Scientific Article

Middle Ear and Respiratory Infections in Early Childhood and Their Association With Early Childhood Caries

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Abstract: ***Purpose:*** *The purpose of this study was to examine the risk of early childhood caries (ECC) in children who had middle ear infections (MEI) or respiratory tract infections (RTI) during early childhood.* ***Methods:*** *Medicaid data from Michigan were analyzed for all continuously enrolled children born in 2001 for whom enrollment, medical, and dental claims were filed during 2001-2004. Proportional hazards survival models were used to assess the risk of ECC in children who had MEI or RTI during the first year of life.* ***Results:*** *Included in the study were 29,485 children (51% males and 49% females). By first year of life, 47% and 69% of children had a claim for MEI and RTI, respectively. Children with at least one claim for MEI or RTI were at 29% higher risk for developing ECC compared to those with no claims (P<.001). Hispanic children with 8 or more claims showed 91% greater risk for developing ECC than those with less than 8 claims (P=.01).* ***Conclusions:*** *The occurrence of middle ear infections or respiratory tract infections during the first year of life is associated with a significantly increased risk for developing early childhood caries during subsequent years. Race and ethnicity are possible predictors for ECC in the studied models. (Pediatr Dent 2008;30:105-10) Received December 12, 2006 / Last Revision June 12, 2007 / Revision Accepted June 13, 2007.*

KEYWORDS: MIDDLE EAR INFECTIONS, OTITIS MEDIA, ACUTE OTITIS MEDIA, RESPIRATORY TRACT INFECTIONS, EARLY CHILDHOOD CARIES

Middle ear infections (**MEI**), or otitis media (**OM**), refer to inflammation of the middle ear without reference to etiology or pathogenesis.[1] It is a condition that affects mostly infants and children, peaking during the first 3 years of life.[2,3] By 3 years of age, 80% of OM children have had at least 1 OM episode and 50% have had at least 3 episodes, while fewer have a first episode after 3 years of age.[4] The condition in its acute form has a rapid onset of signs and symptoms, including pain, fever, irritability, and loss of appetite or vomiting, and is known as acute otitis media (**AOM**).[2]

MEIs—as well as other infectious illnesses of childhood, including pneumonia, diarrhea, urinary tract infections, and varicella—have been linked to a condition known as enamel hypoplasia (EH) or linear enamel hypoplasia.[5,6] This condition is believed to result from an insult to the oxygen-sensitive ameloblasts during enamel formation. It has been associated with elevated levels of salivary mutans streptococci and with a significantly higher risk for developing dental caries.[7,8]

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Because primary teeth continue to calcify throughout the first year of life,[9] we hypothesized that MEI occurring during this period may cause some damage to the ameloblasts. This may result in the formation of hypoplastic primary teeth, therefore increasing their caries susceptibility. Hence, this research was primarily aimed at examining the relationship and possible association between MEI reported during the first year of life and early childhood caries (**ECC**) in subsequent years. The research additionally sheds some light on the associations between ECC and other common childhood infections, including respiratory tract infections (**RTI**) and urinary tract infections (**UTI**).

Methods

This research presents a secondary analysis of existing Medicaid insurance data filed in the state of Michigan between 2001 and 2004. Our analysis included data on all continuously enrolled, healthy children in Michigan who were born between January 1, 2001, and December 31, 2001. Children with serious medical disabilities, such as those covered by the Children's Special Health Care Services were not included in the study.

After obtaining approval from Medicaid and the Institutional Review Board at the University of Michigan, Ann Arbor, Mich, Medicaid claims were released to the researchers. The analysis was carried out using 3 main Medicaid claims files: (1) enrollment; (2) medical; and (3) dental. The data were deidentified (ie, enrollees' names were removed), and each child was represented by

a unique identifying number, which was identical in all 3 data files for each child. The unique identifiers served to link each child's information from the enrollment, medical, and dental claims while protecting the child's identity and privacy.

The enrollment data file contained basic demographic data for children who were born in the year 2001, including date of birth, gender, race, county of residence, zip code, and total months of enrollment. Medical data contained claims submitted for adults and children to Medicaid between 2001 and 2003. The data included a list of all medical claims associated with established diagnoses of middle ear, respiratory, and urinary infections, all represented by the International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) diagnostic codes.[10] Each diagnosis was associated with the date of service on which it was provided. Medical diagnoses, mostly of an infectious nature, were included in the statistical analyses. A variable, including acute middle ear infections (**AOM**), was created and included in the analysis to represent only those visits for which the child presented with AOM symptoms, such as fever or pain. The dental data contained insurance claims for adults and children related to dental services provided between 2001 and 2004.

