Critical Review
The Impact of Recurrent Otitis Media on Phonological Development in Preschool Children
Howden, A.
M.Cl.Sc. (SLP) Candidate
School of Communication Sciences and Disorders, U.W.O.

This critical review examines the relationship between recurrent Otitis Media (OM) and phonological development in children less than 5 years of age. The literature includes a preliminary descriptive-explanatory model, a preliminary structural equation model as well as both prospective and retrospective observational designs. The research offers different conclusions in regards to the topic of interest, with the majority of studies supporting a relationship between recurrent OM and phonological development. Due to the methodological and measurement flaws that were present, the investigations that suggest a relationship provide an inadequate basis for determining whether children with recurrent OM are at risk for phonological delay.

Introduction

Through auditory input, children develop knowledge of sounds, sound patterns and rules, learn to store sound representations in their lexicon and develop the ability to retrieve sound representations to decode language or produce sound sequences. Phonological development in young children is the foundation for building oral language skills and also influences the skills required for reading and writing.

During the critical years of speech development, many children suffer from Otitis Media (OM). OM is one of the most common infections among preschool children. It is characterized by an inflammation of the middle ear and is most often accompanied by fluid [Otitis Media with Effusion (OME)]. For many young children, OM is a recurrent illness typically accompanied by a mild to moderate fluctuating conductive hearing loss and occurs most frequently during the first 18 months to 3 years of age (Paden, 1994; Petinou, Schwartz, Mody & Gravel, 1999). The amount of hearing loss associated with OM can be variable, with some children experiencing little to no hearing loss at all. It has been reported that the average hearing threshold for children experiencing OM is 25 dB HL but may range from 0 to 50 dB HL (Petinou, Schwartz, Mody & Gravel, 1999). Children who suffer from multiple cases of OM may experience a fluctuating hearing loss for extended periods during the crucial years of phonological development.

Although the hearing loss is not significant for all children, the effect of a transient hearing loss may influence the consistency and stability of the auditory signal. Consequently, exposure to an inconsistent or distorted speech signal may have negative repercussions on a child's phonological acquisition during the period of the most rapid phonological growth, 12 to 36 months (Petinou, Schwartz, Mody & Gavel, 1999; Paden, 1994).

Numerous studies have investigated the impact of OM on speech and language development. Controversies surrounding this topic of research have been present for years due to methodological and design limitations as well as the effect of extraneous variables on research outcomes.

For speech-language pathologists and audiologists working with the pediatric population, it is important to be able to provide evidence-based information to parents and caregivers of children with recurrent OM regarding the risk for phonological delay. Although OM is highly variable for many children as the result of varying sociodemographic variables, health status and other environmental factors, it is still necessary to identify if children with recurrent OM automatically require speech services.

Objectives

The primary objective of this paper is to critically evaluate existing literature regarding the impact of recurrent OM on the phonological development of preschool children. The secondary objective is to propose an evidence-based clinical recommendation regarding the risk of phonological delay and the necessity for speech-language pathology intervention.

Methods

Search Strategy
Articles related to the topic of interest were found using the following computerized databases: CINAHL, Medline, PsychINFO, PubMed, Proquest, and the Cochrane Library. Key words used for the database search were as follows:

[(otitis media) OR (OM)]
[(otitis media with effusion) OR (OME)]
[(speech development) OR (speech disorders)]
[(phonological development) OR (phonology)]
[phonological disorders) OR (articulation disorders)]

The search was limited to articles written in English subsequent to 1987.

Selection Criteria
Studies selected for inclusion in this critical review were required to investigate the impact of recurrent OM or OME on phonological development in the first five years of life. Survey designs and case reports were not included. No other restrictions were applied.

Data Collection
Results of the literature search yielded the following types of articles congruent with the aforementioned selection criteria: observational designs (5); preliminary descriptive-explanatory model (1); and preliminary structural equation model (1).

Results
Impact of Recurrent Otitis Media on Phonological Development

An investigation by Petinou, Schwartz, Mody and Gravel (1999) examined the effect of OME on early speech production. The study grouped sixteen infants into an OME positive group (OME+) and OME negative group (OME-) and concluded that there were no apparent differences between the groups in regards to consonants produced per minute (rate of vocalizations). Dissimilarities were evident regarding place and manner of articulation with infants in the OME+ group producing more bilabial stops and those in the OME- group producing more alveolar stops and nasals. In addition, it was concluded that the OME+ group with poor hearing thresholds showed preference for bilabial stops and the children with better hearing thresholds displayed more diversity in their phonetic inventories (Petinou, Schwartz, Mody & Gravel, 1999).

