

# Natural history, definitions, risk factors and burden of otitis media

Kelvin Kong and Harvey LC Coates

In this review, we describe the various forms of otitis media seen in Australia in the two diverse populations of Indigenous and non-Indigenous people, the natural history in these two populations, and the risk factors for otitis media. In addition, we address the social and cost burden of otitis media and its complications in Australia. We have reviewed the major literature on otitis media, especially in the Australian context, to support this discussion.

## Definitions

The terminology used to describe otitis media and its sequelae has changed over the years. Current terminology is consistent with present understanding of the pathogenesis and pathology of the disease.

Acute otitis media (AOM) without perforation involves acute suppurative inflammation with local and systemic symptoms and signs, including otalgia, otorrhoea, fever, irritability, anorexia, vomiting or diarrhoea. The tympanic membrane bulges and is usually opaque, and pneumatic otoscopy reveals little mobility. AOM with perforation refers either to AOM that has perforated the tympanic membrane and caused discharge or otorrhoea from the middle ear within 7 days of infection, or to the presence of discharge through a tympanostomy tube (also known as a ventilation tube or “grommet”) on an acute basis.

Recurrent AOM (RAOM) refers to separate bouts of AOM — three episodes in 6 months, or four to five in 12 months. There are two distinct types of RAOM: that accompanying an upper respiratory tract infection, with total resolution of middle ear fluid between attacks; or recurrent infection with an underlying persistent otitis media with effusion (OME).

OME is the presence of middle ear fluid without symptoms or signs of suppurative infection. It supersedes previous terms, such as serous otitis media, as the effusion may not be serous, and an asymptomatic middle ear effusion can contain bacteria. OME has myriad appearances, including air fluid levels, bubbles or translucent tympanic membrane, but pneumatic otoscopy almost always

## ABSTRACT

- Otitis media remains a major health problem in Australia, with an unacceptably great dichotomy of incidence and severity of otitis media and its complications between Indigenous and non-Indigenous Australians.
- Among most children with acute otitis media, infection resolves rapidly with or without antibiotics, with ongoing middle ear effusion the only sequela.
- Overcrowding, poor living conditions, exposure to cigarette smoke, and lack of access to medical care are all major risk factors for otitis media.
- Estimates of the number of cases of otitis media in 2008 vary between 992 000 and 2 430 000 Australians, with a total estimated cost of \$100–\$400 million.

MJA 2009; 191: S39–S43

shows a retracted tympanic membrane with impaired mobility. Despite the lack of acute suppuration, a child with OME may still have discomfort, pressure, shooting pains in the ear, or balance disorder — OME is the commonest cause of balance disorder in childhood.

Chronic suppurative otitis media (CSOM) is defined as a persistent discharge from the middle ear through a tympanic membrane perforation for more than 6 weeks. CSOM may include a chronic perforation with or without acute or chronic otorrhoea.

These definitions are summarised in Box 1.

## Natural history

Otitis media is one of the commonest childhood illnesses, affecting 80% of Australian children overall by the age of 3 years.<sup>1</sup> The proportion of Indigenous children suffering otitis media and its complications is disproportionately high; up to 73% by the age of 12 months.<sup>2</sup> Non-Indigenous children may be treated expectantly and without antibiotics and 80% will be symptom-free in 3 days (although middle ear effusion may remain), whereas Indigenous children may suffer RAOM that leads to chronic otorrhoea and CSOM. This dichotomy necessitates different perspectives on the aetiology, pathogenesis and management in the two groups.<sup>3</sup>

Among non-Indigenous children, the general improvement in socioeconomic conditions and the advent of routine antibiotic therapy for otitis media have led to a decrease in the more serious extracranial and intracranial complications that were seen in the pre-antibiotic era.<sup>4</sup> Despite a recrudescence in the incidence of otitis media in the past three decades, related to the increasing use of daycare centres for infants and children, there has been a general tendency in the past 10 years to reduce immediate antibiotic treatment for AOM for children aged over 2 years, exercising a “wait and see” policy.<sup>5,6</sup> Among children aged under 2 years, antibiotic therapy results in more rapid resolution of clinical signs (bulging, erythematous tympanic membrane) and

### 1 Otitis media definitions

**Acute otitis media (AOM) without perforation:** presence of middle ear fluid with symptoms or signs of suppurative infection, which may include otalgia, fever, irritability, vomiting or diarrhoea.

