 1987).
- The Nashville algorithm is a three-step algorithm using tympanometry as the only screening tool. Children with abnormal tympanograms (A-/C₁-/C₂/B) are referred only after a further abnormal finding on the 2\textsuperscript{nd} or 3\textsuperscript{rd} screening episode (Lous 1987).

- The Hirtshal algorithm is a three-step algorithm using tympanometry as the only screening tool. Children with abnormal tympanograms are referred only after a further abnormal finding on the 2\textsuperscript{nd} (B) or 3\textsuperscript{rd} (C₂/B) episode (Lous 1987).

- Cantekin et al (1980) a more complicated algorithm, which involves a combination of tympanometry, otoscopy and middle ear muscle, reflex.

- The New Zealand national screening programme algorithm which involves a 2-step algorithm using tympanometry alone at age 3 years and a 2-step algorithm at 5 years involving both tympanometry and audiology (Appendix 4).

Lous (1987) demonstrated that the sensitivity, specificity and positive predictive value (PPV) of different algorithms varies greatly. In a cohort study, 387 7-year children were tested on 9 occasions with tympanometry over a period of one year. The sensitivity, specificity and positive predictive value (PPV) of several algorithms to predict a child with persistent OME (defined as with OME on 5 occasions) in this population were calculated. Along with the ASHA, Nashville and Hirtshal algorithms, an algorithm very similar to that used in New Zealand (Type B tympanogram two consecutive occasions) was examined.

This study demonstrated that the ASHA and Nashville algorithms had reasonable sensitivity in detecting a child with persistent OME, but poor specificity and PPV and high referral rate. In other words, these algorithms identified those children with persistent OME well, but this was at the expense of identifying many children who did not have persistent OME and consequently would lead to over referral of children. The Hirtshals algorithm had a similar sensitivity, but higher specificity and PPV and a much lower referral rate. In other words this algorithm had a similar chance to detecting children with persistent OME, but was less likely to identify and refer children who did not have persistent OME.

The algorithm similar to that used in New Zealand for 3 year old preschool children had a low sensitivity, but high specificity and PPV and low referral rate. However, this cannot be directly compared to the New Zealand programme, as PPV is dependent on the prevalence of OME in the population.
**Table 8.** Sensitivity, specificity and PPV of several screening algorithms (Lous 1987b)

<table>
<thead>
<tr>
<th></th>
<th>ASHA</th>
<th>Nashville</th>
<th>Hirshals</th>
<th>Type B on 1 occasion</th>
<th>Type B on 2 consecutive occasions</th>
<th>Type B on 3 consecutive occasions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>83%</td>
<td>90%</td>
<td>80%</td>
<td>65%</td>
<td>50%</td>
<td>42%</td>
</tr>
<tr>
<td>Specificity</td>
<td>71%</td>
<td>67%</td>
<td>95%</td>
<td>96%</td>
<td>90%</td>
<td>99.6%</td>
</tr>
<tr>
<td>Positive predic-</td>
<td>15%</td>
<td>14%</td>
<td>48%</td>
<td>50%</td>
<td>71%</td>
<td>90%</td>
</tr>
<tr>
<td>tive value (PPV)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Referred</td>
<td>32%</td>
<td>36%</td>
<td>9%</td>
<td>6%</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>Retested</td>
<td>31%</td>
<td>52%</td>
<td>45%</td>
<td>0%</td>
<td>6%</td>
<td>10%</td>
</tr>
</tbody>
</table>
This study did usefully demonstrate that the choice of algorithm is very important in a screening programme for OME. Unfortunately, no studies were identified that would allow for the calculation of sensitivity, specificity, PPV or NPV of the screening algorithms used in New Zealand preschool and new entrant children.

**Cohort studies using health outcome measures**

Only two of the cohort studies that studied screening programmes for OME and conductive hearing loss examined health outcomes. Neither of these studies demonstrated any improvement in health outcomes in children screening for OME and conductive hearing loss.

In a large cohort study in the Nijmegen in the Netherlands, Zielhuis et al (1989) recruited 1328 2 year old children (92.3% of the population) for a screening programme specifically for OME that involved home based testing. Tympanometry was performed at 3 monthly intervals over a 2 year period. Children that had a bilateral type B tympanogram on 2 successive occasions were referred to an ENT surgeon via their general practitioner. Of the 144 children referred to the ENT surgeon, 52 were randomised to either treatment with grommets or a control group. There was no significant difference in the language test performance between the treated children and the controls.