The children in this study were of equal socioeconomic status and consisted of both boys and girls as well African Americans and Caucasians. The study controlled for the caregiver's language proficiency, the language spoken in the child's home environment, the language of the primary caregiver, the language spoken by the child's siblings as well as the language most often used in the child's preferred television programs. It was determined that the participants were full-term infants and did not have cognitive deficits, neurological problems or delayed language. The examiners were blind to the children's OME status, with the exception of one of the authors who grouped the sixteen infants.

OME status was determined by both tympanometry and pneumatic otoscopy during the first year of life. Each child's overall status was determined by the percentage of visits of which the child was bilaterally free of OME or positive for OME. The investigation determined hearing thresholds by the use of visual reinforcement audiometry. The thresholds of the infants designated OME+ ranged from 20 to 36 dB HL whereas the OME- infants had hearing thresholds ranging from 3 to 13 dB HL. The groups were composed of 8 children each and phonetic transcriptions from infants' recorded babbling samples at the ages of 10, 12 and 14 months were analyzed. The rate of vocal output, proportional occurrence of consonants for place of articulation, and proportional occurrence of consonants for manner of articulation were measured.

Several different ANOVAs were completed appropriately and included both within and between subject variables. Post Hoc analyses were completed to account for multiple comparisons as well as to examine the specific differences between groups. Although the study included a multivariate statistical approach, the inclusion of hearing thresholds as well as a well-controlled design, it was deficient in statistical power due to the small sample size and failed to include confidence intervals.

Paden, Novak and Beiter (1987) established that different measures or conditions, in combination, were predictors of phonologic inadequacy. The study concluded that postvocalic singleton obstruents, velars and liquids, along with elevated thresholds at 500 Hz and a history of early onset and late remission from OME, were the most significant variables in characterizing children with atypical phonological development by 3 years of age (Paden, Novak & Bieter, 1987).

The participants of the study included 40 children between the ages of 18 and 35 months who were recruited from a department of otolaryngology where they were referred for tympanostomy and tube insertion. The children reflected a small sample of the general population, only including severe cases documented as persistent unilateral or bilateral OME of more than 3 months' duration or more than four episodes of OME over the preceding 6 months (Paden, Novak & Beiter, 1987). A reliable and consistent protocol was followed to assess each subject otologically, audiologically and phonologically prior to their surgery. It must be noted that the participants of this investigation, except for four children, had undergone at least one tympanostomy and tube insertion procedure before phonologic adequacy scores were obtained, possibly affecting the speech outcomes.

The study did not involve the use of blinding and only controlled for parents' occupation and education. Data regarding the subjects' medical history relating strictly to OME was collected retrospectively and recorded. The study used a restricted speech sample of 20 pre-determined words for phonological analysis.

From the cohort of children with OME, the subjects were divided into 3 groups based on phonological ability. Appropriately, overall discriminant analysis was performed to examine the differences between two or more groups of subjects with respect to several variables. Eight of the sixteen variables considered in the analysis were identified as being important in discriminating the three groups. Further, four separate discriminate analyses were performed on classification (case history), parental occupational and educational levels, audiologic information as well as initial phonological inadequacy scores. Multiple regression was also used appropriately to identify if initial independent variables could predict phonological inadequacy for the two groups that did not have typical development by age 3 (Paden, Novak & Beiter, 1987). The interpretation of correlation coefficient was accurate; however, the investigation failed to report an estimate of power or effect size. The statistical protocol confirmed the importance of using data from multiple areas for identification of phonological delay in children who suffer from OME.

This study identified a number of factors related to phonological deficiency that had significant predictive value; however, the findings must be interpreted with caution as many confounding variables were not controlled for. Although the study did include the use of hearing thresholds as a variable for analysis, the thresholds were based on the pre-operative assessment and did not include thresholds when effusion was present.

Roberts, Burchinal, Koch, Footo and Henderson (1988) conducted a prospective study concluding that the number of days with OME before age 3 did not have negative implications on early phonological development, but rather repercussions for later development. It was found that phonological processes after age 4 ½ tended to remediate slower than children without a history of OM.