**AOM with perforation:** acute suppurative infection with recent discharge from the middle ear or through a tympanostomy tube (within the past 7 days).

**Recurrent AOM (RAOM):** recurrent bouts of AOM — three episodes in 6 months or four to five in 12 months.

**Otitis media with effusion (OME):** presence of middle ear fluid without symptoms or signs of suppurative infection.

**Chronic suppurative otitis media (CSOM):** a persistent discharge from the middle ear through a tympanic membrane perforation for more than 6 weeks. CSOM may include a chronic perforation with or without acute or chronic otorrhoea. ♦

symptoms (fever, otalgia, irritability), although even this guideline is being questioned.<sup>7</sup>

In Australia, surgical management (insertion of grommets or ventilation tubes) for RAOM and OME is the second most common reason for admission to hospital for a procedure in childhood, with 30 126 such procedures in the 2006–07 financial year.<sup>8</sup> However, among non-Indigenous children, resolution of AOM (with or without antibiotic treatment) is the most common outcome, with the prevalence of middle ear effusion declining from 65% at 2 weeks after onset of infection to 25% at 3 months after onset.<sup>9</sup>

Indigenous children in both remote and urban settings tend to suffer otitis media earlier, more frequently and severely, and with more serious complications than non-Indigenous children.<sup>2,10</sup> In developed countries, Australian Aboriginal and Torres Strait Islander children remain, arguably, the most vulnerable in terms of otitis media prevalence and severity.<sup>11,12</sup> There has been no decrease in otitis media complications in this population, in which infective complications — such as CSOM — occur in up to 30% of children in some communities.<sup>13</sup> The end result of RAOM, OME and CSOM, when not treated adequately, is significant conductive hearing loss with a resultant speech and language delay, especially where English may be a child's second or third language. This results in educational problems, social isolation, truancy and ultimately early school-leaving and difficulties gaining employment. Although hearing aids and school sound field systems (where an infrared signal transmits the teacher's amplified voice through loudspeakers) are theoretically suitable approaches to this problem, in reality, they are of limited help to infants and young children with draining ears. Indigenous children suffer a mean of 32 months of hearing loss in childhood, compared with 3 months among non-Indigenous children. Among Indigenous children, symptoms of otitis media include otalgia, ear rubbing, fever, excessive crying, restless sleep and poor appetite. Traditionally, management regimens have tended to centre on symptoms and symptom relief. This is compounded by the poor access to health care and socioeconomic standards experienced by many Aboriginal and Torres Strait Islander populations, and consequently poses a significant impact and burden of disease, not just for this population but for the Australian population in general.

Why is there such variation in the incidence, onset, severity and complication rates of otitis media between these two populations? Although much of this will be covered in other articles in this supplement, in brief, early invasion of the nasopharynx by encapsulated bacteria overwhelms the immature immune system, leading to a failure to elicit an adequate antibody response. Nasopharyngeal carriage, sustained by biofilm formation and intracellular bacterial colonisation, leads to chronic adenoiditis, rhinitis and middle ear infection via the eustachian tube.<sup>14–16</sup> Social conditions, such as poverty, overcrowding, poor nutrition, exposure to cigarette smoke and lack of running water, all have a role to play in perpetuating the milieu conducive to ongoing carriage of pathogenic bacteria throughout the upper respiratory tract.<sup>17</sup> These socioeconomic issues must be addressed, but innovative preventive treatments to diminish bacterial carriage also need to be implemented.

### Risk factors for otitis media

Otitis media is, in essence, an infectious disease with bacterial and viral infection in an environment where the host immune response

counters infection. The main factors that influence the risk of otitis media developing can be host-related factors or environmental factors (summarised in Box 2). These factors primarily interact in the nasopharynx and eustachian tube. Two systematic reviews of risk factors for AOM and RAOM noted that daycare centre attendance and dummy (pacifier) use were modifiable factors, whereas breastfeeding, presence of siblings, passive smoking, craniofacial abnormalities and the presence of adenoids were probably risk factors.<sup>19,20</sup>

### Host-related factors

Several host-related factors for otitis media have been noted.