Although this study did not demonstrate any health benefits to those treated with grommets following intensive screening; the numbers involved in the RCT of surgical intervention were small and may not have been of sufficient power to demonstrate a difference.

The other study that examined health outcomes in a screening programme compared two cohort groups. Feldman et al (1980) conducted a prospective cohort study of two distinct geographic populations of children at school entry. Children were screened with two step audiometry for hearing impairment and referred to their general practitioner if they failed on 2 occasions. Children were screened again 6-12 months later, at which time no difference was found in the performance on audiometry in the two populations. This study unfortunately did not document what action if any was taken for the children who failed the first screen, so little can be concluded about this result.

Neither of the studies had a screening algorithm similar to that used in New Zealand.

**Cohort studies using ENT diagnosis outcomes**

In the 3 other cohort studies, the measured outcomes were confined to the diagnosis at the time of ENT specialist assessment.

In a study in Canada, O’Mara et al (1992) approached 1844 preschool children aged 3-4 years for screening with a one off audiometry screen. Only 2% of children failed with the screening programmes’ high failure criteria. From the reported results it could be calculated that 369 children needed to be screened to find one new case of hearing loss. The cause of hearing impairment was not documented.

Augustsson et al (1990) of Sweden also examined a one step screening programme using audiometry at 4 and 7 years of age. The criteria for failure were lower than O’Mara et al (1992) and consequently a higher failure rate of 8% was found. Of those detected, 39.6% had SOM, 3.7% had sensorineural impairment, 25.7% had known problems and 28% had wax or no problem. A numbers needed to screen at 4 years of age to detect a case of persistent SOM was 75.2 and at 7 years this rose to 413.7.

In Denmark, Fiellau-Nikolajsen and Lous (1982) conducted a prospective study of a screening programme that enrolled just over 500 children (1005 ears) at age 3 years and followed them with serial tympanometry on 4 occasions over 6 months. There were 46 children identified with persistent SOM, giving a numbers needed to screen at 10.9.

Again, these studies demonstrate the differences that different screening algorithms have on such outcomes as the number of referrals.

**New Zealand research**

Two studies examining OME screening conducted in New Zealand were identified.

Claridge et al (1995) examined the referral chain for children who failed the 5 year old screening examination with tympanometry and audiometry in Christchurch. This study reported time delays in children attending their general practitioners after referral from the Hearing and Vision Testers. Waiting times of 20 weeks to a public ENT specialist and 5 weeks to a private specialist were also noted.
In the other New Zealand study, Crampton et al (1996) reported an audit of a pilot screening programme for OME in children under 5 years of age in Porirua after 13 months of operation. Children were screened at 9, 15, 18 months and 2, 3, 4 years by tympanometry. A complex algorithm to determine referral that differed from the established New Zealand screening programme was used. A high percentage of those screened were referred to an ENT specialist (19.3%). They estimated the costs of screening one child as $46.10, the cost of detecting a one case of bilateral OME as $92.85 and the cost of detecting one child that required referral as $117.03.

Unfortunately, there has been no study conducted in New Zealand that fully evaluates that current screening programme for OME and conductive hearing loss.

CONCLUSIONS

- Tympanometry has many of the attributes of a suitable test-screening test for OME.
- Audiometry appears to be a suitable test for conductive hearing loss, but is more difficult to administer to children under the age of 4 years.
- Screening programmes for OME and conductive hearing loss may vary greatly in the way they are constructed (algorithm) and consequently vary in their sensitivity, specificity, PPV and NPV.
- No RCTs were identified that examined screening programmes for OME and conductive hearing loss.
- Two cohort studies were identified that examined health outcomes in screening programmes for OME. Neither demonstrated a health outcome benefit, however both were deficient in their design and not comparable to the New Zealand screening programme.
- Three cohort studies were identified that used diagnostic confirmation by an ENT specialist as the outcome measure. These studies demonstrated the dramatic effect different algorithms of screening have on the referral rate.
- Two studies were identified that examined screening programmes for OME in New Zealand. Neither examined the either the diagnostic outcome at the ENT clinic or health outcomes.
- No studies were identified that examined the effectiveness of opportunistic screening for OME and conductive hearing loss in the primary care setting.
- Research is inadequate to either support or refute the effectiveness of screening programmes for OME and conductive hearing loss, including the New Zealand screening programme.
Table 9. Summary table of studies examining screening programmes for otitis media with effusion