Statistical models

Data included in the medical and dental claims files included both adults and children. Therefore, it was necessary to merge these 2 files with the enrollment data to extract only claims for children who were born during the year 2001. The resultant merged file was used to perform the statistical analysis.

Because children in the sample had different dates of births, each child contributed a different at-risk time to the study. Therefore, we decided to use proportional hazards survival models that could incorporate this varying at-risk time in the model. The models included the occurrence of claims for AOM, RTI, or UTI during the first year of lifefirst year of life as predictors and the development of ECC after the first year of life as the outcome. The age of 12 months was used in the models as the 0 point, after which the risk for ECC was measured and only children free of dental caries at that age were included in the survival models.

This study defined ECC and severe ECC (**S-ECC**) based on a definition suggested by the National Institute of Dental and Craniofacial Research in 1999.[11] The definition of ECC included all children 71 months of age or younger with a diagnosis of dental caries. The definition of S-ECC included any sign of smooth-surface caries in children younger than 3 years of age. Therefore, ECC was considered to be present if the child had, on any of the primary teeth, an: (1) amalgam or resin restoration; (2) stainless steel crown (SSC); (3) sedative filling; (4) core buildup; (5) pulp treatment; or (6) extraction. S-ECC was considered to be present if: (1) ECC was present; and (2) the dental treatment included any one of the smooth tooth surfaces of the primary teeth. Values were considered statistically significant at *P*-values >.05.

Results

The analysis included data on 29,485 children, of which 15,113 (51%) were males and 14,372 (49%) females. Slightly more than half the children in the sample were Caucasian (N=16,256), followed by African American (N=10,531) and Hispanic (N=2064) children. Due to the small number of Asians, Native Americans, migrants, and children of unknown race in the sample, the statistical models included only Caucasian, African American, and Hispanic children, who represented nearly 98% of the total sample (N=28,851).

By the end of the first year of life, 77% of the children in the sample had at least one diagnosis of AOM, RTI or UTI, with RTI being the most common (Table 1). Comparing the 3 major races in the sample (Caucasian, African American, and Hispanic) showed that the percentages of Caucasian and Hispanic children who had at least 1 diagnosis of AOM, RTI, or UTI were generally comparable with no significant difference (chi-square=1.04, *P*=.31). There was, however, a significant difference between the percentage of Caucasian and African American (chi-square=223.71, *P*<.001), and Hispanic and African American (chi-square=42.26, *P*<.001) children who had a medical diagnosis during the first year of life (Table 2). Also, results showed that the number medical claims occurring during the first year of life and those occurring after the first year were significantly positively correlated (r=0.47, *P*<.001).

Table 1. NUMBER OF CHILDREN WITH SPECIFIC MEDICAL DIAGNOSES DURING THE FIRST YEAR OF LIFE, BY GENDER*

Claim type†		Males (N=15,113)	Females (N=14,372)	Total (N=29,485)
Specific medical diagnoses	AOM	7,511 (50%)	6,409 (45%)	13,920 (47%)
	RTI	10,775 (71%)	9,673 (67%)	20,448 (69%)
	UTI	264 (2%)	502 (3%)	766 (3%)
Any included diagnoses‡		11,983 (79%)	10,812 (75%)	22,795 (77%)

* Percents are out of the total number of children in each gender, total percents are out of the total sample size (N=29,485).

† AOM: acute otitis media, RTI: respiratory tract infections, UTI: urinary tract infections.

‡ Children with at least one claim for AOM, RTI, or UTI.

At the end of follow-up, there were 1,518 children diagnosed with ECC, which represented about 5% of the total sample. Of these, 1,015 had S-ECC, which represented nearly 67% of children with ECC and 3% of the total sample. A child's gender was found to be significantly associated with ECC (chi-square=55.6, *P*<.001) and S-ECC (chi-square=27.63, *P*<.001), with slightly more males than females having ECC