The study sample was not representative of the general population as it included 55 children who attended a multidisciplinary day-care program, were identified as at

risk for poor school performance due to socioeconomic factors and consisted of primarily African American children. The children's health status was reviewed each weekday and OME detection was assessed by pneumatic otoscopy as well as tympanometry. The investigation assessed hearing in specific cases but hearing measurement was not a standard protocol of the study as children were classified into groups based on their duration of OME. Speech was assessed annually when children were between 2 ½ and 8 years using the Goldman Fristoe Test of Articulation as well as calculating the total number of consonants in error (CER) and total phonological processes (TPP) present in the conversational sample (Roberts et al., 1988).

Total days of OME was used as the variable for analyses. Spearman correlations were employed to determine if a relationship was present between ranks on Total OME, CER, TPP and five individual processes at any given age. The study concluded that there were no significant correlations at a younger age; however, it indicated a mild correlation between Total OME and median TPP in the 4 ½ to 8 year age category. Post hoc tests, used to correct for multiple comparisons and to further examine the observed linear association, confirmed that older children with a higher incidence of OME had an increased usage of phonological processes and there was an unexpected association between unilateral OME and total phonological processes (Roberts et al., 1988)

Statistically, due to multiple analyses, the data was susceptible to Type I errors, which affected the possibility of an accurate decision (Roberts et al., 1988). In addition, selection bias was evident as the sample consisted of disadvantaged children who were identified as at risk for school-related issues in later development. Due to the selection of participants, the many confounding variables present and the lack of blind raters, it was not unlikely that a statistical association was found in this investigation.

A study by Shriberg, Friel-Pattie, Flipsen and Brown (2000) considered hearing loss as the independent variable of study and investigated the risk for speech delay associated with early recurrent OME with and without hearing loss. The study indicated that children who experienced a 20 dB average hearing threshold from 12 to 18 months of age had a higher prevalence of a speech disorder.

The subjects included a subsample of 70 children followed prospectively in the Dallas Cooperative Project on Early Hearing and Language. All children included in the study were from middle to high-middle class, monolingual English speaking homes, were of full-term gestation (37 weeks or greater), were a singleton birth and typically developing at the time of enrolment (i.e., no neurological problems or major physical defects). In addition, the subjects were required to have appropriate language samples as well as complete records available for all tests given in the Dallas study.

OME status was monitored using both pneumatic otoscopy and tympanometry by trained professionals. The children were classified based on their otologic histories during three time periods: 6-12 months, 12-18 months, and 6-18 months. Children classified as OME+ had OME for 2 or more episodes during a 6 month period or 4 or more episodes for a 12 month period. Children in the study had their hearing levels measured at 6 months using auditory brainstem response and at 12 months using sound field visual reinforcement audiometry. Hearing level averages were used for categorical classification of children's hearing during each of the three developmental periods. Children were classified as affected (HL+) if average hearing levels were greater than 20 dB during each period and classified as non-affected (HL-) if average hearing levels were 20 dB or less. The study completed analyses to address the likelihood of false negatives. In addition, tests were completed to verify that there were not any significant differences in the proportion of children of each gender meeting OM classification or hearing level criteria.

Language testing was conducted to confirm that the children were not at risk for a language delay or disorder. Conversational samples selected for the study were transcribed by blind research assistants and evaluated by Programs to Evaluate Phonetic and Phonological Evaluation Records (PEPPER) to compute the children's scores for 10 metrics of articulatory competence.

Three statistical approaches were used to assess associations among OME, hearing loss and speech outcomes. Both differences and associations using Wilcoxon-Mann-Whitney rank orders statistics, Pearson correlations as well as Structural Equation Modeling (i.e., a powerful alternative to the use of multiple regression) were analyzed. The statistical methods used were appropriate, rigorous and examined both continuous and categorical variables involved; however, an estimate of power was not given and the confidence intervals of the statistical measures were not reported.

The study included hearing measures in both the design and the statistical analysis and supported the risk of increased hearing thresholds related to OME. Although the statistical approach was conducted appropriately, the design limitations must be acknowledged. The participants were selected from a sample of children already participating in a study examining the relationship between language development and OME and were of middle to high-middle class only. In addition, the design employed a retrospective analysis of both records and conversational samples relying on the reliability of others' record management.