<table>
<thead>
<tr>
<th>Study</th>
<th>Study type</th>
<th>Sample</th>
<th>Condition surveyed</th>
<th>Screening algorithm used</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nijmegen, Netherlands Zielhuis et al (1989) &amp; Rech et al (1991)</td>
<td>Cohort study with RCT for treatment with grommets</td>
<td>From N= 1439 (All children in one Nijmegen were invited on turning 2 years) N= 22 who were randomised to grommets N= 21 who were controls</td>
<td>CME</td>
<td>Tympanometry at 3 monthly intervals from the age of 2 to 4 years Performed at home Children with bilateral type B tympanograms on 2 successive occasions were referred to ENT surgeon via a general practitioner</td>
<td>Language outcome: Reynell Developmental Language Scales for verbal expression and comprehension</td>
<td>Population based. Outcome measure is based on health outcome of disability. Few subjects at in the trial may have meant insufficient power: • 1439 invited/ 1328 participated. • 288 had 2 successive bilateral type B tympanograms. • 144 referred to ENT. • 84 eligible for the trial. • 52 consented and 43 completed the trial.</td>
</tr>
<tr>
<td>Study Type</td>
<td>Sample Description</td>
<td>Condition Description</td>
<td>Screening Algorithm Used</td>
<td>Results</td>
<td>Comments</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Feldman et al. (1989)</td>
<td>Proprietary study conducted in a public hospital, involving two geographical areas.</td>
<td>N=723 were not screened, based on test results.</td>
<td>AGE not specified</td>
<td>Test results were similar, but no further details provided.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Koh et al. (2000)</td>
<td>Proprietary study conducted in a public hospital, involving two geographical areas.</td>
<td>N=723 were not screened, based on test results.</td>
<td>AGE not specified</td>
<td>Test results were similar, but no further details provided.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pohl et al. (2001)</td>
<td>Proprietary study conducted in a public hospital, involving two geographical areas.</td>
<td>N=723 were not screened, based on test results.</td>
<td>AGE not specified</td>
<td>Test results were similar, but no further details provided.</td>
<td></td>
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</tbody>
</table>

Table 9. Summary table of studies examining screening programmes for otitis media with effusion (continued)
### Table 9. Summary table of studies examining screening programmes for otitis media with effusion (continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Study type</th>
<th>Sample</th>
<th>Condition surveyed</th>
<th>Screening algorithm used</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian</td>
<td>Retrospective cohort</td>
<td>N=1844 approached</td>
<td>Hearing impairment</td>
<td>One step algorithm with pure tone audiometry at 500, 1000, 2000 and 4000 kHz</td>
<td>Only 2% failed (35)</td>
<td>Outcome measure is based on the diagnosis and this is limited only of the child and not any health outcome. Only based in childcare centres. High level of lack of cooperation. Even though this programme with examining hearing impairment, the main outcomes were OME.</td>
</tr>
<tr>
<td>O’Meara et al</td>
<td>study</td>
<td>N= 1830 screened</td>
<td></td>
<td></td>
<td>Of these only 29 were contactable</td>
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<tr>
<td></td>
<td></td>
<td>(186 were uncooperative with audiometry)</td>
<td></td>
<td></td>
<td>26 went to seek follow-up (2 who did not were already known to have ear problems)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Children 3 and 4 years attending child care centres</td>
<td></td>
<td></td>
<td>Of these 26:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- 14 received some form of treatment for their ear problems</td>
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<td></td>
<td></td>
<td></td>
<td>- 15 were referred to a ENT specialist or paediatrician</td>
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<td></td>
<td></td>
<td>- 11 had their hearing tested with 8 having confirmed impairment (only 5 were new and all had OME, which was 0.3% of the original population)</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>PPV was 31%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NNS was 1844/8 = 230.5 for one case of confirmed hearing impairment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NNS was 1844/5 = 369 for one new case of confirmed hearing impairment</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Study type</td>
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<td>Screening algorithm used</td>
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<td>Comments</td>
</tr>
<tr>
<td>-------</td>
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</tr>
</tbody>
</table>
| Sweden Augustsson et al (1990) | Prospective cohort study           | N = 2460 of which N = 2330 were actually screened at age 4 years N = 2482 were screened at 7 years | Hearing impairment | One step algorithm with pure tone audiometry at 500, 1000, 2000, 4000 and 6000 kHz Children were referred to ENT specialist if they had 2 failures at 25 dB between 500-2000 kHz 1 failure at 40 dB at 500-4000 kHz 1 failure at 50 dB at 600kHz Those that failed were referred to ENT specialist who reviewed those with SOM again in 4-6 weeks | At 4 years:  
  - 167 had hearing impairment (8%)  
  - At the first visit, of these 39.6% (74) had SOM, 3.7% (7) had sensorineural impairment (2 were serious), 25.7% had known problems, 28% had no problems or wax and 3% were not seen  
  - The children with SOM (74) who were reviewed again, only 41.9% (31) had persistent SOM and of these 27 were treated  
  - NNS for persistent SOM was 75.2  
At 7 years:  
  - 146 had hearing impairment (5.9%)  
  - At the first visit, of these 17.8% (26) had SOM, 2.7% had sensorineural hearing impairment (all mild), 41.1% had known problems, 34.2% had either wax or no problems and 4.1% were not seen  
  - The children with SOM (26), only 23.1% had persistent SOM  
  - NNS for persistent SOM was 2442.6 = 413.7 | Population based. Did not state numbers that were uncooperative. |