Table 2. NUMBER OF CHILDREN WITH VARIOUS MEDICAL DIAGNOSES DURING THE FIRST YEAR OF LIFE, BY RACE*

Diagnosis type	Diagnosis †	RACE							
		Caucasian (N=16,256)	African American (N=10,531)	Hispanic (N=2,064)	Native Americans (N=136)	Asian (N=353)	Migrant (N=21)	Unknown (N=124)	Total (N=29,485)
Specific medical diagnoses	AOM	8,390 (52%)	4,173 (40%)	1,060 (51%)	87 (64%)	143 (41%)	15 (71%)	52 (42%)	13,920 (47%)
	RTI	11,739 (72%)	6,832 (65%)	1,461 (71%)	89 (65%)	245 (69%)	16 (76%)	66 (53%)	20,448 (69%)
	UTI	436 (3%)	238 (2%)	69 (3%)	5 (4%)	11 (3%)	3 (14%)	4 (3%)	766 (3%)
Any included diagnoses ‡		13,055 (80%)	7,631 (72%)	1,638 (79%)	107 (79%)	265 (75%)	17 (81%)	82 (81%)	22,795 (77%)

* Percents are out of the total number of children in each race.

† AOM: acute otitis media, RTI: respiratory tract infections, UTI: urinary tract infections.

‡ Children with at least one claim for AOM, RTI, or UTI.

Table 3. THE PREVALENCE OF EARLY CHILDHOOD CARIES AND SEVERE EARLY CHILDHOOD CARIES DURING 2001-2003, BY RACE

RACE	ECC children		SECC children	
	N	(%)*	N	(%)*
Caucasian (N=16,256)	666	4	457	3
African American (N=10,531)	669	6	436	4
Hispanic (N=2,064)	145	7	93	4
Native Americans (N=136)	6	4	3	2
Asian (N=353)	20	6	17	5
Migrant (N=21)	3	14	2	10
Unknown (N=124)	9	7	7	6
Total (N=29,485)	**1,518**	**5**	**1,015**	**3**

* Percents are out of the total number of children in each race.

and S-ECC. The prevalencs of ECC and S-ECC varied among children of different races (Table 3). Chi-square tests of independence showed a significant difference in the proportion of ECC children between Caucasians and African Americans (chi-square=68.8, *P*<.001), and between Caucasians and Hispanics (chi-square=39.12, *P*<.001), but not between African Americans and Hispanics (chi-square=1.57, *P*=.21). Chi-square tests of independence also showed a significant difference in the proportion of S-ECC children between Caucasians and African Americans (chi-square=46.88, *P*<.001), and between Caucasians and Hispanics (chi-square=17.43, *P*<.001), but not between African Americans and Hispanics (chi-square=0.02, *P*=.9).

Table 4 summarizes the results of the proportional hazards survival models, which included medical claims (AOM or RTI) between birth and 12 months of age, and their relationship with ECC development after 12 months of age, to the end of the follow-up period. Table 4 presents:

1. models that show the associations between ECC and medical claims occurring during specific time periods in the first year of life (section A);
2. medical claims represented as a dichotomous variable (ie, whether the child had or did not have medical claims [section B]);
3. medical claims represented as a categorical variable based on the frequency of such claims (section C); and
4. a model comparing children with 8 or more medical claims to those with more than 8 claims (section D).

Table 4 also gives hazard ratios (**HR**) for each covariate in each model. A hazard ratio greater than 1 indicates that the variable is associated with an increased risk for ECC. A ratio less than 1 indicates a decreased risk for ECC, and a HR of 1 indicates no association. When each of the medical diagnoses (AOM, RTI, or UTI) was individually included in a proportional hazards model, AOM and RTI were individually significantly associated with the risk of ECC. The occurrence of AOM during the first year of life was associated with an 11% increase in the risk of ECC (HR=1.11, *P*=.05), and RTI was associated with a 34% increase (HR=1.34, *P*<.001). Because the number of children with UTI was extremely small and UTI was not found to be significantly associated with ECC (HR=1.02, *P*=.91), all models summarized in Table 4 were exclusively tested for the effects of AOM and RTI. This was done by including a variable called "AOM/RTI claims," which was coded as yes if the child had at least 1 claim for AOM or RTI during the first year of life, and no if the child did not have a diagnosis of AOM or RTI. In addition to the significant association between ECC and AOM/RTI claims as a dichotomous variable, Table 4 shows a dose-dependent response, where the strength of association was found to

Table 4. PROPORTIONAL HAZARDS SURVIVAL MODELS SHOWING THE RELATIONSHIP BETWEEN MEDICAL CLAIMS DURING THE FIRST YEAR OF LIFE AND EARLY CHILDHOOD CARIES IN THE FOLLOW-UP PERIOD