A retrospective design by Shriberg, Flipsen, Thielke, Kwiatkowski, Kertoy, Katcher, et al. (2000) examined data from two retrospective studies and employed statistical comparisons as well as risk techniques that provided estimates of the effects of OME on speech production in preschool children. The investigation reported varied results among the two samples examined, concluding that OME was associated with increased risk for a speech disorder within one sample but was not considered a risk factor within the other (Shriberg et al., 2000).

The first group of subjects consisted of 35 typically developing children from middle class families and had well-educated parents. The subjects' otologic histories were constructed from physician entries, contact letters as well as phone calls to caregivers. The children were English speaking and free of major medical and psychosocial conditions. The investigation failed to control for race or ethnicity but mandated that children had not participated in past speech therapy programs. The children participating in

the study had 0 to 58 weeks of middle ear involvement with the most involvement occurring between 6 and 24 months of age. Based on duration of OME, the subjects were assigned to either an OME+ or OME- group with these two groups comprising a total group of which all children from both studies belonged. In addition, an OME severity subgroup was established and children were delegated based on the severity of their OME.

The second sample consisted of 50 English speaking, Native American children followed at a tribal health clinic. The use of this second sample of Native American children had many implications as the tribe selected had a very high prevalence of OME and was considered socioeconomically disadvantaged. The protocol of group assignment was similar to group one, with the sample of children being classified as OME+ or OME-. As with the first sample of children, there were many variables that were not accounted for, including the following: birth weight, familial history of speech disorder and gestational age.

There were no significant differences in the composition of both groups based on gender or age. Raters were blind and the protocol of assessment was similar in both groups and consisted of examination of the oral mechanism, pure tone testing, otoscopic examination as well as acoustic-immittance data.

The study measured speech outcomes by employing many different metrics sensitive to the structural levels of phonology. Wilcoxon-Mann-Whitney rank order statistics were completed for all between group comparisons. In addition, both relative risk ratio and odds ratio analyses were used to assess the risk for a phonological disorder for children exposed to OME. Statistically significant findings were limited to the second sample of Native American children and indicated that those subjects were at an increased risk for a speech disorder. The study reported broad confidence intervals which indicated the variability in the estimate of risk was quite large. The power estimate reported for the first sample had a relatively small value; however, the estimate for the second sample was moderately high.

There were several weaknesses in the design of this study. Bias was especially evident with the selection of Native American children as subjects for the second sample. Further, the additional differences and the possibility of confounding variables between the two groups of children decreased applicability to the larger population of children with OM. This study also failed to measure hearing thresholds and account for any hearing loss experienced by the children, an important variable and the premise behind phonological deficiency related to OM.

A prospective study by Paradise, Dollaghan, Campbell, Feldman, et al. (2000) investigated the effects of OM on speech, language, cognitive and psychosocial development. The study examined the children's cumulative duration of middle ear effusion in their first 3 years of life and the children's scores on measures of speech, sound production, and cognition at 3 years of age. No significant correlations between duration of middle ear effusion to speech sound production were found.

The investigation selected 241 children of 3 years of age that failed to meet randomization criteria for a larger study. The spectrum of OME experienced by the children varied from no occurrence to having an OME duration that was insufficient for meeting the randomization criteria for the larger study (i.e., bilateral OME for 90 days or unilateral OME for 135 days). The children were placed into four subgroups based on the number of total days with OME and then selected randomly based on site grouping and maternal education to achieve a subsample of equal size from the four groups that were matched sociodemographically (Paradise, Dollaghan, Campbell, Feldman, et al., 2000).

Ear status was monitored monthly throughout the first 3 years of life by pneumatic otoscopy as well as the use of tympanometry and the validity of these measures were carefully and routinely examined. Hearing was measured based on selected criteria and was not used in statistical analysis. Measurement of speech sound production was done through a spontaneous conversation sample and was analyzed using Programs to Evaluate Phonetic and Phonological Evaluation Records (PEPPER) to yield the Percentage of Consonants Correct–Revised (PCC-R). All examiners were blind to children's OME histories, maternal education as well as health status and high inter-transcriber agreement was established

Many variables other than speech outcomes were investigated in the study and therefore, many statistical measures were used. Chi-squared tests were utilized to test for differences between proportions of subjects and included the incorporation of the Yates correction. Pearson pairwise correlations were also used to test for associations between scores on tests and proportion of days with OME. Linear regression was employed to adjust for potentially confounding variables (e.g., socioeconomic status) (Paradise, Dollaghan, Campbell, Feldman, et al., 2000). Statistically, there were no significant correlations between the sample as a whole or any of the subgroups with OME and scores on speech production.