Table 9. Summary table of studies examining screening programmes for otitis media with effusion (continued)
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<table>
<thead>
<tr>
<th>Study</th>
<th>Study type</th>
<th>Sample</th>
<th>Condition surveyed</th>
<th>Screening algorithm used</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark. Feilauer, Nikolajsen and Lous (1982)</td>
<td>Prospective cohort study</td>
<td>N= 1005 ears on children aged 3 years. N= 704 ears screened again at age 6 years</td>
<td>SOM</td>
<td>At 3 years: Typanometry at 3 years of age and repeated 1.3 and 6 months after the initial test, if the tympanogram was C1/C2/B (if A the ear was tested again) At 6 years Typanometry Pure tone audiometry Otoscopy</td>
<td>At 3 years: 46 children had consistently type C or B tympanograms and were treated with adenoidectomy and myringotomy. Of the 18 ears later had grommets. NNS 105/2/46 = 10.9 At 6 years: 9.3% ears had Type B tympanogram 7.1% failed the audiometry Single type B tympanogram at age 3 was not predictive of problems at age 6 Repeated type B tympanograms with persistence over 3 months was predictive of type B tympanogram at 6 years (no statistical analysis)</td>
<td>Population based. Swaps between discussing ears and children and makes interpretation difficult.</td>
</tr>
<tr>
<td>Christchurch, New Zealand Claridge et al. (1995)</td>
<td>Audit of the referral clinic after screening positive / cross-sectional study</td>
<td>N= 508 preschool children who failed screening</td>
<td>CME</td>
<td>Typanometry screening at age 3–4 years and 5 years: children with type B tympanogram referred at a 10–16 week interval. Those failing the 2nd test are referred to their general practitioner</td>
<td>78% had been rested within 20 weeks, 95% by 40 weeks 67% had visited their general practitioner within 4 weeks of failing their test: 87% had by 20 weeks the mean time interval between general practitioner visit and consultation with ENT specialist was 20 weeks in the public system and 5 weeks in the private system (p &lt;0.001)</td>
<td></td>
</tr>
</tbody>
</table>

SCREENING PROGRAMMES FOR OME AND CONDUCTIVE HEARING LOSS
Table 9.  Summary table of studies examining screening programmes for otitis media with effusion (continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Study type</th>
<th>Sample</th>
<th>Condition surveyed</th>
<th>Screening algorithm used</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUCHS' New Zealand Crampton et al (1996)</td>
<td>Audit of pilot screening programme of first 13 months of pilot</td>
<td>N=731 children under the age of 5 years were screened in a pilot CME screening programme in an ethnically mixed low socio-economic status population</td>
<td>CME</td>
<td>Tympanometry screening at age 9, 15, 18 months, 2, 3, 4 years:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- 91.2% of the population participated, with 2.6 tests per individual 
- 40.7% had bilateral CME at least once, of these, 68% were treated with antibiotics 
- 19.3% (141) were referred to a public ENT clinic 
- Average waiting time was 159 days 
- 22.7% failed to attend appointments at the ENT clinic 
- Average cost of each child screened was $46.10 
- Cost of the detection of a case of bilateral CME was $92.85 | Protocol for referral criteria changed during pilot, because of high rates of referrals. Screening was undertaken by nurse practitioner and testing occurred at home. Intensive efforts made for recall. No health outcomes recorded. |
Summary

The objective of this report was to undertake a review of research on the effectiveness of preschool and school entrant screening programmes for otitis media with effusion and conductive hearing loss.