- Incidence of otitis media peaks at two age groups: between the ages of 6 and 24 months, when infants are weaned and exposed to environmental conditions, and at age 4–5 years, when children enter kindergarten. Among Indigenous children, infection occurs as early as 2 months of age.<sup>21</sup>
- Otitis media, in particular middle ear effusion, has a higher incidence among boys; reasons for this are unknown.<sup>1</sup>
- In Australia, Indigenous status significantly increases the risk of middle ear disease in urban, rural and remote locations. This is also the case for other ethnic groups, including Inuit, Native American and Maori children.<sup>22</sup>
- Individual factors such as age, sex and ethnicity may be secondary to eustachian tube size differences.<sup>23</sup>
- Premature birth has been variously reported as either having no effect or increasing the risk of otitis media.<sup>24</sup>
- The influence of allergy as a risk factor for otitis media is contentious. An association is noted, with supportive epidemiological and therapeutic evidence in some studies, whereas other studies show no association.<sup>25,26</sup>
- Immune deficiencies associated with RAOM may include deficiencies in secretory IgA, which is implicated in bacterial and viral adherence and has been shown to reduce bacterial colonisation of the nasopharynx. RAOM that is non-responsive to conventional medical and surgical therapy may reveal low serum IgG2 levels, poor response to *Haemophilus influenzae* polysaccharide–protein conjugate vaccination and low levels of specific IgG antibodies against pneumococcal capsular polysaccharides 6A and 19F.<sup>27</sup>
- Genetic factors may play a part in susceptibility to otitis media. A Norwegian study of 2750 twin pairs concluded that heritability of otitis media susceptibility was 74% among girls and 45% among boys.<sup>28</sup> The *HLA-A2* gene has been noted to be associated with RAOM but not OME.<sup>29</sup>
- OME is over-represented among children with Down syndrome and unrepaired cleft palate and craniofacial disorders. The high incidence of disease is related to the dysfunction of the eustachian tube together with lack of functional resistance to aspiration of nasopharyngeal content.<sup>30</sup>
- The current weight of expert opinion is that the presence of infected adenoids or tissue, with biofilm and intracellular bacteria identified in the tissue, is a greater contributor to AOM and OME than the physical bulk or size of the adenoids. A large Western Australian study of 50 000 children who underwent ventilation tube insertion showed a 50% reduction in subsequent grommet insertion following adenoidectomy.<sup>31</sup>
- Despite studies showing pepsinogen carried by gastro-oesophageal reflux into the middle ear fluid in OME and grommet otorrhoea, further definitive studies are required.<sup>32,33</sup>

**2 Risk factors for otitis media**

Risk factor	Comment	NHMRC level of evidence* <sup>18</sup>
<b>Host-related</b>		
Age	Highest incidence between 6 and 11 months	A
Sex	Slightly higher preponderance among males	C
Ethnicity	Indigenous children are at increased risk of earlier and more severe disease	A
Premature birth	Increased risk	C
Allergy	Link noted, but pathways unclear	D
Immunosuppression	Subtle immune deficiencies often noted in recurrent acute otitis media	A
Genetic predisposition	Familial clustering noted	A
Craniofacial abnormalities	Increased incidence in children with cleft palate, Down syndrome and craniofacial anomalies	C
Adenoids	Infected adenoids or tissue increases risk more than size of adenoids	C
Gastro-oesophageal reflux	Link noted, but further study required	D
<b>Environmental</b>		
Daycare or overcrowding	Higher incidence with daycare attendance	B
Siblings	Increased risk with older siblings	B
Upper respiratory tract infection	Viruses predispose to otitis media	B
Seasonality	Increased incidence in winter months	D
Cigarette smoke exposure	Increased risk	B
Breastfeeding	Has a protective effect	C
Socioeconomic status	Variable but generally increased risk with lower status	C
Dummy (pacifier) use	Increased risk after age 11 months	B

NHMRC = National Health and Medical Research Council.

\*NHMRC levels of evidence: A = body of evidence can be trusted to guide practice. B = body of evidence can be trusted to guide practice in most situations.

C = body of evidence provides some support for recommendation(s) but care should be taken in its application.

D = body of evidence is weak and recommendation must be applied with caution.



**Environmental factors**

There is much epidemiological evidence indicating that otitis media and middle ear effusions have a higher incidence in winter and lower incidence in summer in both hemispheres.