The use of the extensive exclusion criteria, control over confounding variables, statistical rigor and the use of a large sample size were strengths of the design. Although the investigation was thorough, it failed to account for hearing thresholds and the possible impact hearing loss has on the association between OME and speech measures as well as the interaction between hearing loss and OME duration.

The presented investigations regarding the impact of OM on phonological development in preschool children consisted primarily of lower grade research evidence. Of the six articles considered, one reflected mixed findings within the study, one failed to support a relationship and four investigations provided support or predictive value for a relationship between OM and phonological deficiency. Of the studies that supported the relationship between OM and phonological inadequacy, strong correlations between associations were not present.

The inclusion criteria for each study were generally acceptable; however, many of the studies displayed weaknesses in regards to subject selection. For example, the study by Paden, Novak and Beiter (1987) selected children with the most severe cases of OM who were referred for tympanostomy and tube insertion. Other studies selected participants based on current participation in an ongoing study related to OM and language or children from low socioeconomic environments. Due to the possible confounding variables associated with specific populations,

it could be argued that the selection of high-risk or disadvantaged participants placed children at an increased risk for inadequate phonological development due to the relationship of OM with other environmental variables and not the independent effect of OM. In addition, the restricted focus on particular ethnic, socioeconomic or other defined groups limited the applicability and generalization to the larger population of children with OM.

The majority of investigations used similar procedures for measurement of speech outcomes and reported acceptable inter-rater reliability measures. In most cases criterion-referenced methods known to the profession were used to measure phonological outcomes. Measures included assessments that indicated the children's repertoire of sounds, the number of consonants in error as well as the phonological processes being used by the children. It can be argued that the measurement of consonant errors at such a young age was not a reliable measurement due to the variability in each child's phonological development.

It was addressed in some of the studies, and can be assumed in others, that children were medically treated when OM was present. Treatment included the use of antibiotics as well as tympanostomy and tube insertions. It would be unethical not to treat children with OM; however, it is difficult to determine whether the medical treatment which diminished the effusion aided in the acquisition of phonological skills and was a possible confounder to the weak correlations found between OM and phonological development.

Detection of OM and classification was consistent among the studies. All studies used pneumatic otoscopy tympanometry and the reliability among examiners was consistently calculated and reported. Some of the studies included measurement of hearing thresholds; however, only two of the studies incorporated hearing loss as a part of the statistical analyses of the investigation. The premise behind much of the research in this area is that the conductive hearing loss, as a result of effusion, is the factor responsible for possible phonological delay. Although the duration of OM was a relevant area of study, it was necessary to identify and incorporate hearing thresholds into analyses as the number of days with OM could not independently predict if the condition had an impact on phonological development.

Conclusions

Based on the methodological and measurement weaknesses present in the reviewed literature, it cannot be concluded with certainty that a child with a history of recurrent OM during the preschool years is at risk for delayed phonological development. The contribution of sociodemographic variables, such as low socioeconomic status as well as a lack of parental education, may have played a significant role in creating a correlation in some of the studies where a relationship was identified.

Recommendations

Due to the inconclusiveness of the evidence it is recommended that children with recurrent histories of OM, especially those accompanied by the above-mentioned sociodemographic variables, be referred to and monitored by a speech-language pathologist as well as an audiologist.

Until conclusive evidence is provided, it is recommended by the American Academy of Pediatrics to monitor oral communication skills in children who experience persistent OME and/or recurrent acute OM for 3 months or more (Abraham, Wallace & Gravel, 1996). A speech-language pathologist's involvement may include, but not be limited to, providing parent education regarding phonological milestones as well as teaching techniques to assist with phonological development.

As a result of the varied findings, in addition to the methodological and design flaws of the studies examined, further research should be conducted in this area before definite conclusions are assumed. Most importantly, future researchers should strongly consider analyzing the relationship of OM and phonological development using hearing loss as the independent variable of study. Although duration of OM is a relevant variable, it is the conductive loss of OM that impedes the acoustic signal and therefore may possibly affect phonological development. In addition, future studies should investigate the threshold levels necessary for phonological development. By identifying thresholds required for normal development, it can be determined if a child is at risk for phonological delay due to the conductive hearing loss caused by middle ear effusion.

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