OME and associated hearing loss is widely recognised as an important health issue for New Zealand children, particularly in Maori and Pacific Island children who have high levels of OME. Screening programmes designed to detect OME are seen as an important measure to detect children who may benefit from treatment of OME. However, concerns have been expressed over whether current screening for OME is effective.

RESEARCH QUESTIONS

What is the prevalence of the OME and conductive hearing loss between the ages of 0 and 5 years?

Prevalence of OME is high in children with peaks at age 2 and 5 years as high as 20%. OME appears to be more common in Maori and Pacific Island children than non-Maori/Pacific Island children.

What is the natural history of OME and conductive hearing loss?

The natural history of OME is responsibly well understood.

OME frequently follows episodes of upper respiratory infection. It has high rates of spontaneous resolution and may be unilateral or bilateral. Those children with more persistent OME appear to have more frequent rather than longer duration episodes of OME. Hearing impairment is found in around 50% of children with OME. There are a number of associated risk factors including male gender, socioeconomic group, exposure to tobacco smoke, bottle-feeding and attendance at day-care centres.

What are the consequences of OME and conductive hearing loss in terms of disability at that time or later?

Studies have attempted to establish the link between OME and conductive hearing loss and developmental delay and disability. These studies results are conflicting and cannot support or refute a relationship between OME, conductive hearing loss and disability.

What is the effect of treatment on OME conductive hearing loss on hearing and on disability?

Long-course antibiotics appear to increase the rate of resolution of OME, but this benefit is only short-term (<20 days). Grommets and adenoidectomy offer modest improvement in hearing. Prophylactic antibiotic therapy appears to reduce the frequency of OME episodes.

However, the effect of treatment on the prevention of disability cannot be determined because, with the exception of one study, studies have not examined disability-related outcomes.

Is there a suitable screening test for OME and conductive hearing loss?

Tympanometry and audiometry fulfil most of the criteria for a suitable screening test for OME and conductive hearing loss.

What is the evidence of effectiveness of screening programmes for OME and conductive hearing loss?

Current research cannot support or refute the effectiveness of screening programmes designed to detect OME and conductive hearing loss in improving disability related outcomes.

CONCLUDING COMMENTS

It can be demonstrated that OME and conductive hearing loss are common in preschool and new entrant school children, particularly in the Maori and Pacific Island children. However, it cannot be either confirmed or refuted as to whether there are any long-lasting effects from OME and conductive hearing loss, whether treatment is effective in reducing possible long-lasting effects or whether screening programmes are effective. Unfortunately, it is therefore not possible to conclude from
the literature reviewed in this report, if screening programmes for OME and conductive hearing loss in preschool and school entrant children are an effective health strategy.

More specifically, conclusions cannot be drawn on specific aspects of the current screening programme for OME and conductive hearing loss. Currently no recommendation can be made on:

- High risk targeted screening
- Changing the age of screening (either younger or older)
- Changing the screening interval

Similarly, it must also be noted that it cannot be concluded that current screening programmes for OME and conductive hearing loss in New Zealand are ineffective.

To determine whether screening programmes for OME and conductive hearing loss in preschool and new entrant school children are an effective health strategy, more research is needed. Although research is difficult in this area, a thorough critical evaluation of New Zealand's own screening programme and its outcomes would be help in part to determine the best choice for effective health strategies for OME and conductive hearing loss.
References


### Appendix 1

**TYPICAL TYMPANOGRAMS**

<table>
<thead>
<tr>
<th>SHAPE</th>
<th>READINGS</th>
<th>INTERPRETATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TYPE A</strong></td>
<td>MEP: −100 to +100 daPa Comp: 0.3 to 1.6ml P. Vol: (approx) Adults: 1.0 to 1.5ml Children: 0.7 to 1.0ml</td>
<td>normal normal normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TYPE B</strong></td>
<td>MEP: not definable Comp: less than 0.3 ml P. Vol: smaller than normal within normal range significantly larger than normal (ie ≥ 2.5 in adult) (ie &gt; 2.0 in child)</td>
<td>wax middle ear effusion perforation or grommet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TYPES C</strong></td>
<td>MEP: more negative than −100 daPa Comp: normal P. Vol: normal</td>
<td>eustachian tube obstruction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TYPE Ad</strong></td>
<td>MEP: normal Comp: greater than 1.6ml P. Vol: normal</td>
<td>Healing perforation. Possible ossicular chain discontinuity Atrophy of ear drum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TYPE As</strong></td>
<td>MEP: normal Comp: less than 30ml P. Vol: normal</td>
<td>Scarring or adhesions Possible ossicular fixation</td>
</tr>
</tbody>
</table>