By far the largest environmental factor for the “mini-epidemic” of otitis media and OME in the past three decades has been the increase in daycare attendance by children; one in five children in full-time daycare may have ventilation tubes in situ.<sup>34</sup> This is directly related to the number of children in each daycare centre. There is a threefold increased risk of upper respiratory tract infection with daycare attendance.<sup>34</sup> The same factors hold for overcrowding in homes and families with a number of older siblings.<sup>26</sup>

Upper respiratory tract infections occur most frequently in the winter months, and respiratory viruses can be isolated from the middle ear fluid in 19% of children with AOM; these may include respiratory syncytial virus, rhinovirus, adenovirus and coronavirus.<sup>35</sup>

Passive cigarette smoking increases the risk of otitis media among Aboriginal and non-Aboriginal children. In the Kalgoorlie Otitis Media Research Project, 64% of Aboriginal children and 40% of non-Aboriginal children were exposed to environmental tobacco smoke.<sup>17</sup> A meta-analysis demonstrated a significant increase in risk (66%) of RAOM and chronic OME in the presence of parental smoking (risk ratio [RR], 1.66; 95% CI, 1.33–2.06).<sup>20</sup>

Breastfeeding has a protective effect on the development of middle ear disease related to the immunological properties of breast milk; a

meta-analysis showed that breastfeeding for at least 3 months reduced the risk of AOM by 13% (RR, 0.87; 95% CI, 0.79–0.95).<sup>20</sup>

Low socioeconomic status with limited access to health care may be a factor affecting the association with otitis media. There is great variability, however, in the association between otitis media and low socioeconomic status.

The use of a dummy after the age of 11 months is significantly associated with otitis media. In a meta-analysis, the use of a dummy increased the risk of AOM by 24%.<sup>20</sup>

**Modifying risk factors**

The authors of a 2-year population-based study of 2512 children, 825 of whom experienced otitis media, estimated that one in five children could have avoided otitis media, and two in five affected could have avoided RAOM, if they had been moved from full-time daycare to home care.<sup>36</sup> They concluded that about 14% of all episodes of otitis media could have been avoided if all of these children had been cared for at home. The other modifiable risk factors of significance are cessation of dummy use after the age of 11 months and reduction in passive cigarette exposure.

**The burden of disease in Australia**

Otitis media is a common and debilitating condition that affects up to 73% of children by the age of 12 months. In Australia, the difficulty in establishing the incidence and prevalence rates of

otitis media in children is due to definitional and diagnostic differences and uncertainty. An estimate of the number of new cases of otitis media in 2008 among all Australians suggested that between 658 006 and 1 615 486 Australians were affected, with 12.8% of these accounted for by Indigenous children.<sup>37</sup>

Otitis media is one of the most common conditions diagnosed in the primary health care setting, is one of the most common diagnoses resulting in antibiotic prescription for children, and is a major contributor to childhood morbidity. Few children escape experiencing a form of otitis media before they reach school.

Of Australian children aged 14 years and under experiencing otitis media each year, 15 will suffer permanent hearing loss and over 250 000 will experience temporary hearing loss. Further, 60 263 will experience CSOM, of whom 217 will have intracranial complications and 237 will have mastoiditis. A cross-sectional survey of remote communities in 2001 showed a prevalence of 16.5% for CSOM.<sup>2</sup> In 2008, treatment costs (mainly general practitioner visits and prescriptions) accounted for between \$100 million and \$400 million. The estimated net cost of lost wellbeing due to otitis media in 2008 varied between \$1.05 billion and \$2.6 billion.<sup>37</sup>

The estimated number of Indigenous Australians with otitis media in 2008 was between 98 097 and 240 841; 12.8% of these cases occurred before the age of 14 years (47 000 children).<sup>37</sup> Aboriginal and Torres Strait Islander children are more likely to experience recurrent disease that sets in at a much earlier age than non-Indigenous children.

Aboriginal and Torres Strait Islander children are at particular risk, enduring living standards equivalent to those in developing nations. In Australia, where non-Indigenous populations generally experience high standards of living and health care, Aboriginal and Torres Strait Islander children continue to suffer an unacceptable incidence of ear disease. This inequality has a significant impact on growth, development and education, and the negative social implications remain difficult to measure.