Predictors in each model *	Hazard ratio	Chi-square	*P*-value
Section (A): Model including:			
• Medical claims† (AOM and RTI) at 0-3 mos (yes/no)	1.02	0.11	.74
• Medical claims (AOM and RTI) at 4-6 mos (yes/no)	1.18	9.10	.003
• Medical claims (AOM and RTI) at 7-9 mos (yes/no)	1.12	4.18	.04
• Medical claims (AOM and RTI) at 10-12 mos (yes/no)	1.09	2.63	.10
• Male gender (reference is female)	1.10	3.39	.07
• Hispanic (reference is Caucasian)	1.76	38.13	<.001
• African American (reference is Caucasian)	1.60	71.65	<.001
Section (B): Model including:			
• Medical claims (AOM and RTI) at 0-12 mos as a dichotomous variable (yes/no)	1.29	15.18	<.001
• Male gender (reference is female)	1.11	3.67	.06
• Hispanic (reference is Caucasian)	1.76	38.17	<.001
• African American (reference is Caucasian	1.57	66.99	<.001
Section (C): Model including:			
• Medical claims (AOM and RTI) at 0-12 mos as a categorical/dummy variable:			
✓ Group 1: 0 medical claims (N=6,531)	1 1.23	– 8.85	– .003
✓ Group 2: 1-3 medical claims (N=13,282)	1.36 1.58	15.37 15.44	<.001 <.001
✓ Group 3: 4-7 medical claims (N=7.173)	1.10 1.77	3.27 38.75	.07 <.001
✓ Group 4: ≥8 medical claims (N=1,886)	1.61	71.79	<.001
• Male gender (reference is female)			
• Hispanic (reference is Caucasian)			
• African American (reference is Caucasian)			
Section (D): Model including:			
• Medical claims (AOM and RTI) at 0-12 mos (≥8 claims vs <8 claims)	0 1.30	0 6.47	0 .01
• Male gender (reference is female)	1.11	4.2	.04
• Hispanic (reference is Caucasian)	1.76	38.39	<.001
• African American (reference is Caucasian)	1.57	65.78	<.001

* AOM=acute otitis media; RTI=respiratory tract infections; UTI=urinary tract infections.

† Refers to the variable "AOM/RTI claims."

significantly increase as the frequency of AOM/RTI claims increased (Table 4, section C).

The survival model in Table 4, section C was studied further by comparing the nature of the association between ECC and AOM/RTI claims in children who had more frequent AOM/RTI claims to those with fewer or no AOM/RTI claims (section D). Children with frequent AOM/RTI claims were defined as those who had ≥8 claims for either AOM or RTI during the first year of life (group 4, section C). These children were compared to those who had <8 such claims (groups 1-3, section C). For all children combined (Caucasian, African American, and Hispanic), those who had ≥8 claims during the first year of life had a 30% higher risk for ECC compared to those with less frequent claims. When this model was stratified by race, a significant association between ECC and AOM/RTI claims was noted only in Hispanic children, who showed nearly a 91% increase in ECC risk for those who had more frequent AOM/RTI claims.

Discussion

Our results show that the risk of having ECC after the first year of life significantly increases in children who are diagnosed with AOM or RTI during the first year of life.

The data demonstrate the high prevalence of infections occurring during the first year of life, which hypothetically may have put the affected children at some risk for developing enamel hypoplasia (**EH**) during primary teeth formation. Previous research has shown that frequent pediatric care and infections in early childhood—such as AOM, RTI, and UTI—can be risk factors for EH.[5,12] In Guatemala where the prevalence of EH is high, children with such lesions demonstrated nearly twice the prevalence of infectious diseases in the first 35 days of life than those with no EH.[5,13] In their 2005 study on preschool children, Nelson et al reported no association between ear infection history and dental caries, despite the presence of a trend for the mean number of ear infections in children with dental caries being greater than that in children with no dental caries.[14] The lack of association between UTI and ECC could be explained by the fact that only a few children in the sample were reported to have had UTI during the first year of life.

It may be that children who experience these childhood infections at such an early age tend to have more recurrences later in life and are generally sicker than those who go through the first year without

infections. Our data show that there is, in fact, a positive correlation between having infections during the first year of life and having them after the first year. It is possible that these sick children may be put on many therapeutic regimens, both prescription or over-the-counter (**OTC**) medication, during the first several years of life, and are affected by the sugar content of these medications. Additionally, parents of frequently sick children may be consoling them by modifying their diet and including more sugar-containing items—a known risk factor for dental caries.