Source: Department of Health 1992
Appendix 2

RECOMMENDED TREATMENT OF OME

Acute otitis media → Chronic middle ear effusion

Prescribe 1-week course of antibiotic, eg. amoxycillin → Longer course antibiotic, eg. co-trimoxazole for 3 weeks

Frequently recurrent otitis media → Resolution ? until next time

Long term antibiotic prophylaxis, eg. co-trimoxazole 480mg daily for 6 months or Consider tympanostomy tubes: ? Adenoids, especially over 2 years old ? Sinusitis, especially over 5 years old

Resolution ? until next time → Failure to respond → Persistent effusion for >3 months or significant hearing loss or other significant symptoms

Tubes out ? start again

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## Appendix 3

### CAN YOUR CHILD HEAR

Check these developmental stages with parents:

<table>
<thead>
<tr>
<th>6 WEEKS</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>When there is a sudden loud noise, does your baby:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• jump or blink</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• stir in his or her sleep</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• stop sucking for a moment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• look up from sucking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• cry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When you talk, does your baby:

- seem to be aware of your voice
- stop sucking or crying

<table>
<thead>
<tr>
<th>3 MONTHS</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your baby:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• blink or cry when there is a sudden noise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• stop crying or sucking when you talk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• wake or stir to loud sounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• oo or smile when you talk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• turn his or her eyes towards voices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• seem to like a musical toy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• stop moving when there is a new sound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• seem to know your voice</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6 MONTHS</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your baby:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• turn towards a sound or someone speaking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• smile when you talk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• cry when there is a sudden noise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• stop moving when there is a new sound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• like music</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• make lots of different babbling sounds</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9 MONTHS</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your baby:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• respond to his or her own name</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• look around to find new sounds, even quiet sounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• understand “no” and “Attrib”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• listen when people talk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• like copying sounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• use babbling that sounds like real speech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• try to talk back when you talk</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12 MONTHS</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your baby:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• point to things and people he or she knows when asked to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• copy or repeat simple words or sounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• try to talk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• understand things like “come here”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• use his or her voice to get attention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• say 2 or 3 words</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• listen when people talk</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>18 MONTHS</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your baby:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• do what he or she is told</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• say sentences with 2 words in them like “me drink”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• know a few parts of the body</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• do one thing when asked, like “get your shoes”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• ask for things by pointing and trying to say the word</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• understand things like “give me that” and “don’t touch”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2 YEARS</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your child:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• do 2 things when asked, like “get the ball and bring it here”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• repeat what you say</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• know lots of words</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• like being read to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• point to a picture when asked, like “show me the baby”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3 YEARS</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your child:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• knows a few nursery rhymes or songs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• understand most words</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• find you when you call from another room</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• sometimes use whole sentences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• use words like “go, me, in, big”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• tell a story</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• say now he or she feels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• remember and tell about things that have happened</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• count to 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• speak clearly so that everyone can understand him or her</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• ask lots of “why” and “what” questions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• like naming things she or he sees and knows</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4 YEARS</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your child:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• tell a long, clear story about things he or she has done</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• speak well with only a few sounds wrong, like “s, th, l”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• know what things are for, like hat, apple, plate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• like books and being read to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• understand most of what you say</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SCREENING PROGRAMMES FOR OME AND CONDUCTIVE HEARING LOSS
Cohort: All 3 year olds
Test: Tympanometry

Failure
Retest: All abnormals (including absentees)
Interval: 10 - 16 weeks
Test: Tympanometry

Failure
Refer

Pass
Retest at age 5 years
Audiometry and Tympanometry

SCREENING PROGRAMME FOR 3 YEAR OLD PRESCHOOL CHILDREN

Cohort: All 5 year olds
Test: Pure Tone and Tympanometry

Failure
Retest: All abnormals (including absentees)
Interval: 10 - 10 weeks
Test: Pure Tone and Tympanometry

Failure
Refer

Pass
Normal hearing but OME may still recur

SCREENING PROGRAMMES FOR 5 YEAR OLD NEW ENTRANT SCHOOL CHILDREN
# Appendix 5

## WELL CHILD CHECKS

*Summary of the National Schedule’s recommendations on OME and hearing screening*