### Acknowledgements

We especially acknowledge the nurses and Indigenous health workers who work tirelessly for the benefit of our patients in urban, rural and remote Australia.

### Competing interests

Harvey Coates has been a consultant for GlaxoSmithKline and Alcon Laboratories.

### Author details

Kelvin Kong, BSc, MBBS, FRACS, Paediatric and Adult Otolaryngology, Head and Neck Surgeon<sup>1</sup>

Harvey L C Coates, AO, MS, FRACS, Clinical Professor,<sup>2</sup> and Senior Ear, Nose and Throat Surgeon<sup>3</sup>

1 John Hunter Hospital, Newcastle, NSW.

2 University of Western Australia, Perth, WA.

3 Princess Margaret Hospital for Children, Perth, WA.

Correspondence: KelvinKongENT@gmail.com

### References

1 Teele DW, Klein JO, Rosner B. Epidemiology of otitis media during the first seven years of life in children in greater Boston: a prospective, cohort study. *J Infect Dis* 1989; 160: 83-94.

2 Morris PS, Leach AJ, Silberberg P, et al. Otitis media in young Aboriginal children from remote communities in Northern and Central Australia: a cross-sectional survey. *BMC Pediatrics* 2005; 5: 27.

3 Gunasekera H, Knox S, Morris P, et al. The spectrum and management of otitis media in Australian Indigenous and non-Indigenous children: a national study. *Pediatr Infect Dis J* 2007; 26: 689-692.

4 Baxter JD. Otitis media in Inuit children in the Eastern Canadian Arctic — an overview — 1968 to date. *Int J Pediatr Otorhinolaryngol* 1999; 49 Suppl 1: S165-S168.

5 Glasziou PP, Del Mar CB, Sanders SL, Hayem M. Antibiotics for acute otitis media in children. *Cochrane Database Syst Rev* 2004; (1): CD000219.

6 American Academy of Pediatrics Subcommittee on Management of Acute Otitis Media. Diagnosis and management of acute otitis media. *Pediatrics* 2004; 113: 1451-1465.

7 Bezáková N, Damoiseaux RA, Hoes AW, et al. Recurrence up to 3.5 years after antibiotic treatment of acute otitis media in very young Dutch children: survey of trial participants. *BMJ* 2009; 338: b2525.

8 Australian Institute of Health and Welfare. Australian hospital statistics 2006–07. Health services series no. 31. Canberra: AIHW, 2008. (AIHW Cat. No. HSE 55.)

9 Rosenfeld RM, Kay D. Natural history of untreated otitis media. In: Rosenfeld RM, Bluestone CD. Evidence-based otitis media. 2nd ed. Hamilton, Ont: BC Decker, 2003: 180-198.

10 Williams CJ, Coates HL, Pascoe EM, et al. Middle ear disease in Aboriginal children in Perth: analysis of hearing screening data, 1998–2004. *Med J Aust* 2009; 190: 598-600.

11 Leach AJ, Morris PS, McCallum G, et al. What will Pevnar do for chronic suppurative otitis media in Indigenous Australian children? 3rd International Symposium on Pneumococci and Pneumococcal Diseases; 2002 May 4; Anchorage, Alaska.

12 World Health Organization. Chronic suppurative otitis media: burden of illness and management options. Geneva: WHO, 2004.

13 Leach A, Morris P. Annotation perspectives on infective ear disease in Indigenous Australian children. *J Paediatr Child Health* 2001; 37: 529-530.

14 Morris PS, Leach AJ, Halpin S, et al. An overview of acute otitis media in Australian Aboriginal children living in remote communities. *Vaccine* 2007; 25: 2389-2393.

15 Coates HL, Morris PS, Leach AJ, et al. Otitis media in Aboriginal children: tackling a major health problem [editorial]. *Med J Aust* 2002; 177: 177-178.

16 Coates H, Thornton R, Langlands J, et al. The role of chronic infection in children with otitis media with effusion: evidence for intracellular persistence of bacteria. *Otolaryngol Head Neck Surg* 2008; 138: 778-781.

17 Jacoby P, Coates H, Arumugaswamy A, et al. The effect of passive smoking on the risk of otitis media in Aboriginal and non-Aboriginal children in the Kalgoorlie-Boulder region of Western Australia. *Med J Aust* 2008; 188: 599-603.

