The impact of otitis media on cognitive and educational outcomes

Corinne J Williams and Ann M Jacobs

ABSTRACT

- Otitis media is a common disease in childhood that can adversely affect cognitive and educational outcomes. The literature in this area is equivocal, and findings may be influenced by research design.
- The impact of otitis media on individual children's development appears to depend on the inter-relationship between several factors. Children who have early-onset otitis media (under 12 months) are at high risk of developing long-term speech and language problems.
- Otitis media has been found to interact negatively with pre-existing cognitive or language problems.
- For biological or environmental reasons, some populations have a pattern of early onset, higher prevalence and episodes of longer duration; this pattern leads to a higher risk of long-term speech and language problems.
- These factors suggest that Indigenous children may be at higher risk of cognitive and educational sequelae than non-Indigenous children.

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Otitis media occurs commonly in early childhood.[1,2] It has been reported that as many as 80% of children experience otitis media by the age of 4 years.[1,3] Otitis media is most likely to occur during the first year of life and is less common in subsequent years;[1] acute otitis media is uncommon among European and North American children older than 7 years.[4]

Early onset of otitis media has been associated with an increased likelihood of repeated episodes, which in turn are thought to have long-term effects.[5] Among Aboriginal and Torres Strait Islander children, rates of otitis media are high, the disease manifests early in life, and it may continue to occur in adolescence and beyond.[6] High rates of otitis media have been found in Aboriginal children living in rural, remote and urban areas.[7] Damage to the tympanic membrane is common, and evident in both children and adults.[6]

Fluctuating mild-to-moderate conductive hearing loss often co-occurs with episodes of otitis media. This loss can be present for a few weeks or can persist for some months.[3,8] Australian data indicate that Indigenous Australian children experience otitis media for a cumulative total of 32 months between the ages of 2 and 20 years.[6] Non-Indigenous children experience 3 months of otitis media within the same period.[9]

The area of otitis media spans health, general development and education. The occurrence of otitis media is a medical issue, but the associated hearing loss has the potential to adversely affect cognitive development and, ultimately, educational achievement. The literature does not, however, demonstrate a clear causal relationship between otitis media and later problems. Problems in research design contribute to this lack of clarity. A meta-analysis of the research documented the difficulty of comparing children with varying degrees of hearing loss, and of failing to differentiate between children with otitis media of differing levels of severity.[10] A retrospective study cited methodological diversity and lack of information on sociodemographics and hearing as reasons for the differences in findings among the 27 studies examined in its literature review.[11]

This article presents the view, supported by reference to the literature and to the clinical (speech pathology) experience of the authors, that Indigenous children who suffer otitis media are at increased risk of negative cognitive and educational sequelae.

Impact on cognitive development

The areas of cognition perceived as most likely to be affected by the hearing loss associated with otitis media are auditory processing skills, attention, behaviour, speech and language.

Auditory processing skills are skills that allow for processing of auditory information, and are thought to underlie auditory behaviour such as sound localisation, discrimination of speech sounds and the ability to analyse sound in difficult situations (eg, in noisy contexts).[12] It has been suggested that the conductive hearing loss present in otitis media may cause asymmetry in the hearing levels of the ears, as would be the case when otitis media is present in only one ear. This asymmetry may have a negative effect on complex auditory processing (eg, in binaural hearing), which may continue after hearing loss has resolved. Measures thought to be related to the ability to detect speech in background noise have also been shown to suffer in children with otitis media, even when hearing levels have returned to normal.[13] Further research is needed to fully determine the relationship between otitis media and auditory processing skills, and to examine the possible impact on real-world functioning.[13]

Otitis media could contribute to difficulties in behaviour and attention. Although some studies support this hypothesis,[14,15] others do not support a relationship — one article concluded that there is no definitive evidence to suggest that otitis media affects behaviour and attention.[13]

The possible impact of otitis media on the development of speech and language has received considerable attention in the literature. The evidence in this area is also conflicting. Speech perception skills, such as the ability to distinguish between similar sounds, are thought to underlie language development in subtle ways and might not be evident in standardised tests of language.[16] There are few studies of speech perception, but those that are available support the hypothesis that otitis media causes difficulty in speech perception.[13] Research into the development of speech perception suggested that early-onset otitis media reduces input during optimal periods of speech development, and the cascading or dependent nature of these sensitive periods can have a knock-on effect for later development.[17] A study of 5-year-olds with normal hearing and a history of severe recurrent otitis media found that some children had normal language abilities and others had delayed language acquisition.[18] Both groups demonstrated deficits in speech perception compared with children without a history of otitis media, and children with language delay and a history of

otitis media performed more poorly than children with typical language and a history of otitis media.[18] This suggests that episodes of hearing loss in infancy can change perceptual capabilities, and this can in turn affect language learning.