<table>
<thead>
<tr>
<th>Age</th>
<th>Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn</td>
<td>Complete newborn well child check including hearing risk assessment and detailed examination of ears</td>
</tr>
<tr>
<td>6 week check</td>
<td>Questioning on hearing</td>
</tr>
<tr>
<td>5 month vaccination</td>
<td>Questioning on hearing</td>
</tr>
<tr>
<td>8-10 month check</td>
<td>Questioning on hearing and tympanometry suggested</td>
</tr>
<tr>
<td>15 month vaccination</td>
<td>Questioning on hearing and tympanometry suggested</td>
</tr>
<tr>
<td>21-24 month check</td>
<td>Questioning on hearing</td>
</tr>
<tr>
<td>3 year check</td>
<td>Questioning on hearing and tympanometry as part of screening programme</td>
</tr>
<tr>
<td>School entrants</td>
<td>Tympanometry and audiology assessment as part of screening programme</td>
</tr>
</tbody>
</table>

The study designs included in this review were:

- Meta-analysis
- Randomised-controlled trial
- Cohort study
- Case-control study
- Before and after studies (using a before and after comparison of an intervention)
- Descriptive studies (including cross sectional studies and ecological studies).

The meta-analyses in this review were composed of randomised-controlled trials with one exception. In the case of an evaluation of the effectiveness of influenza vaccinations, the meta-analysis was composed of cohort studies. This study design is not considered further.

Before and after studies are poorly described in epidemiology textbooks. Its main advantage is that a comparison can be performed about an intervention that was introduced beyond the control of the investigators. Thus, typically this study design investigates new policies that were introduced and the investigator had no control over the policy’s implementation. Its key limiting factor is a lack of control over changes with time.

The remainder of this appendix is derived from material contained in Elwood (Elwood 1988). This is presented in the Table.
## A Description of Study Designs

<table>
<thead>
<tr>
<th>Study design</th>
<th>Description</th>
<th>Main role</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Randomised-controlled trial</td>
<td>Random selection of intervention and control arms of the study population.</td>
<td>Assessment of treatment</td>
<td>• Controls who receives the intervention</td>
<td>• Applicability limited to trials likely to be beneficial&lt;br&gt;• Difficulties with ethics, logistics and cost</td>
</tr>
<tr>
<td>Cohort study</td>
<td>Observational study that follows exposed and unexposed participants to defined outcomes.</td>
<td>• Useful for prognosis&lt;br&gt;• Primary method of studying unusual or new exposures</td>
<td>• Good in rare exposures&lt;br&gt;• Allows multiple endpoints to be assessed&lt;br&gt;• Temporal relationship clear&lt;br&gt;• Exposure assessed prior to outcome, avoiding bias</td>
<td>• Often requires many years of follow up (if performed in a prospective manner)&lt;br&gt;• Needs large numbers of participants if the outcome is rare&lt;br&gt;• Susceptible to selection bias</td>
</tr>
<tr>
<td>Case-control study</td>
<td>Observational study that start with an outcome event and (generally) retrospectively analyse exposures.</td>
<td>• Identification of causes of a new outcome&lt;br&gt;• Useful in evaluations of population screening</td>
<td>• Efficient in terms of sample size required (particularly rare outcomes)&lt;br&gt;• Retrospective method is rapid&lt;br&gt;• Multiple exposures can be assessed&lt;br&gt;• Relatively low exposure use</td>
<td>• Unable to calculate absolute or relative risk&lt;br&gt;• Susceptible to recall bias&lt;br&gt;• Retrospective methods limits exposure information&lt;br&gt;• Adequate control group may be difficult to define or obtain</td>
</tr>
<tr>
<td>Cross sectional study</td>
<td>Makes observations at one point in time</td>
<td>• Measure prevalence&lt;br&gt;• Assessment of associations</td>
<td>• Relatively simple so participation tends to be relatively high&lt;br&gt;• Representative samples of a population can be drawn&lt;br&gt;• Methods can be standardised, reliable and single blind&lt;br&gt;• Can be repeated using similar methods</td>
<td>• Does not allow a assessment of causation due to lack of time dimension&lt;br&gt;• Inefficient when prevalence or exposure is low</td>
</tr>
</tbody>
</table>
SEARCH STRATEGIES