18 National Health and Medical Research Council. How to review the evidence: systematic identification and review of the scientific literature. Endorsed November 1999. Canberra: NHMRC, 2000.

19 Neto JFL, Hemb L, de Silva DB. Systematic literature review of modifiable risk factors for recurrent acute otitis media in childhood. *Jornal de Pediatria* 2006; 82: 87-96.

20 Uhari M, Mäntysaari K, Niemelä M. A meta-analytic review of the risk factors for acute otitis media. *Clin Infect Dis* 1996; 22: 1079-1083.

21 Watson K, Carville K, Bowman J, et al; Kalgoorlie Otitis Media Research Project Team. Upper respiratory tract bacterial carriage in Aboriginal and non-Aboriginal children in a semi-arid area of Western Australia. *Pediatr Infect Dis J* 2006; 25: 782-790.

22 Boswell JB, Nienhuys TG. Patterns of persistent otitis media in the first year of life in Aboriginal and non-Aboriginal infants. *Ann Otol Rhinol Laryngol* 1996; 105: 893-900.

23 Doyle WJ. A functional-anatomic description of eustachian tube vector relations in four ethnic populations: an osteologic study [PhD dissertation]. Pittsburgh: University of Pittsburgh, 1977.

24 Engel J, Anteunis L, Volovics A, et al. Prevalence rates of otitis media with effusion from 0 to 2 years of age: healthy-born versus high-risk-born infants. *Int J Pediatr Otorhinolaryngol* 1999; 47: 243-251.

25 Tomonaga K, Krono Y, Mogi G. The role of nasal allergy in otitis media with effusion: a clinical study. *Acta Otolaryngol Suppl* 1988; 458: 41-47.

26 Pukander J, Luotonen J, Timonen M, Karmap. Risk factor affecting the occurrence of acute otitis media among 2-3-year-old urban children. *Acta Otolaryngol* 1985; 100: 260-265.

## OTITIS MEDIA 2009: AN UPDATE

- 27 Prellner K, Kalm O, Harsten G, et al. Pneumococcal serum antibody concentration during the first three years of life: a study of otitis prone and non-otitis prone children. *Int J Pediatr Otorhinolaryngol* 1989; 17: 267-279.
- 28 Kvaerner KJ, Harris JR, Tambs K, et al. Distribution and heritability of recurrent ear infections. *Ann Otol Rhinol Laryngol* 1997; 106: 624-632.
- 29 Kalm O, Johnson U, Prellner K, Ninn K. HLA frequency in patients with recurrent acute otitis media. *Arch Otolaryngol Head Neck Surg* 1991; 117: 1296-1299.
- 30 Balkany TJ, Downs MP, Jafek BW, et al. Otologic manifestations of Down syndrome. *Surg Forum* 1978; 29: 582-585.
- 31 Kadhim AL, Spilsbury K, Semmens JB, et al. Adenoidectomy for middle ear effusion: a study of 50,000 children over 24 years. *Laryngoscope* 2007; 117: 427-433.
- 32 Tasker A, Dettmar PW, Panetti M, et al. Is gastric reflux a cause of otitis media with effusion in children? *Laryngoscope* 2002; 112: 1930-1934.
- 33 Antonelli PJ, Lloyd KM, Lee JC. Gastric reflux is uncommon in acute post-tympanostomy otorrhea. *Otolaryngol Head Neck Surg* 2005; 132: 523-526.
- 34 Wald ER, Dashefsky B, Byers C, et al. Frequency and severity of infections in daycare. *J Pediatr* 1988; 112: 540-546.
- 35 Ruuskanen O, Heikkinen T. Viral-bacterial interaction in acute otitis media. *Pediatr Infect Dis J* 1994; 13: 1047-1049.
- 36 Alho OP, Laara E, Oja H. Public health impact of various risk factors for acute otitis media in northern Finland. *Am J Epidemiol* 1996; 143: 1149-1156.
- 37 Access Economics. The cost burden of otitis media in Australia. Perth: GlaxoSmithKline, 2009: 49-50. <http://www.access-economics.com.au/publicationsreports/getreport.php?report=190&id=244> (accessed Sep 2009).

(Received 29 Apr 2009, accepted 26 Aug 2009)

□