An Australian study compared the speech perception of Indigenous children with otitis media with that of peers who did not have otitis media, and non-Indigenous peers without otitis media.[9] All Indigenous children spoke an Indigenous language as their first language. The group with otitis media had the greatest difficulty differentiating English consonant pairs, and the most difficulty discriminating phonemes that differed by few features.[9]

A review found that studies had mixed results regarding the development of speech, but found that, on balance, there is insufficient evidence to suggest that otitis media is a significant risk to speech production.[13] That is, it seems unlikely that there will be long-term detrimental effects on children's ability to produce the speech sounds of their native language. However, the impact might be more significant for children learning more than one language.[19] This is likely to be the case for Indigenous children learning more than one language or dialect that may have very different phonological systems.[9]

There are also conflicting reports on the effect of otitis media on the development of receptive and expressive language,[8] and it has been suggested that various factors could mediate the effect of otitis media on language development. These include the quality of daycare[8] and the higher incidence of otitis media in low socioeconomic groups,[20] which typically have lower language levels.[21] Studies of language development in children with otitis media use standardised measures of language, and may therefore fail to identify more subtle language difficulties that may be present in real-world interactions (eg, in the home and classroom). One study suggested that parents of children with otitis media may provide less facilitative parental input than parents of peers without otitis media.[22] This may affect language development, which is driven by parent interaction.

Educational impact

There are several reasons for predicting that otitis media negatively affects educational outcomes. If otitis media during preschool years affects auditory processing skills, children could find it difficult to process auditory information in the suboptimal listening conditions of the classroom.[9] If speech perception is affected, phonemic awareness (awareness of sounds in words) is also likely to be affected;[23] this can, in turn, lead to difficulties with reading and spelling. If language development is affected, there can be long-term effects on reading, and in particular on reading comprehension. Although a review indicated that there is no conclusive evidence that a history of otitis media affects academic achievement, the evidence is mixed, with some studies showing effects on reading, emergent literacy skills and mathematics.[13] One study considered the effect of a cumulative history of otitis media on various measures of attention, behaviour and literacy into the teenage years.[24] Children whose otitis media occurred early or was of short duration were excluded from consideration. The study demonstrated effects of otitis media on developmental outcomes, including reading, which were still evident during adolescence.

For Indigenous children with otitis media, the accompanying hearing impairment is an important factor contributing to poor educational outcomes. Indigenous children who are learning English as a second language (typical among those who live in remote areas) face even greater problems.[9] Difficulties have also been demonstrated in urban Aboriginal children. One of the few studies that directly addressed the early literacy skills of urban Aboriginal children found that children with otitis media had significantly poorer phonological awareness, reading and spelling skills than their peers who did not have otitis media.[25] A large survey of Aboriginal children's health in Western Australia reported that children who experienced recurrent otitis media with discharge had a higher likelihood of hearing difficulty and difficulties with speech, language and learning.[26]

Classroom amplification has been clearly shown to reduce the impact of hearing, listening and attention deficits in the classroom, irrespective of aetiology. Research has shown that, however it is used, amplification is most effective when combined with analysis and modification of classroom acoustics.[27,28] Children must also be taught effective listening behaviour so that a meaningful signal can be received and processed. For Indigenous children learning English as a second language, it is also necessary to focus specifically on teaching phonological awareness as a means to improve literacy outcomes.[9]

A multifactorial approach

The lack of congruence in the literature reflects the number of factors that can mediate the effect otitis media has on children's development. Some of these factors play a causal role, whereas others help explain the variation in outcomes for children with otitis media. Factors that have a causal role include passive smoking, decline in breastfeeding, daycare attendance and presence of a sibling.[29-31] Factors that have been associated with variability in outcomes include the degree of hearing loss, parenting style, and access to medical care.[32]

A significant factor reliably related to a higher risk of later problems with speech and language is early-onset otitis media.[33,34] Children who sustain a hearing loss before the age of 12 months, the optimal period for development of the sound system, are at higher risk of long-lasting consequences of otitis media. Children whose hearing loss during this period is relatively greater and lasts longer are at the most risk of lasting consequences.[32,35-37] Current research indicates that some Indigenous populations in Australia demonstrate peak prevalence for otitis media at age 5–9 months; one-third of 6-month-old infants had a hearing loss of 40 dB or greater.[30]