The strong association between race and medical claims and between race and ECC was evident in our data. It may be difficult to identify the exact role that race plays in disease prevalence because of its possible association with other predictors of disease risk and ascertainment, such as socioeconomic status, or access to medical care. Socioeconomic status is a risk factor known to be associated with the individual's susceptibility to RTI and with dental caries.[15-19] Our results show that Hispanic children continued to be at higher risk for ECC compared to Caucasian children, despite no significant difference between the proportion of Hispanic and Caucasian children who had medical claims during the first year of life. This may be explained by the fact that dental caries has other risk factors—including diet, and exposure to fluoride—that could not be controlled for in our models due to the unavailability of data. Compared to Caucasian and African American children, Hispanic children also showed the highest increase in risk for ECC for those who had more frequent medical claims during the first year of life. It is possible that Hispanic children who had more frequent medical claims were also extremely socially and economically disadvantaged, which had put them at more risk for having dental caries as well.

This study had some limitations that were essentially due to the inherent nature of the claims data. We had information on children who were able to seek health and dental care, but these were not necessarily representative of all enrolled children. Children who did not have claims may not all be healthy. It may be that: 1) their symptoms were mild and did not necessitate medical or dental attendance; 2) they had difficulty accessing care: or 3) parents preferred to start with OTC medications as a first response to illness. This study included healthy children not covered by the Children's Special Health CareServices. The latter is a program that provides medical coverage for individuals with chronic illnesses—including more than 2,700 diagnoses, such as cancer, cerebral palsy, cleft lip and palate, and deformed limbs. As such, it can be said that the majority of children included in this study were free of serious medical conditions, as well as some of the most common chronic conditions that may result in enamel hypoplasia. The sample, however, still may have missed some children with less serious conditions that can also be linked to enamel hypoplasia. We believe that these children represent a slim proportion of those included in the sample.

Also, due to the nature of insurance data, our measurement of ECC may not have detected children with incipient caries for whom treatment had not been provided. Therefore, our measured prevalence of infections and ECC may have been an underestimate of the true incidence of the conditions studied.

Despite these limitations, this research provides some information on the nature of the association between ECC and some of the more common early childhood infections, and may be used for caries risk assessment and to support further longitudinal research.

Conclusions

Based on this study's results, the following conclusions can be made:

1. The risk of ECC after the first year of life significantly increases in children who were diagnosed with either AOM or RTIs during the first year of life.
2. Hispanic children showed the greatest increase in risk for ECC for those with more frequent diagnoses of AOM or RTI during the first year of life.

Acknowledgements

The authors would like to extend their gratitude to Dr. Stephen Eklund (Professor Emeritus of Dental Public Health, Department of Epidemiology, School of Public Health & Adjunct Clinical Prof of Dentistry, Dept of Cariology, Restorative Science & Endodontics, School of Dentistry, Kathy Welch (statistical consultant) , Kevin Dombkowski (Assistant Research Professor, Pediatrics-Ambulatory Care Program), and Lisa Cohn (Database Analyst/Programmer Sr), all at the University of Michigan, Ann Arbor,Mich., for their efforts in obtaining and analyzing Medicaid data.

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Abstract of the Scientific Literature

Three-year survival of single- and two-surface ART restorations in a high-caries child population

The aim of this study was to evaluate the survival of single- and two-surface atraumatic restorative treatment (ART) restorations in the primary and permanent dentitions of children from a high-caries population, in a field setting. The study was conducted by four Dutch dentists in the rainforest of Suriname, South America. Four hundred seventy-five ART restorations were placed in the primary dentition and 54 in permanent first molars of 194 children (mean age 6.09±0.48 years). Three-year cumulative survivals of single- and two-surface ART restorations in the primary dentition were 43 and 12%, respectively. Main failure characteristics were gross marginal defects and total or partial losses. Three-year cumulative survival for single-surface ART restorations in the permanent dentition was 30%. Main failure characteristics were secondary caries and gross marginal defects. The results show extremely low survival rates for single- and two-surface ART restorations.

Comments: *This study shows an unexplained extremely low survival of ART restorations that authors suggest that may result from possible interfering factors including cultural and seasonal dietary influences.* ***YHW***

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