MEDLINE AND HEALTHSTAR

#GENERAL
exp hearing disorders/otitis media with effusion/otitis media/
(effusion or serous or secretory or chronic or recurrent).tw.
3 and 4
glue ear.tw.
ear, middle/se
exp hearing loss, sensorineural/
1 or 2 or 5 or 6 or 7 or 8
child/
child, preschool/
child:.tw.
pediatr:.tw.
paediatr:.tw.
or/10-14
randomized controlled trial.pt.
randomized controlled trials/
random allocation/
double blind method/
single blind method/
placebos/
exp clinical trials/
exp research design/
or/16-23
9 and 15 and 24
limit 25 to english

#Natural History
exp hearing disorders/
otitis media with effusion/
otitis media/
(effusion or serous or secretory or chronic or recurrent).tw.
3 and 4
glue ear.tw.
ear, middle/se
exp hearing loss, sensorineural/
1 or 2 or 5 or 6 or 7 or 8
child/
child, preschool/
child:.tw.
pediatr:.tw.
paediatr:.tw.
or/10-14
prognosis/
disease progression/
long term course.tw.
natural course.tw.
clinical course.tw.
natural history.tw.
or/16-21
9 and 15 and 22
otitis media/et
23 or 24
limit 25 to english
letter.pt.
animal/
human/
28 not (28 and 29)
26 not 27
31 not 30

#Disability
exp hearing disorders/otitis media with effusion/otitis media/(effusion or serous or secretory or chronic or re-
current).tw.3 and 4glue ear.tw.ear, middle/seexp hearing loss, sensorineural/
1 or 2 or 5 or 6 or 7 or 8
child/
child, preschool/
child:tw.
pediatr:tw.
paediatr:tw.
or/10-14
exp language disorders/
exp speech disorders/
disabled/
(read: or language or speech).tw.
disability.tw.
or/16-20
9 and 15 and 21
limit 22 to english
letter.pt.
23 not 24
animal/
human/
26 not (26 and 27)
25 not 28

#Incidence
exp hearing disorders/otitis media with effusion/otitis media/(effusion or serous or secretory or chronic or re-
current).tw.3 and 4glue ear.tw.ear, middle/se
exp hearing loss, sensorineural/
1 or 2 or 5 or 6 or 7 or 8
child/
child, preschool/
child:tw.
pediatr:tw.
paediatr:tw.
or/10-14
incidence/
prevalence/
(prevalence or incidence).tw.
ep.fs.
sn.fs.
eh.fs.
or/16-21
9 and 15 and 22
limit 23 to english
letter.pt.
24 not 25
animal/
human/
27 not (27 and 28)
26 not 29

#Treatment Outcome
exp hearing disorders/otitis media with effusion/otitis media/(effusion or serous or secretory or chronic or recurrent).tw.3 and 4
glue ear.tw.
ear, middle/se
exp hearing loss, sensorineural/
1 or 2 or 5 or 6 or 7 or 8
child/
child, preschool/
child:.tw.
pediatr:.tw.
paediatr:.tw.
or/10-14
exp "outcome and process assessment (health care)"
exp treatment outcome/
outcome.tw.
follow-up studies/
cost-benefit analysis/
or/16-20
9 and 15 and 21
limit 22 to english
letter.pt.
23 not 24
animal/
human/
26 not (26 and 27)
25 not 28

#Screening
exp hearing disorders/otitis media with effusion/otitis media/(effusion or serous or secretory or chronic or recurrent).tw.
3 and 4
glue ear.tw.
ear, middle/se
exp hearing loss, sensorineural/
1 or 2 or 5 or 6 or 7 or 8
child/
child, preschool/
child:.tw.
pediatr:.tw.
paediatr:.tw.
Screening programmes for OME and conductive hearing loss

or/10-14
mass screening/
screen:tw.
exp hearing tests/
or/16-18
9 and 15 and 19
limit 20 to english
letter:pt.
animal/
human/
23 not (23 and 24)
21 not 25
21 not 22

#CINAHL

otitis media/(serous or secretory or recurrent or chronic or effusion).tw.1 and 2from 3 keep 1-2,7-8,14-15,19,21,23,25,31-32,36,39,41-43,47
exp hearing disorders/
hearing loss, sensorineural/
hearing.tw.
screen:tw.
hearing screening/
from 9 keep 4,21,30,33,35,49,52
5 or 6 or 7
8 and 11
12 not 9
child/
child:tw.
14 or 15
16 and 13
from 17 keep 7,9,13,16-17,21,26,28-30,32-33,35
10 or 18