The occurrence of otitis media has also been documented as a common denominator associated with greater defect in children who have pre-existing conditions that place them at high risk of language or cognitive deficits.[36] Children with cleft palate who had early intervention for otitis media had a statistically significantly higher IQ at 4 and 5 years of age than children who were not treated ($P = 0.02$).[38] In a sample of premature infants at risk of cognitive and language deficits, children with persistent otitis media were three times more likely to have language delay than children without persistent otitis media.[39]

The number of factors that mediate the impact otitis media can have on a particular child's development, and the complexity of the inter-relationships between factors, means each child will have a different presentation. Otitis media needs to be considered from both a medical and a social perspective so that all factors that could predict lasting consequences are considered.

We have summarised the likely relationships between the factors that mediate the impact of otitis media on development in the Box.

Factors that increase the risk of sustaining long-term speech and language deficits as a consequence of otitis media

Factors likely to be associated with high risk

- Early onset of otitis media (under 12 months of age)
- More than one episode of otitis media before 12 months of age
- Long periods of infection
- Poor or no access to medical management
- Compromised environment (passive smoking, overcrowding, poor nutrition, non-compliance with medical management)
- Pre-existing cognitive or language deficit
- Disrupted attachment
- Degree of hearing loss

Factors likely to be associated with moderate risk

- Late onset of otitis media (after 2 years of age)
- Long periods of infection
- Compromised environment (passive smoking, overcrowding, poor nutrition, non-compliance with medical management)
- Disrupted attachment
- Poor access to developmental support (eg, playgroups, kindergarten)
- Degree of hearing loss

Factors likely to be associated with low risk

- Late onset of otitis media (after 2 years of age)
- Few episodes of infection of short duration
- Good medical management with opportunistic ear checks at each presentation in the early years
- Supportive environment (good nutrition, adherence to clinical care pathways)
- No pre-existing cognitive or language deficits
- Caregiver–child bond intact
- Access to developmental support (eg, playgroups, kindergarten) ◆

Individual children may experience different combinations of factors, with differing individual outcomes. Children who experience more factors associated with high risk require greater surveillance.

The lack of agreement in the literature also reflects differences in the research approaches taken and in the ways otitis media is defined. When evaluating any publication in this area, it is important to consider how otitis media was defined and measured, the presence and extent of conductive hearing loss, whether research participants were children with a history of otitis media that is now resolved, or whether they had ongoing otitis media and hearing impairment. This latter distinction is seldom clarified, but is particularly important when examining the educational effects of otitis media on Indigenous children. For this group, otitis media and associated hearing impairment can persist throughout the school years and can therefore be realistically predicted to have significant deleterious effects on educational achievement.

Conclusion

The literature regarding the effects of otitis media on cognition and educational outcomes raises many questions. There is a clear need for more research in the area, and in particular for prospective research that includes measurement of hearing levels in addition to middle ear function. The cumulative effects of otitis media and the effects for children with ongoing otitis media must be clearly differentiated within the literature. Despite the equivocal evidence, it is too soon to discount the possibility that, for at least some children, otitis media has a negative effect on cognitive, language and educational development.

There is clear evidence that some patterns of the disease do predict long-term negative outcomes for speech and language. Early onset, more frequent infections, and infections of longer duration have all been shown to act as risk factors for long-term consequences. The highest risk of long-term speech and language deficits is evident when these patterns of disease interact with compromised environments and lack of developmental support.

In the case of Indigenous children, the possibility of negative outcomes is more likely to be a probability. Results of a systematic review suggested that it is likely that ear disease has a significant impact on the developmental future of Indigenous children.[6] For many reasons, the burden of the disease may be greater for these children. One article mentioned the need to study the effects of otitis media in "special" populations.[13] Within the Australian context, Indigenous children are an important special population. There is a clear need for approaches to otitis media in this population that encompass both medical and educational considerations.

Competing interests

None identified.

Author details

Corinne J Williams, PhD, Senior Lecturer[1]
Ann M Jacobs, BAppSc(Speech and Hearing), Speech Pathologist[2]
1 School of Psychology and Speech Pathology, and Curtin Health Innovation Research Institute, Curtin University of Technology, Perth, WA.
2 Perth, WA.
Correspondence: c.j.williams@curtin.edu.au

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